Mindfulness and critical thinking: structural relations, short-term state effects, and long-term intervention effects

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MINDFULNESS AND CRITICAL THINKING: STRUCTURAL RELATIONS, SHORT-TERM STATE EFFECTS, AND LONG-TERM INTERVENTION EFFECTS

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Abstract

Background

In recent years, many claims have been made regarding the application of mindfulness practice to the improvement of everyday thinking skills. Everyday thinking skills are best measured using assessments developed in the field of research focused on critical thinking. When considering the theoretical foundation of a relationship between mindfulness and critical thinking, there are generally two main perspectives put forward. One view suggests that mindfulness does not facilitate critical thinking due to the association between mindfulness and acceptance. Another view suggests that since mindfulness practice appears to result in improved executive functioning, it may facilitate the operation of reflective processes which are crucial to effective critical thinking. However, no previous studies have directly examined the relationship between mindfulness and critical thinking. The present research sought to address this gap in the literature.

Methods

Study 1 examined individual differences in the present-moment attention and non-reactivity facets of dispositional mindfulness and their relationships to the core executive functions of updating, inhibition and shifting, and critical thinking. Study 2 examined the effects of an experimental manipulation of state mindfulness on performance on a complex executive function task and a critical thinking task. Participants were randomly assigned to either complete a brief mindfulness meditation or a sham meditation consisting of guided mind-wandering. The extent to which individual differences in dispositional mindfulness, need for cognition and actively open-minded thinking moderated the effects of the experimental manipulation of state mindfulness on the primary measures was also examined. Study 3 consisted of a double-blinded, randomised controlled trial comparing the effects of an online mindfulness training program with those of an online guided sham meditation program on executive functioning, thinking dispositions and critical thinking.
Results

Study 1 demonstrated a significant but weak indirect effect between both facets of mindfulness and critical thinking through inhibition. A negative direct effect of non-reactivity on critical thinking was also found. Study 2 found that there was no difference between the experimental condition and the control condition in terms of performance on both the executive function task and the critical thinking task. However, moderation analyses suggested that the brief mindfulness meditation did improve critical thinking for those lower in need for cognition and those lower in actively open-minded thinking. Study 3 found that there were no differences between the mindfulness meditation group and the sham meditation group in the extent to which executive functioning, thinking dispositions and critical thinking changed from baseline to follow-up.

Conclusion

The results of these studies together suggest that the effects of mindfulness on critical thinking are mostly small and, in experimental contexts, indistinguishable from those of closely matched control conditions. Furthermore, only limited support was found for the mediating role of executive functioning in the relationship between mindfulness and critical thinking. These results suggest that claims regarding the supposed benefits of mindfulness practice for critical thinking should be tempered until further research is conducted.
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“Don't gobblefunk around with words.”
— Roald Dahl, The BFG

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List of Abbreviations

ACT - Acceptance and Commitment Therapy
AIC - Akaike Information Criteria
BF - Bayes Factor
CCTST - California Critical Thinking Skills Test
CAMS - Cognitive and Affective Mindfulness Scale
CBT - Cognitive Behavioural Therapy
CPE - Cognitive Psychological Education
CAAPCT - Collegiate Assessment of Academic Proficiency Critical Thinking
CFI - Comparative Fit Index
CCTT - Cornell Critical Thinking Test
CV - Covariate
DBT - Dialectical Behaviour Therapy
DV - Dependent variable
EWCTET - Ennis-Weir Critical Thinking Essay
ERN - Error-Related Negativity
ERP - Event-Related Potential
FFMQ-SF - Five Facet Mindfulness Questionnaire short form
FFMQ - Five Factor Mindfulness Questionnaire
FMI - Freiburg Mindfulness Inventory
HCTA - Halpern Critical Thinking Assessment
IELTS - International English Language Testing System
IFI - Incremental Fit Index

IV - Independent Variable

KIMS - Kentucky Inventory of Mindfulness Skills

LMS - Langer Mindfulness Scale

MedV - Mediator variable

MAAS - Mindful Attention and Awareness Scale

MBCT - Mindfulness-based Cognitive Therapy

MBSR - Mindfulness-based Stress Reduction Programme

MTCT - Minnesota Test of Critical Thinking

MM - Mindfulness Meditation

ModV - Moderator variable

PANAS - Positive Affect and Negative Affect Schedule

RCT - Randomised Controlled Trial

RT - Reaction Time

SM - Sham Meditation

SMQ - Southampton Mindfulness Questionnaire

SEM - Structural Equation Modelling

TAM - Technology Acceptance Model

TOEFL - Test of English as a Foreign Language

TMS-S - Toronto Mindfulness Scale

TLI - Tucker-Lewis index

WGCTA - Watson-Glaser Critical Thinking Appraisal
List of Works

Below is a list of publications and presentations which disseminated the research presented in this thesis.

Publications

Peer-reviewed Journal Articles

Noone, C. & Hogan, M. J. (Under Review) A randomised active-controlled trial to evaluate the effects of an online mindfulness intervention on executive control, critical thinking and key thinking dispositions in a university student sample. *BMC Psychology*


Presentations


Chapter 1

Mindfulness and the Clarity of Thought

1.1 Thesis Aim

Mindfulness is a particular mental state, usually cultivated through meditation, which is often characterised as involving the focusing of attention to the present-moment in a non-judgmental or non-reactive manner (Kabat-Zinn, 1994; Quaglia, Brown, Lindsay, Creswell, & Goodman, 2014; Rau & Williams, 2016). The concept of mindfulness and the practices associated with mindfulness have their roots in Buddhist philosophy within which they have been discussed for thousands of years (Siegel, Germer, & Olendzki, 2009). This thesis seeks to examine recent claims regarding the effects of mindfulness on everyday thinking skills, with a particular focus on critical thinking. In doing so, it will build on research carried out over the last thirty years in psychology on the effects of mindfulness and consider whether clarity of thought – a key outcome of mindfulness discussed in Buddhist writings and which is relevant to the claims mentioned above – has been overlooked as a focus of research in the psychology of mindfulness. Traditional Buddhist texts described mindfulness as an enhanced awareness of changes in the phenomena of experience. The Buddhist scholars who authored these texts saw the mind as being made up of successive momentary states. Awareness and clear comprehension of these momentary states was referred to as “sati”, which was later translated into the English as mindfulness (Bodhi, 2011). The primary outcomes of mindfulness were said to be the reduction of suffering and the cultivation of clarity of thought (Mikulas, 2010; Siegel et al., 2009; Teasdale & Chaskalson, 2011).

This thesis will show that while the promise of reducing suffering inspired a plethora of research, a focus on the link between mindfulness and the clarity of thought has been somewhat neglected in research (Dreyfus, 2011; Quaglia et al., 2014). Despite this neglect, claims have proliferated regarding the effects of mindfulness on outcomes related to the clarity of thought such as enhanced skill in problem-solving, decision-making and critical thinking. Indeed, many researchers, practitioners, commercial and
non-profit organisations and governments have made claims regarding the application of mindfulness practice to the improvement of everyday thinking skills (Mindfulness All-Party Parliamentary Group, 2015; Good, Lyddy, Glomb, & Bono, 2016; Insead Knowledge, 2014; Penman, 2015; Pykett, Lilley, Whitehead, Howell, & Jones, 2016; Search Inside Yourself, 2016). Closer examination of these references shows that many of these claims have been made in blogs, magazines and policy documents rather than peer-reviewed sources and with little reference to direct empirical evidence. Currently there is no solid evidence to suggest that these claims are true and, in general, very few studies on the effects of mindfulness on thinking skills have been conducted (Mikulas, 2011). The intention behind this thesis is to address this significant gap in the research by subjecting these claims to critical scrutiny, linking them to psychological theory and evidence regarding critical thinking and describing a series of studies carried out to empirically test these claims. As such, the central research question of this thesis is “Does mindfulness enhance performance on critical thinking tasks?”.

1.2 Chapter Outline

This chapter will briefly trace the import of mindfulness from Eastern philosophy to Western science and then examine the range of conceptualisations, operational definitions and measures of mindfulness which have been proposed by psychologists. Self-regulation is common to these varying descriptions of mindfulness and this chapter will argue that self-regulation and related executive functioning skills could underlie both the clarity of mind and reduction of suffering associated with mindfulness. Research supporting this perspective will be presented and the methods and tools used to investigate the effects of mindfulness will be discussed. At the end of this chapter, the reader will be aware of the historical, theoretical and empirical reasons which justify a greater focus on the association between mindfulness and clarity of thought. In chapter two, it will be argued that this focus should include the study of the relationship between mindfulness, executive functioning and critical thinking.
1.3 The Ubiquity of Mindfulness

Before tracing the historical roots of mindfulness to how it has been studied within psychology in recent times, it is worth stating just how popular mindfulness has become, both with researchers and the public. This will elucidate the context in which the research described in this thesis was conducted. The popularity of mindfulness is evidenced by its presence within mental health services (Shonin, Gordon, & Griffiths, 2015), medicine (Ludwig & Kabat-Zinn, 2008), education (Bush, 2011; Hyland, 2015), business (Glomb, Duffy, Bono, & Yang, 2011), the military (Brewer, 2014), public policy (Mindfulness All-Party Parliamentary Group 2015), sports and executive coaching (Hall, 2013) and the self-help literature (e.g. Kabat-Zinn, 1990; Puddicombe, 2011; Williams & Penman, 2011; including the recent phenomenon of adult colouring books; Arthington, 2016). Furthermore, 8% of a representative sample of Americans reported that they practiced meditation practices related to mindfulness (Clarke, Black, Stussman, Barnes, & Nahin, 2015). The corresponding increase in research interest in mindfulness is remarkable. For example, where 1 in every 3,645 psychology journal articles in the 1990s focused on mindfulness, approximately 1 in every 120 psychology articles between 2008 and 2012 focused on mindfulness (Valerio, 2016).

Mindfulness is clearly popular but what are the popularly accepted beliefs in relation to mindfulness? Laypeople appear to view mindfulness as related to meditation and involving awareness of experience, being in the present moment and being in control of one’s emotions (Hitchcock, Martin, Fischer, Marando-Blanck, & Herbert, 2016). Those applying the modern conceptualisation of mindfulness in their work – from doctors to teachers to psychotherapists and beyond – tend to describe mindfulness as present-moment attention deployed with a non-judgmental and accepting attitude (Dreyfus, 2011). This is consistent with a number of modern conceptualisations of mindfulness that have been researched and promoted within psychology. At the same time, traditional Buddhist definitions of mindfulness and definitions of mindfulness within psychological science
highlight a broad range of other features of mindfulness. These will be considered in more detail later in this chapter.

This widespread acceptance of mindfulness into contemporary Western culture has been met with very few critiques throughout the years, although a recent “mindfulness backlash” has emerged in the mainstream media and among Buddhist scholars (Purser, 2014). Those few critiques which exist highlight the lack of scrutiny given to the quality of mindfulness research and propose that the import of mindfulness into psychology has been so successful because its divorce from its Buddhist roots has allowed mindfulness to be portrayed as a panacea and appropriated as a tool to further neoliberal ideology (Arthington, 2016; Cook, 2016; Loy & Purser, 2013; Reveley, 2016; Stanley, 2012). Specifically, it has been argued that the import of mindfulness into Western culture has bolstered the neoliberal ideology that the reduction of suffering is an individual concern rather than a societal concern (Arthington, 2016). These arguments suggest that mindfulness prioritises individual choice over social-structural and environmental changes as a means to achieve wellbeing and liberation (Hülsheger, 2015). It should be noted that these critiques apply to the secularised (or “disembedded”; Valerio, 2016) version of mindfulness currently popularly practiced and studied in the West rather than mindfulness in its native cultural and religious context. How we derived the popular, modern perspective on mindfulness from the traditional Buddhist conceptualisation will be briefly explored later in this chapter, but a critical point here is that the popularity of mindfulness, and general lack of accompanying scepticism, has resulted in many unsubstantiated claims being made regarding the supposed positive effects of mindfulness. While we will see that there is adequate evidence to support some of claims about mindfulness – in particular, claims linking mindfulness to reduced suffering in certain contexts – other claims linking mindfulness to improved clarity of thought have persisted with little reference to evidence (Purser & Cooper, 2014). The high level of publication bias identified in the literature on mindfulness suggests that when claims have been disconfirmed, the research has not been published and this artificial abundance of positive results may
have led to the assumption that most claims regarding the benefits of mindfulness, regardless of the specific outcome, are true (Coronado-Montoya et al., 2016).

In relation to mindfulness and the clarity of thought, among the most popular claims are those regarding the supposed benefits of mindfulness for higher-order thinking and decision-making. These claims have spurred attempts to apply mindfulness in education, management and beyond. For example, in a report on the integration of mindfulness meditation into higher education, Shauna Shapiro and Kirk Brown, respected psychologists who study mindfulness, claimed that one reason to support such a move was that mindfulness would likely facilitate critical thinking among students – though they acknowledge that no previous research has ever been done on this topic (Shapiro, Brown, & Astin, 2011). To contextualise the theoretical and empirical reasons for and against the claim that mindfulness improves critical thinking, a brief overview of the historical roots of mindfulness and its import into Western science is useful. This overview will show the emergence and nature of the contemporary, disembodied conceptualisation of mindfulness to which these claims pertain. This will be followed by a review of how contemporary mindfulness has been defined, measured and researched in psychology.

### 1.4 The Historical Roots of Mindfulness

The roots of mindfulness can be found in the writings of Buddhism, an eastern philosophy and religion which originated in the northeast of India approximately 2,500 years ago (Siegel et al., 2009). Though it is overly simplistic to refer to Buddhism as a unitary school of thought – there have been and are many Buddhist traditions – most agree that the initial development of this way of thinking can be attributed to an individual known as the Buddha (Monteiro, Musten, & Compson, 2014; Sun, 2014). His teachings, known as Dhamma or Dharma, consisted of a set of practices which were meant to facilitate people in attaining happiness and spiritual freedom. The Buddha summarised his teaching in what are known as the four noble truths which deal with what suffering is, how it originates, the
possibility of its reduction and how it is reduced through following what is known as the eight-fold path (Bodhi, 2011). Mindfulness is a key part of the eight-fold path which is, essentially, a proposed model for the reduction of suffering. The eight-fold path describes the so-called “right” ways to engage in perception (including view and intention), action (including speech, action and livelihood) and mental development (including effort, concentration and mindfulness) in order to reduce suffering (Kirmayer, 2015). The use of the word “right” also denotes an ethical and moral component to these practices. Traditionally meditation was the primary means of cultivating mindfulness and it was practiced within the context of these seven other interdependent practices. In fact, practicing mindfulness without also practising the other seven interdependent practices of the eight-fold path was referred to as “wrong mindfulness”. Perhaps relevant to the question of how mindfulness relates to critical thinking is that the eight-fold path implies that “in the context of traditional mindfulness…. meditative practice is necessary but not sufficient for discernment, wise action, or wisdom to arise” (Monteiro et al., 2014, p.3).

Mindfulness is described by Buddhist scholars as being achieved through a series of mental processes including observation of stimuli, motivation to engage in the practice, and both meta-awareness (i.e. knowing that one is aware and what one is aware of in a given moment) and clear comprehension of the experience of stimuli (Bodhi, 2011). One reportedly representative definition of mindfulness in Buddhist texts is that it involves:

“contemplating feelings in feelings … contemplating mind in mind … contemplating phenomena in phenomena, ardent, clearly comprehending, mindful, having removed covetousness and displeasure in regard to the world.” (Bodhi, 2000 as cited in Bodhi, 2011, p. 20)

The purported outcome of engaging in this type of awareness is not just the reduction of suffering but also the cultivation of clarity of thought. This claim is supported by repeated reference to “clear comprehension” in traditional descriptions of mindfulness (Dreyfus, 2011; Dryden & Still, 2006). It is thought that, in this context, “clear comprehension” refers to the
idea that “the meditator not only observes phenomena but interprets the presentational field in a way that sets arisen phenomena in a meaningful context” (emphasis in original; Bodhi, 2011, p. 22). Interpreting phenomena in this way involves engaging with the object of meditation so as to discern its “true nature” (Bodhi, 2011). “Right” mindfulness is said to involve integrating this clarity with the ethical aspects of the eight-fold path in order to “evaluate mental qualities and intended deeds, make judgments about them, and engage in purposeful action” (Bodhi, 2011, p. 26). This focus on evaluation, judgment and purposeful action is consistent with modern conceptualisations of critical thinking (Facione, 2013; Halpern, 2013). This traditional view suggests that mindfulness may facilitate a more objective view of the world, one that is less clouded by biases and other cognitive distortions (Dreyfus, 2011; Kang & Whittingham, 2010; Quaglia et al., 2014). As such, from the traditional Buddhist perspective, there is more to the practice of mindfulness than simply the reduction of suffering (Kirmayer, 2015; Mikulas, 2010). As the Buddhist scholar Georges Dreyfus puts it:

“… it is important not to lose sight that mindfulness is not just a therapeutic technique but is a natural capacity that plays a central role in the cognitive process” (Dreyfus, 2011; p. 52)

Therefore, there is a historical basis to recent claims regarding the relationship between mindfulness and critical thinking. A broader historical discussion of mindfulness in the Buddhist tradition is beyond the scope of this thesis and has been previously offered by scholars of Buddhism (Bodhi, 2011; Dreyfus, 2011), critical psychology (Arthington, 2016) and the history of psychology (Gordon, 2009). These historical analyses highlight that there are many different conceptualisations of mindfulness across different schools of Eastern philosophy and throughout history. The contemporary secular version of mindfulness which found its way into psychology is in fact a combination of handpicked insights from just a couple of these schools of thought (McCown, Reibel, & Micozzi, 2010; Monteiro et al., 2014). The next section describes the import of mindfulness into western science, particularly psychology and medicine.
1.5 Mindfulness in Western Science

Between the 1950s and 1970s, greater access to air travel and more flexible immigration policies in America allowed more scholarly exchange between East and West. There was a cultural zeitgeist for all things spiritual and the teachings of Buddhism began to garner much attention as did the practice of meditation. This zeitgeist – sometimes referred to as the “Zen boom” – was due in part to the Japanese cultural influence brought home by those stationed overseas during the second world war (McCown et al., 2010). Scholars such as D.T. Suzuki, Erich Fromm and Alan Watts regularly discussed Buddhist philosophy during these years and garnered much public interest. This and the availability of teachers to guide people in practices such as insight meditation and transcendental meditation increased public curiosity regarding Buddhism (Siegel et al., 2009). However, it was the work of a medical doctor, Jon Kabat-Zinn, which was the strongest influence in bringing mindfulness specifically into mainstream Western culture. Kabat-Zinn saw the potential for bringing the reduction of suffering offered by Buddhism to the public by divorcing the practice of mindfulness meditation from its religious and philosophical context (Dryden & Still, 2006; Kirmayer, 2015). We will see that his “disembedding” of mindfulness led to the widespread acceptance of mindfulness in medicine, then psychology and then in society more generally (Sun, 2014).

Jon Kabat-Zinn’s enthusiastic application, investigation and promotion of mindfulness as a tool for reducing suffering and self-improvement began with applying it to the treatment of patients with chronic illnesses. Such conditions tend to lead to psychological distress and, in many cases, co-morbid mental health conditions (Bishop, 2002). With chronic health conditions, there is little choice but to manage the condition and the Mindfulness-based Stress Reduction Programme (MBSR) developed by Kabat-Zinn offered a new way of doing this (Kabat-Zinn, 2011). This programme was based on Kabat-Zinn’s attempt to distil the techniques of mindfulness into an acceptable and accessible behavioural intervention for those seeking coping strategies for the stress associated with chronic illness
(Kirmayer, 2015). His simplified working definition described mindfulness as:

“moment-to-moment, non-judgemental awareness, cultivated by paying attention in a specific way, that is, in the present moment, and as non-reactively and as non-judgmentally and openheartedly as possible” (Kabat-Zinn, 2005, p. 108)

This definition, more than any traditional Buddhist definition, has influenced the vast majority of operational definitions of mindfulness developed in psychology, as will be discussed later (Chiesa, 2012; Sun, 2014). Initial study of MBSR demonstrated evidence for a shift of view of meditation as a relaxation or mood management technique and towards seeing it as “a form of mental training to reduce cognitive vulnerability to reactive modes of mind that might otherwise heighten stress and emotional distress or that may otherwise perpetuate psychopathology” (Bishop et al., 2004, p. 231) by encouraging patients to actively observe their symptoms in a non-judgmental manner. As the view of mindfulness meditation as a way of training the mind to be less reactive gained traction, more studies were conducted on the effects of mindfulness on different physical conditions and symptoms and associated symptoms of psychological distress. It was in the 1990s that mindfulness fully captured the attention of researchers and practitioners in clinical psychology (Dryden & Still, 2006).

1.6 Mindfulness in Psychology

The success of MBSR inspired researchers and practitioners in mainstream clinical psychology to integrate the concept of mindfulness into their models of depression (Fennell & Segal, 2011). Cultivating the non-judgmental attention to experience described by Kabat-Zinn was seen as a way of training clients to approach their thoughts and feelings and embrace them as they are without trying to avoid or suppress them (Dorjee, 2010). This represented a stark change in approach from behavioural therapies, which attempted to remove maladaptive thoughts and feelings through punishment or change them through shaping, and cognitive therapies which focused on changing the contents of maladaptive thoughts. In this way,
mindfulness became strongly associated with the notion of acceptance (Valerio, 2016).

Perhaps the most well-known integration of mindfulness into clinical psychology is the development of Mindfulness-based Cognitive Therapy (MBCT) by John Teasdale and colleagues, but other so-called “Third Wave” behavioural therapies such as Acceptance and Commitment Therapy (ACT) and Dialectical Behaviour Therapy (DBT) have also included aspects of mindfulness in their development (Chiesa & Malinowski, 2011; Fennell & Segal, 2011; Fletcher & Hayes, 2005; Linehan, 1993). MBCT was developed by prominent researchers within the cognitive behavioural therapy (CBT) tradition who noticed that approaching maladaptive thoughts with a non-judgmental, accepting awareness cultivated through mindfulness could overcome the potential for triggering rumination that came with challenging such thoughts – one of the primary therapeutic tools in CBT (Siegel et al., 2009).

The developers of MBCT also saw mindfulness as a set of skills that could be applied to everyday experience, whereas the tools of CBT could only be applied in the presence of depressive symptoms (Dryden & Still, 2006; Monteiro et al., 2014; Teasdale, Segal, & Williams, 1995). Specifically, Teasdale and colleagues saw mindfulness as a way patients could develop awareness of the negative cycles of thought and affect which characterised their everyday experience. These theoretical ideas were developed in the context of the Interacting Cognitive Subsystems information processing model of depression (Teasdale & Chaskalson, 2011). The endorsement and integration of mindfulness within established models of depression was instrumental in the surge in research interest in mindfulness within psychology. However, it also resulted in research primarily focusing on the reduction of suffering rather than cognitive outcomes related to the cultivation of mental clarity (Dryden & Still, 2006).
There are a number of reasons for the emergence of mindfulness, its popularity within medicine and psychology and, subsequently, many other fields and the wider public, including but not limited to the following: First, the emerging focus on health and wellbeing within discourse on mindfulness in the 1980s and 1990s gave it more practical value than the more esoteric and academic focus on the nature of consciousness associated with earlier writings and other meditative practices, such as transcendental meditation. Second, mindfulness was promoted vigorously by a charismatic “leader” in the form of Jon Kabat-Zinn who initially saw the applied value of mindfulness for chronic health conditions and pursued scientific investigation of this application. Third, mindfulness practices were directed towards a public, the chronically ill and stressed, desperate for a useful tool for self-improvement. Finally, prominent psychologists who were proponents of the dominant CBT paradigm saw the potential of mindfulness to resolve and improve upon limitations of the CBT model of depression (Dryden & Still, 2006). Furthermore, many of the senior clinical researchers and practitioners who now apply, research and promote mindfulness were young people in 1960s and 1970s and were influenced by the Zen boom. Some of the popularity of mindfulness can be attributed to their ambition, in the formative years of clinical psychology, to discover alternative methods of reducing human suffering (Siegel et al., 2009).

Some of these reasons can also explain why as mindfulness became disembedded from its Buddhist roots, the focus on mental clarity, and potential links to higher-order thinking skills, was greatly overshadowed by the goal of reducing suffering – particularly in research. As a result, it is only very recently that researchers have turned their attention to related cognitive outcomes of mindfulness (Valerio, 2016). As interest in mindfulness was held primarily by clinicians across diverse areas within psychology and medicine, mindfulness research carried out in the decades following the development of MBSR, MBCT and other mindfulness-based approaches continued in the absence of an agreed operational definition of mindfulness (Bishop et al., 2004). Since the middle of the last decade, several operational definitions have been proposed, each influenced by
different traditions within psychological science. Common to many of these
definitions of mindfulness is a focus on self-regulation.

1.7 A Note on Self-Regulation

Before considering the various operational definitions of
mindfulness which have been proposed, a brief overview of the psychology
of self-regulation is useful. This is due to the frequency of references to
constructs related to self-regulation in the mindfulness literature (Bishop et
al., 2004; Rau & Williams, 2016; Rosch, 2015). Essentially, self-regulation
is the ability to monitor and exert control over one’s behaviour. This ability
is considered useful in circumstances where the immediate situation does
not meet a specific personal standard or where learned responses are
insufficient to achieve a specific goal, and thus conscious control of
behaviour is needed (Forgas, Baumeister, & Tice, 2011). Self-regulation
therefore involves (1) conscious recognition of some personal standard,
often referred to as one’s goal, (2) awareness of one’s current state, (3)
analysis of the discrepancy between one’s current state and their goal (4)
motivation to reduce any discrepancy which is noticed and (5) the ability to
influence one’s own behaviour such that this discrepancy is reduced
(Hofmann, Schmeichel, & Baddeley, 2012; Ostafin, 2015). Therefore, self-
regulation broadly involves the monitoring and control of behaviour and
failures to self-regulate can occur due to insufficient monitoring or the lack
of ability or motivation to exert control.

Models of self-regulation influenced by cognitive psychology
emphasise the importance of working memory as the means by which self-
regulatory goals are mentally represented (Hofmann et al., 2012). Working
memory is a construct which represents the ability of humans to actively
maintain a mental representation of information in a way that allows the
manipulation of this information by higher-order cognitive processes
(Baddeley & Hitch, 1974). The information maintained in working memory
may be encoded from the environment or it may be retrieved from long-term
memory stores and it is widely accepted that the capacity of working
memory is limited (Baddeley, 2012). An important feature of the working
memory model is that it includes independent stores for different types of information. The visuo-spatial sketchpad stores information of a visual or spatial nature and the phonological loop stores verbal information (Repovš & Baddeley, 2006). Another store which integrates different types of information into coherent scenes or episodes has been referred to as the episodic buffer (Baddeley, 2000).

The encoding, storage and manipulation of information in working memory must be controlled and it is the cognitive processes that achieve this control which are most important in the context of self-regulation (Baddeley, 2012; Hofmann et al., 2012). Together these control processes make up what scholars call the central executive and research consistently suggests that the central executive can be fractionated into three basic processes, known as executive functions. These three executive functions are updating, shifting and inhibition. Working memory updating involves the active revision and monitoring of thinking. Shifting involves switching flexibly between tasks or mental sets. Inhibition refers to the suppression of pre-potent thoughts or responses (Miyake & Friedman, 2012; Miyake et al., 2000). This three-component model of executive functioning is referred to as the unity/diversity model as it proposes that updating, inhibition and shifting are related but independent aspects of executive functioning. The behavioural assessment of executive functioning can focus on complex tasks which require combinations of updating, inhibition and shifting or more basic tasks focused on one of these executive functions specifically.

The executive functions are proposed to be important cognitive processes underlying self-regulation as they support the coordination of thoughts and actions in a goal-directed manner and are essential for success in education, work and everyday living (Hofmann et al., 2012). Each of the executive functions are thought to support self-regulation in specific ways. The updating and maintenance of working memory allows accurate active representation of goals and goal-related information (Hofmann, Schmeichel, & Baddeley, 2012). Inhibitory control protects goal representations from thought intrusion and has been found to support self-regulation in behaviours ranging from eating behaviour to sexual fidelity (Hofmann,
Chapter 1 - Mindfulness and the Clarity of Thought

Gschwendner, Friese, Wiers, & Schmitt, 2008; Nederkoorn, Houben, Hofmann, Roefs, & Jansen, 2010; Pronk, Karremans, & Wigboldus, 2011). Shifting is implicated in the ability to switch flexibly between different means of achieving the same goal as well as the ability to switch between several simultaneous goals (Hofmann et al., 2012). The importance of the executive functions is exemplified by studies showing that individual differences in executive functioning account for important positive outcomes such as wellbeing (Short, Mazmanian, Oinonen, & Mushquash, 2016), health behaviour (Allan, McMinn, & Daly, 2016; Limbers & Young, 2015), decision-making (Del Missier et al., 2010).

In summary, the ability to monitor and exert voluntary control over one’s behaviour is referred to as self-regulation. Research on the cognitive processes which subserve self-regulation has identified three basic underlying processes which are referred to as the executive functions – updating, inhibition and shifting. The relationship between specific facets of mindfulness, the executive functions underlying self-regulation and critical thinking will be elaborated in Chapter 2 and is central to the theoretical and empirical focus of this thesis. To fully inform that discussion, the definition and measurement of mindfulness must first be considered.

1.8 Stepping back – Defining mindfulness

Broadly, there are two schools of thought in psychological research on mindfulness, one stemming from Kabat-Zinn’s work and another firmly rooted in a cognitive information-processing framework proposed by Ellen Langer (Hart, Ivtzan, & Hart, 2013). This variation in the nature of definitions of mindfulness calls into question the homogeneity of the studies that are described as focusing on mindfulness (Chiesa & Malinowski, 2011). Though conceptualisations of mindfulness vary, all share the core feature of self-regulation of attention towards a focus on the present moment and most contrast mindful information processing with automatic, habitual or heuristic information processing, often referred to as mindlessness (Brown, Ryan, & Creswell, 2007; Glomb et al., 2011; Rona Hart et al., 2013; Langer, 1992).
Kabat-Zinn’s description of mindfulness, as quoted earlier, served as a working definition in research for many years, despite its limitations such as the lack of defining criteria for what constituted mindfulness and failure to specify associated psychological processes (Bishop et al., 2004; Sun, 2014). However, it was recognised that an operational definition which described the defining behavioural and experiential features of mindfulness was needed. Several operational definitions emerged which took Kabat-Zinn’s description as their basis (Sun, 2014).

A consensus meeting of psychologists interested in mindfulness developed a conceptualisation which situated aspects of Kabat-Zinn’s definition within cognitive research on attention and self-regulation (Bishop et al., 2004). Specifically, mindfulness is operationalised by Bishop and colleagues as a two-component process. The first component involves the deployment of attention to both internal and external experience in the present moment. Bishop and colleagues elaborate on this component of mindfulness by describing the cognitive processes that are likely to be involved in maintaining attention to all internal and external stimuli in the present moment. They focus on sustained attention, shifting and inhibition as the cognitive processes most likely to be underlying mindful present-moment attention. Skill in sustained attention means an individual can maintain vigilance over time despite changing conditions, increasing the likelihood of detecting stimuli in the environment (Barkley, 1997; Sarter, Givens, & Bruno, 2001). Sustained attention therefore is attention which is constantly directed to current experience. Rather than suppressing thoughts and feelings in order to sustain attention to the present moment, mindfulness practitioners learn to simply acknowledge their thoughts and sensations. As thoughts and sensations arise through experience, skill in shifting is required to switch attention back to current experience once a given thought or sensation has been acknowledged. The role of inhibition is to prevent excessive thinking about one’s experience beyond the simple acknowledgment of thoughts and sensations. In this way, maladaptive elaborative processes such as worry and rumination are not engaged (Bishop et al., 2004). The second component of mindfulness is characterised by an
accepting orientation to experience. This component is less clearly defined in terms of its underlying cognitive processes. Rather it is described as resulting from the cultivation of an attitude of curiosity and openness towards experience. This orientation to experience involves disengagement from any urge to change one’s experience. The authors suggest that this should lead to decreased experiential avoidance (Bishop et al., 2004).

Shapiro and colleagues (2006) developed a similar but extended definition from a developmental perspective with the aim of understanding the positive effects of mindfulness in the therapeutic context. This definition characterises mindfulness as paying attention to internal and external stimuli with an attitude of non-judgment but also emphasises the importance of the intention an individual has for practicing mindfulness. According to this view of mindfulness, the reason a person engages in mindfulness practice (i.e. their intention) changes with practice, usually starting with the aim of improving self-regulation and gradually moving towards the aims of self-exploration and self-liberation (Shapiro, Carlson, Astin, & Freedman, 2006). A major limitation of this definition is its reduction of the operationalisation of mindfulness to meditation within a therapeutic setting.

Brown et al. (2007) developed a much broader conceptualisation of mindfulness based on their original view of mindfulness as an innate human capacity for “a receptive attention to and awareness of present events and experience”. This conceptualisation views mindfulness as a quality of consciousness and it is heavily influenced by traditional writings on mindfulness meditation. It has in common with other definitions of mindfulness a focus on present-moment attention. In addition, it specified that mindfulness involves clarity of awareness of both internal and external experience, non-conceptual and non-discriminatory awareness of one’s own construction of reality, flexibility of awareness and attention, and an empirical stance on reality (Brown et al., 2007, p.212). Notably, this is the only definition of mindfulness which directly addresses clarity of awareness, which Brown and colleagues posit as leading to clarity of thought. Specifically, they suggest that clarity of awareness leads to more effective and precise thinking which is “less likely to be coloured by beliefs,
prejudices and other biases that are not supported by objective or experiential evidence” (Brown et al., 2007, p.213). This definition is detailed but is limited as an operationalisation. First, it is unclear how distinct measurement strategies would emerge from the descriptions of concepts as similar as clarity of awareness and non-discriminatory awareness. It is notable that no measures have been developed based on this definition. Second, some aspects of the definition may be better described as outcomes of mindfulness. For instance, clarity of awareness and non-discriminatory awareness may be dependent on an initial orientation of non-judgment. Similarly, an empirical stance towards reality can be seen as a result of the bottom-up processing style engaged when paying attention to both internal and external stimuli in the present-moment. Furthermore, flexibility of awareness and attention may be supported by both non-judgmental and present-moment attention and may be more accurately operationally defined as the shifting sub-process of executive functioning (Hofmann et al., 2012).

Mindfulness is also of interest to researchers in the field of contextual behaviourism based on evidence suggesting that mindfulness practices help to decrease levels of experiential avoidance and increase psychological flexibility (Ruiz, 2010). Working within this framework, Hayes and Shenk (2004) define mindfulness in terms of four interrelated processes: acceptance, defusion, present-moment awareness, and self-as-context. While acceptance and present-moment awareness align with aspects of previously described definitions, defusion and the perspective of the self-as-context are unique to this conceptualisation of mindfulness (Hayes & Shenk, 2004). Defusion is the result of seeing thoughts as they are rather than as ontological truths. Hayes and Shenk (2004) link it to the idea of non-judgment in other definitions of mindfulness but consider it to be broader and, as a result, more useful. Self-as-context, on the other hand, refers to a detached experience of self where experiences are observed rather than identified with (Fletcher, Schoendorff, & Hayes, 2010).

In parallel to the development of the conceptualisations of mindfulness described above, which are heavily influenced by, though
divorced from, its Buddhist roots, another approach was developed which was completely independent of Buddhism. Ellen Langer’s “Western” approach to mindfulness emerged from her initial research on cognitive failures which she attributed to an overreliance on learned automatic responses (Haigh, Moore, Kashdan, & Fresco, 2011; R Hart, Ivtzan, & Hart, 2013). Langer describes mindfulness as “a general style or mode of functioning through which the individual actively engages in reconstructing the environment through creating new categories or distinctions, thus directing attention to new contextual cues that may be consciously controlled or manipulated as appropriate” (Langer, 1989, p. 4).

Langer suggests that this conceptualisation of mindfulness consists of four inter-related components: engagement, novelty-seeking, novelty-producing and flexibility (Haigh et al., 2011; R Hart et al., 2013; Langer, 1989; Pirson, Langer, Bodner, & Zilcha-Mano, 2012). Both novelty-seeking and engagement refer to how one’s attention is deployed. They require focused attention to external stimuli and the context in which these stimuli are situated in order to facilitate receptiveness to new information (Haigh et al., 2011). Specifically, novelty-seeking is described as a curious orientation towards one’s environment. Engagement is defined as active attention to changes in one’s environment. This requires the control of attention in order to actively inhibit automatic responses (Hart et al., 2013). Novelty-producing and flexibility refer to how one performs cognitive operations on incoming information. Novelty-producing involves the active creation of new categories for incoming information rather than accommodation to previously constructed schemas. Flexibility involves viewing experiences from multiple perspectives and adjusting behaviour accordingly. Here creative manipulation of incoming information is key (Pirson et al., 2012). This contrasts with conceptualisations of mindfulness which have their roots in Buddhism. In these Buddhist-based conceptualisations of mindfulness, the inhibition of elaborative processing of internal and external stimuli is a central component (Bishop et al., 2004). However, it has been suggested that the inhibition of elaborative processing discussed might relate only to affective information (Baer, 2003; Teper, Segal, & Inzlicht, 2013).
While Langer’s approach to mindfulness and Buddhist-based approaches to mindfulness differ considerably, there are key similarities, especially with present-moment attention and self-regulation being central to each (Bishop et al., 2004; Haigh et al., 2011). A content analysis of the scales developed by Langer and colleagues to measure their conceptualisation of mindfulness suggested that the factor representing engagement is the only factor which appears to assess present-moment attention. The authors of this study argued that novelty-seeking, novelty-producing and flexibility are more accurately described as aspects of creative thinking and that Langer’s view of mindfulness could be considered specifically as mindful attention applied to creative thinking (Hart et al., 2013).

It is evident that there is considerable diversity in the conceptualisation of mindfulness within psychology. While the most highly cited definition is that of Bishop and colleagues (2004), current research employs a variety of definitions (Nilsson & Kazemi, 2016). Attempts at operationalising and measuring mindfulness have not been any more successful in producing consensus. The next section reviews the structures of available measures of mindfulness.

1.9 Measuring mindfulness

Psychological research on mindfulness has led to the development of instruments to measure the extent to which an individual is currently engaged (i.e. state measures), or generally tends to engage (i.e. dispositional measures), in mindful awareness. There are behavioural measures of state mindfulness in development but the vast majority of studies which measure state mindfulness use self-report questionnaires (Frewen, Hargraves, DePierro, D’Andrea, & Flodrowski, 2016). Since no reliable behavioural or physiological indicator of mindfulness has been identified, all measures of dispositional mindfulness rely on self-report.

Currently, measures of the extent to which individuals are currently engaged in a state of mindfulness are usually employed in laboratory-based studies as a form of manipulation check (Eisenlohr-Moul, Peters, & Baer,
These lab-based studies tend to focus on the effects of single, brief guided mindfulness meditations on cognitive, emotional and physiological outcomes (Davidson & Kaszniak, 2015). Three questionnaires have been developed to measure the extent to which individuals are engaged in a mindfulness state, the Toronto Mindfulness Scale (TMS-S; Lau et al., 2006), the State Mindfulness Scale (Tanay & Bernstein, 2013) and the Mindful Attention and Awareness Scale – State (MacKillop & Anderson, 2007). Each of these scales produces a total state mindfulness score, though the Toronto Mindfulness Scale has a two-factor structure consisting of decentering and curiosity, and the State Mindfulness Scale consists of two factors focusing on mindfulness of physical sensations and mindfulness of mental events respectively. Preliminary work has been done on the development of two new behavioural measures of state mindfulness (Frewen, Unholzer, Logie-Hagan, & MacKinley, 2012; Frewen et al., 2016; Levinson, Stoll, Kindy, Merry, & Davidson, 2014). The Mindfulness Breath Awareness Score task is a self-report measure of attention during a brief mindfulness meditation. Participants are required to report whether their attention was focused on their breath or not by placing a tick in the appropriate space on a piece of paper on front of them at 3 minute intervals during the meditation (Frewen et al., 2016; Frewen, Lundberg, MacKinley, & Wrath, 2011). The Breath Counting task requires participants to count each breath they take by pressing a button and to indicate every ninth breath by the press of a different button. Counting accuracy is then checked by comparison to physiological measures of respiration (Levinson et al., 2014). However, these behavioural measures have been used rarely and require further validation.

Remarkably little research has been conducted on the link between state mindfulness and trait mindfulness. One study, which employed a repeated measures design and a latent growth approach to analysis, has shed light on this relationship (Kiken, Garland, Bluth, Palsson, & Gaylord, 2014). Measures of state mindfulness were taken every week after a guided meditation session during an eight-week mindfulness meditation intervention. Analyses combined a path model to study pre-post changes in
dispositional mindfulness and distress and a latent growth model to examine individual trajectories of change in state mindfulness. Changes in state mindfulness (using the TMS-S) were found to significantly predict changes in dispositional mindfulness (using the Five Facet Mindfulness Questionnaire) and psychological distress from baseline to follow-up.

At least 11 dispositional mindfulness scales have been published since 2003 (See Table 1.1 for a comparison). These questionnaires assume that mindfulness is an innate human capacity (i.e. it is engaged in even by those never exposed to mindfulness practices) and that it is trait-like, because it naturally varies in the general population and is stable over time unless manipulated through engagement in a mindfulness-based practice (Baer, 2011; Bergomi, Tschacher, & Kupper, 2012a; Rau & Williams, 2016). This assumption implies that innate mindfulness and mindfulness cultivated through the various relevant practices are the same. However, there is some evidence for a distinction between innate mindfulness and trained mindfulness as studies have shown differential item function between meditators and non-meditators in two popular scales (Van Dam, Earleywine, & Borders, 2010; Van Dam, Earleywine, & Danoff-Burg, 2009). These studies also supported a related criticism which suggests that since mindfulness involves enhanced awareness, those who are learning a mindfulness practice will be more conservative in their self-report than those never exposed to a mindfulness practice as they are more aware of their lapses in mindfulness (Grossman & Dam, 2011).

Dispositional measures of mindfulness vary in their underlying structural models and theoretical underpinnings. For instance, a review identified nine distinct aspects of mindfulness across the eight scales reviewed (Bergomi et al., 2012a). These included observing experiences, acting with awareness, non-judgment/acceptance, self-acceptance, non-avoidance, non-reactivity to experience, non-identification with experiences, insightful understanding and describing of experiences. Intercorrelations between scales range from .3 to .6 (Grossman & Van Dam, 2011). There is considerable debate regarding the acceptability of such conceptual pluralism (Sauer et al., 2013). Some claim that it reflects a healthy progression.
Table 1.1. Comparison of available dispositional and state mindfulness scales.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Factors</th>
<th>Definition</th>
<th>Number of Items &amp; Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disposition</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mindful Attention and Awareness</td>
<td>1 -</td>
<td>Open or receptive awareness of and attention to what is taking place in the present</td>
<td>15 I find myself preoccupied with the future or the past.</td>
</tr>
<tr>
<td>Scale (MAAS)</td>
<td>4 Acceptance</td>
<td>Being non-judgmental or non-evaluative about present-moment experience</td>
<td>39 I tell myself that I shouldn’t be feeling the way I’m feeling.</td>
</tr>
<tr>
<td>Kentucky Inventory of</td>
<td>Accept without Judgment</td>
<td>Engaging fully in one’s current activity with undivided attention</td>
<td>When I do things, my mind wanders off and I’m easily distracted.</td>
</tr>
<tr>
<td>Mindfulness Skills (KIMS)</td>
<td>Act with Awareness</td>
<td>Labelling, or noting of observed phenomena by covertly applying words</td>
<td>I’m good at finding the words to describe my feelings.</td>
</tr>
<tr>
<td></td>
<td>Describe</td>
<td>Noticing, or attending to internal and external stimuli</td>
<td>I intentionally stay aware of my feelings.</td>
</tr>
<tr>
<td>Freiburg Mindfulness</td>
<td>2 Acceptance</td>
<td>Non-judgmental attitude</td>
<td>14 I am able to appreciate myself.</td>
</tr>
<tr>
<td>Inventory (FMI)</td>
<td>Presence</td>
<td>Attention to the present moment</td>
<td>I watch my feelings without getting lost in them.</td>
</tr>
<tr>
<td>Cognitive and Affective</td>
<td>4 Acceptance</td>
<td>Acceptance and non-judgment of thoughts and feeling</td>
<td>12 I am able to accept the thoughts and feelings I have.</td>
</tr>
<tr>
<td>Mindfulness Scale - Revised</td>
<td>Attention</td>
<td>Ability to focus attention without getting distracted</td>
<td>It is easy for me to concentrate on what I am doing.</td>
</tr>
<tr>
<td>(CAMS-R)</td>
<td>Awareness</td>
<td>Ability to notice and describe thoughts and feelings without judgment</td>
<td>I try to notice my thoughts without judging them.</td>
</tr>
<tr>
<td></td>
<td>Present-focus</td>
<td>Ability to stay pay attention to the present moment</td>
<td>I am preoccupied by the future.</td>
</tr>
</tbody>
</table>
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<table>
<thead>
<tr>
<th>Measure</th>
<th>Item</th>
<th>Description</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Southampton Mindfulness Questionnaire (SMQ)</td>
<td>1</td>
<td>Assesses individuals’ relationship with distressing thoughts and images</td>
<td>16</td>
</tr>
<tr>
<td>Toronto Mindfulness Scale – Trait (TMS-T)</td>
<td>2</td>
<td>Curiosity Stance of wanting to learn more about one’s experiences.</td>
<td>13</td>
</tr>
<tr>
<td>Developmental Mindfulness Scale (DMS)</td>
<td>1</td>
<td>Decentering Tendency to relate to one’s thoughts or feelings in a wider field of awareness rather than being overly absorbed in one’s internal experiences.</td>
<td>30</td>
</tr>
<tr>
<td>Comprehensive Inventory of Mindfulness Experiences (CHIME)</td>
<td>8</td>
<td>Inner awareness Awareness toward internal experiences</td>
<td>37</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Outer awareness Awareness toward external experiences</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Acting with awareness Maintaining awareness without distraction</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Openness Openness to experiences</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Acceptance Accepting and non-judgmental orientation</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Decentering/Non-reactivity Tendency to notice thoughts without reacting to them</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Insight Insightful understanding</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Relativity Relativity of thoughts</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>As I practice paying attention to what is happening right now, I notice the causes of my emotions.</td>
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<tr>
<td></td>
<td></td>
<td>I clearly notice changes in my body, such as quicker or slower breathing.</td>
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<tr>
<td></td>
<td></td>
<td>I notice sounds in my environment, such as birds chirping or cars passing.</td>
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<tr>
<td></td>
<td></td>
<td>In everyday life, I get distracted by memories, images or reverie.</td>
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<td></td>
<td></td>
<td>I try to distract myself when I feel unpleasant emotions.</td>
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<td></td>
<td></td>
<td>Even when I make a big mistake, I treat myself with understanding.</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>When I experience distressing thoughts or images, I am able just to notice them without having to react immediately.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>I need to smile when I notice how I sometimes see things as more difficult than they actually are.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>It is clear to me that my evaluations of situations and people can easily change.</td>
<td></td>
</tr>
<tr>
<td>Scale</td>
<td>Facet</td>
<td>Description</td>
<td>Item</td>
</tr>
<tr>
<td>-----------------------------------------</td>
<td>------------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Philadelphia Mindfulness Scale (PHLMS)</td>
<td>Acceptance</td>
<td>Tendency to be highly aware of one’s internal and external experiences.</td>
<td>I try to put my problems out of mind.</td>
</tr>
<tr>
<td></td>
<td>Awareness</td>
<td>Tendency to accept and not to judge internal and external experiences.</td>
<td>Whenever my emotions change, I am conscious of them immediately.</td>
</tr>
<tr>
<td>Five Facet Mindfulness Questionnaire (FFMQ)</td>
<td>Observing</td>
<td>Tendency to observe, notice, or attend to internal and external phenomena.</td>
<td>I intentionally stay aware of my feelings.</td>
</tr>
<tr>
<td></td>
<td>Acting with Awareness</td>
<td>Tendency to focus undivided attention on the current activity or avoiding automatic pilot; concentration.</td>
<td>I easily get lost in my thoughts and feelings.</td>
</tr>
<tr>
<td></td>
<td>Non-judgment</td>
<td>Tendency to accept without making judgments or evaluations.</td>
<td>I disapprove of myself when I have irrational ideas.</td>
</tr>
<tr>
<td></td>
<td>Non-reactivity</td>
<td>Tendency not to react to one’s experience.</td>
<td>I watch my feelings without getting lost in them.</td>
</tr>
<tr>
<td></td>
<td>Describing</td>
<td>Tendency to Describe or label sensations, perceptions, thoughts, emotions, etc. with words.</td>
<td>My natural tendency is to put my experiences into words.</td>
</tr>
<tr>
<td>Langer Mindfulness Scale (LMS)</td>
<td></td>
<td>A general style or mode of functioning through which the individual actively engages in reconstructing the environment through creating new categories</td>
<td>I try to think of new ways of doing things.</td>
</tr>
<tr>
<td>State Mindfulness Scale (SMS)</td>
<td>Mindful attention to physical sensations</td>
<td>Mindful attention to physical sensations</td>
<td>I clearly physically felt what was going on in my body.</td>
</tr>
<tr>
<td>Mindful Attention and Awareness Scale – State (MAAS – S)</td>
<td>Body</td>
<td>Mindful attention to mental events</td>
<td>I noticed emotions come and go.</td>
</tr>
<tr>
<td>Toronto Mindfulness Scale – State (TMS – S)</td>
<td>Curiosity</td>
<td>A receptive state of mind in which attention, informed by a sensitive awareness of what is occurring in the present, simply observes what is taking place</td>
<td>I was doing something without paying attention</td>
</tr>
<tr>
<td></td>
<td>Decentering</td>
<td>An attitude of wanting to learn more about one’s experiences</td>
<td>I was curious about my reactions to things.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A shift from identifying personally with thoughts and feelings to relating to one’s experience in a wider field of awareness</td>
<td>I experienced myself as separate from my changing thoughts and feelings.</td>
</tr>
</tbody>
</table>
towards a greater ability to describe how mindfulness operates in different
cultures and contexts (Sauer et al., 2013) while others assert that this
diversity in construct validity impairs our ability to synthesise mindfulness
research (Siegling & Petrides, 2014). However, there is evidence that most
of these scales load on a common factor and have a shared variance of
between 56% and 67% which suggests they measure the same construct to
varying degrees of breadth (Siegling & Petrides, 2014, 2016). The one
exception is the Langer Mindfulness Scale (LMS; Haigh et al., 2011; Pirson
et al., 2012) which appears to measure a distinct construct reflecting
mindlessness. It did not load on a common mindfulness factor and showed
distinctive relationships with personality variables (Siegling & Petrides,

To study dispositional mindfulness in healthy participants who do
not necessarily have experience in mindfulness-based practices, the Five
Factor Mindfulness Questionnaire (FFMQ) is currently considered to be the
best option for researchers (Rau & Williams, 2016; Sauer et al., 2013). This
scale was developed by the team that had previously designed the Kentucky
Inventory of Mindfulness Skills (KIMS) by subjecting the items from the
KIMS, Cognitive and Affective Mindfulness Scale (CAMS), Southampton
Mindfulness Questionnaire (SMQ), Mindful Attention and Awareness Scale
(MAAS) and the Freiburg Mindfulness Inventory (FMI) to an exploratory
factor analysis (Baer, Smith, Hopkins, Krietemeyer, & Toney, 2006). The
FFMQ is considered to have superior construct validity in comparison to the
individual scales it draws its items from (Siegling & Petrides, 2016). The
FFMQ is considered the most suitable for use with healthy participants who
have no experience with mindfulness-based practices because some scales,
such as the FMI, Toronto Mindfulness Scale and Developmental
Mindfulness Scale are only relevant to those who regularly practice
meditation (Bergomi, Tschacher, & Kupper, 2012b) and others, such as the
SMQ and CAMS, were developed with a focus on the application of
mindfulness to psychopathology (Sauer et al., 2013). In addition, both the
MAAS and LMS are thought to measure entirely different constructs to
mindfulness (Rau & Williams, 2016; Sauer et al., 2013). As referred to
above, the LMS appears to measure a tendency towards mindlessness. The MAAS has been criticised for its narrow focus on attention and the negative formulations of its items. It is widely considered now to reflect a tendency towards attentional lapses rather than mindfulness (Bergomi et al., 2012b; Grossman, 2011; Siegling & Petrides, 2014). While the Comprehensive Inventory of Mindfulness Experiences measures mindfulness as an even broader multidimensional construct than the FFMQ does, it has not been validated in English yet (Bergomi et al., 2012a). Finally, the Philadelphia Mindfulness Scale is considered to be too narrowly defined since it focuses on experiential avoidance rather than the quality of attention applied, in addition to a factor reflecting attention to the present-moment. This experiential avoidance factor did not load on a global mindfulness factor in a recent factor analytic study (Siegling & Petrides, 2016).

The FFMQ is not without its own limitations. First, it is not grounded in a specific theoretical framework but rather was empirically derived using exploratory factor analysis of previously existing scales which had different theoretical backgrounds (Tran et al., 2014). As a result, evidence for method effects in responding to the FFMQ have been found. In one study, a model composed of a positive method factor and a negative method factor achieved better fit indices than any model composed of the FFMQ subscales. In this study, a factor reflecting negative wording accounted for more overall variance in responding than did the acting with awareness and non-reactivity subscales (Van Dam, Hobkirk, Danoff-Burg, & Earleywine, 2012).

Second, the FFMQ factor representing observing has sometimes produced results which are not in line with mindfulness theory. For example, in non-meditating samples, the observe subscale is sometimes found to be unrelated to or negatively correlated with other FFMQ subscales (Siegling & Petrides, 2016). Furthermore, studies which compare regular meditators to people who do not meditate tend to show that levels of observing are related to positive outcomes only in groups of meditators but not in groups of non-meditators. For example, scores on the observing subscale only moderate the effects of stress on psychological distress in
meditators as opposed to being generally adaptive across levels of mindfulness meditation experience (Neale-Lorello & Haaga, 2015). In addition, in non-meditating samples, scores on the observing subscale have been found to correlate positively with negative outcomes including dissociation, absent-mindedness, symptoms of psychological distress and thought suppression (Baer et al., 2008).

These differential effects of observing between regular meditators and novices are thought to be a result of novices having not yet developed skill in non-reactivity (Tran et al., 2014). Without the ability to inhibit elaborative processes, a greater tendency to observe the present moment can be maladaptive (Anicha, Ode, Moeller, & Robinson, 2011; Desrosiers, Vine, Curtiss, & Klemanski, 2014). For example, in a sample of people with substance use disorders, observing was associated with higher substance use only in those individuals who reported low levels of non-reactivity (Eisenlohr-Moul, Walsh, Charnigo, Lynam, & Baer, 2012). It has been suggested that observing and non-reactivity appear to have different developmental trajectories with skill in present-moment awareness developing before skill in cultivating a non-reactive orientation towards experience develops (Lilja, Lundh, Josefsson, & Falkenström, 2013). Using cluster analysis on a large sample of meditators and non-meditators, Lilja and colleagues showed that the clusters with high levels of non-reactivity all included significantly more meditators than non-meditators while the clusters with low levels of non-reactivity all included significantly more non-meditators than meditators. Levels of observing were more evenly distributed across the clusters (Lilja et al., 2013).

In order to obtain a fine-grained analysis which is coherent with the definition of mindfulness proposed by Bishop and colleagues (2004), the observe and non-reactivity subscales of the FFMQ were focused on in the studies conducted for the present thesis, as done previously by Anicha and colleagues (2011) and Eisenlohr-Moul and colleagues (2012). The Bishop et al. (2004) definition is the most useful definition to employ in research focusing on the cognitive outcomes of mindfulness as it is still the definition which most clearly delineates the cognitive processes involved in producing
a mindful state. The use of the observing subscale (which assesses self-regulation of attention; Tran et al., 2013) and the non-reactivity subscale can be further justified by examining the commonalities between the available mindfulness scales and how they relate to what we know about the cognitive processes underlying mindfulness.

1.10 A two-component cognitive model of mindfulness

Considering the dispositional mindfulness questionnaires together, it is evident that all conceive of mindfulness as including *present-moment attention* to internal and external stimuli. Almost every scale also suggests that this attention is deployed in a particular manner or has a particular quality. While the Bishop et al. (2004) definition suggests that this quality of attention can be described as *non-judgmental acceptance*, an overview of current dispositional mindfulness scales show that it may also involve an orientation of *non-reactivity*, *non-identification with thoughts and feelings*, *openness*, and *insightful understanding* (Bergomi et al., 2012b). Across different scales, these descriptors of the manner or quality of attention deployed in mindfulness vary in the extent to which they are related or distinct. Some have recommended bringing these aspects together under one higher-order *orientation to experience* factor (Sauer et al., 2013; Tran et al., 2014, 2013). Recent studies with the FFMQ have supported the existence of this higher-order factor along with an additional higher-order factor focused on *self-regulation of attention* which consists of acting with awareness and observation of the present moment (Tran et al., 2014, 2013). Notably, two recent systematic reviews of dispositional mindfulness measures both concluded that mindfulness appears to be generally characterised by these two distinct factors reflecting self-regulation of attention towards the present moment and a non-judging, accepting and non-reactive orientation to experience (Rau & Williams, 2016; Sauer et al., 2013).

It is important to note that there are two remaining factors presented in some scales which can be considered distinct from present-moment attention and non-judgment/non-reactivity – describing of experiences and
decentering. However, there is evidence to suggest that though these are related to mindfulness, they are distinct constructs which happen to increase through mindfulness practice (Bergomi et al., 2012b). For example, a recent study demonstrated using structural equation modelling that mindfulness and decentering are not overlapping constructs and that decentering mediates the effects of mindfulness on symptoms of depression (Gecht et al., 2014). As regards describing, meta-analytic evidence suggests that mindfulness interventions have only small effects on measures that assess skill in describing experiences ($g = 0.28$; Quaglia et al., 2016).

In explaining their two-component definition of mindfulness, Bishop and colleagues (2004) describe the cognitive processes involved in maintaining attention on the present moment but are less clear on the cognitive processes underlying the mindful orientation to experience. An account of mindfulness from Teper, Segal and Inzlicht (2013), which aligns with the Bishop et al. (2004) definition, may explain the cognitive process from which the mindful orientation to experience described above arise. Teper and colleagues suggest that the key cognitive process underlying this accepting and non-judgmental orientation to experience is the processing of affective signals without further elaboration. Elaborative processes include rumination, worry, over-identification with thoughts or feelings, and judgment-making (Bishop et al., 2004; Desrosiers, Vine, Curtiss, & Klemanski, 2014). The inhibition of such processes facilitates the broad, open and non-judgmental orientation to experience suggested by mindfulness measures (Hogan, 2014). The inhibition of elaborative processing can be referred to more simply, and more in line with some mindfulness measures, as non-reactivity. Non-reactivity is defined as the “tendency to allow thoughts and feelings to come and go, without getting caught up in or carried away by them” (Baer et al., 2008, p. 330). Allowing thoughts to come and go without getting caught up in them requires the inhibition of elaborative processes (Bishop et al., 2004; Teper et al., 2013).

Quasi-experimental evidence using the FFMQ supports the idea that non-reactivity is specifically related to inhibition. Anicha and colleagues (2011) found that while higher scores on the observing scale of the FFMQ
were associated with greater perceptual skill in visual working memory and temporal order tasks, they were not significantly related to inhibitory control on a Stroop task. However, higher scores on non-reactivity subscale of the FFMQ were associated with greater inhibitory control on a Stroop task (Anicha et al., 2011). This supports Teper and colleagues’ cognitive model of mindfulness and suggests that the inhibition of elaborative processing might not be a side-effect of maintaining attention on the present-moment, as suggested by Bishop and colleagues (2004), but rather the result of a non-reactive orientation to experience. This evidence is limited by its correlational nature. Additional experimental studies supporting this model and linking it to enhanced self-regulation will be discussed in more detail in Chapter 2.

Considering the diversity in the definitions and measures of mindfulness presented it is evident that great variation exists in the conceptualisation and assessment of mindfulness. However, there are several key concepts running through each approach. First, the mindfulness state can be characterised as at least the presence of present-moment attention and a non-reactive orientation to experience (Bishop et al., 2004; Teper et al., 2013; Tran et al., 2014). Second, the extent to which individuals are engaged in a mindfulness state at a given moment can be measured. These measures are generally used in experimental studies which manipulate engagement in practices which are intended to produce a mindfulness state (Eisenlohr-Moul et al., 2015; Tanay & Bernstein, 2013). Third, it has been assumed that people naturally tend to experience this state to some extent, even without having ever engaged in mindfulness meditation practices, and dispositional measures of mindfulness have been developed to measure these tendencies (Baer, 2011; Siegling & Petrides, 2014). Fourth, longer-term mindfulness-based interventions can increase dispositional mindfulness and this may be attributed to increases in the ability to engage in a mindful state through meditation (Kiken et al., 2014). Furthermore, these increases in dispositional mindfulness can account for other adaptive outcomes such as mental health improvement (Quaglia et al., 2016). The
next section will review different research designs employed in the study of mindfulness.

1.11 Designing mindfulness studies

Various designs have been employed either using mindfulness measures in correlation or prediction models, directly manipulating mindfulness in some way and then measuring its effects on other variables, or both. Research on mindfulness has focused on cross-sectional studies of dispositional mindfulness in novice meditators (e.g. Galla, Hale, Shrestha, Loo, & Smalley, 2011), cross-sectional comparisons between expert practitioners and novices (e.g. Moore & Malinowski, 2009), lab-induced mindfulness (e.g. using guided meditations) in participants with differing levels of mindfulness experience (e.g. Wenk-Sormaz, 2005), and a variety of longer-term mindfulness interventions with novice practitioners (which can vary in length, focus and intensity; e.g. Jha et al., 2010; Lutz et al., 2009; Shapiro et al., 2012; van Vugt, Hitchcock, Shahar, & Britton, 2012).

Cross-sectional studies of dispositional mindfulness in novice meditators are particularly useful for initial exploratory analysis of the effects of individual differences in dispositional mindfulness and possible mechanisms underlying the effects of mindfulness on other variables (Goodman & Brown, 2015). This is usually achieved applying regression-based or Structural Equation Modelling-based mediation and moderation analyses. Of the few studies which focus on the mechanisms of mindfulness, most employ this design (e.g. Gecht et al., 2014; Isbel & Mahar, 2015; Noone, Bunting, & Hogan, 2016; Paul, Stanton, Greeson, Smoski, & Wang, 2013). A major limitation of studies like these is that it is not possible to claim a causal relationship based on cross-sectional data.

Comparisons between expert practitioners and novices are useful for learning more about the long-term effects of mindfulness. However, even with demographically matched control participants, isolating mindfulness as the cause of any effects demonstrated is problematic as there are a myriad of other individual differences which could contribute to someone continuing
mindfulness practice to the point that they are an expert (Davidson & Kaszniak, 2015).

The induction of mindfulness states in laboratory settings is perhaps the most experimentally rigorous design possible, at least when participants have not been exposed to mindfulness training previously. It is impossible to disentangle dispositional and experimental effects in studies where a mindfulness state is induced in regular practitioners of mindfulness. Inducing a mindfulness state tends to involve participants listening to guided meditations which vary in length from five to twenty minutes long. These usually consist of instructions to pay full attention to the intake and outtake of breath while taking care to non-judgmentally bring attention back to the breath as soon as this attention drifts. These guided meditations are generally compared to a condition involving the induction of some other state of mind known to have a specific effect (or none) on the outcome variable of interest, for example, rumination or mind-wandering (Arch & Craske, 2006; Huffziger et al., 2013). This design is useful for its rigour but it has been criticised for not being ecologically valid as it is unknown to what extent the effects of one short meditation relate to those of regular mindfulness practice (Eisenlohr-Moul et al., 2015).

Engagement in regular mindfulness meditation in the context of a mindfulness training intervention is assumed to increase the participants’ levels of dispositional mindfulness (Kiken et al., 2014; Quaglia et al., 2016). The effects of regular mindfulness practice are best assessed in a randomised-controlled trials (RCTs) of mindfulness training interventions over the course of several weeks with a plausible active-control condition. However, the majority of mindfulness intervention studies carried out thus far have not employed such stringent controls. In fact, this design has been described as a “high bar” for mindfulness researchers in a recent methodological review (Davidson & Kaszniak, 2015). Instead, most mindfulness RCTs employ treatment as usual or waitlist control groups. Manipulation checks and follow-up checks are rarely employed (Creswell, 2016). Furthermore, it is rare that the amount of mindfulness practice engaged in by participants is objectively recorded. As a result, little is
known about what determines adherence to these programmes (Barkan et al., 2016) or the nature of dosage effects. Dosage effects would ideally be investigated experimentally by randomising participants to interventions of varying lengths but no such study has been conducted yet (Davidson & Kaszniak, 2015).

In mindfulness intervention studies, intervention content varies widely and is rarely reported in sufficient detail (Davidson & Kaszniak, 2015). MBSR, MBCT and other more “pure” guided mindfulness meditation programmes are employed in most intervention studies (Dorjee, 2010). While studies employing these and related programmes have provided us with the most information regarding the utility of mindfulness-based approaches in physical and mental health care, their outcomes cannot be specifically attributed to mindfulness due to the presence of various other “active ingredients”. MBSR, for example, involves cultivating mindfulness through meditation and yoga but also includes group discussions, exercises and individual support with stress management (Bishop, 2002). MBCT includes psychoeducation and exercises developed within the tradition of cognitive therapy in addition to mindfulness exercises (Willett & Lau, 2015). Central to this problem is the lack of studies employing appropriately matched control conditions (Dimidjian & Segal, 2015). Currently, there are well-matched control conditions available for MBSR, MBCT and pure mindfulness meditation interventions. The Health Enhancement Programme was developed to match MBSR in terms of structure and non-mindfulness specific factors. For example, both require the same amount of participant involvement, both include group work and daily practice and participants can expect benefits for their wellbeing from both programmes (MacCoon et al., 2012). MBCT can be compared to Cognitive Psychological Education (CPE), a programme which involves every aspect of MBCT except meditation training. The only aspect that is not matched between the two programmes is the amount of homework, as there is no substitute for meditation-based homework in CPE (Williams et al., 2014). Interventions where the only active ingredient is mindfulness-based meditation can be compared to sham meditation programmes. These involve breathing
Chapter 1 - Mindfulness and the Clarity of Thought

exercises which are introduced to participants under the label of meditation. These exercises are guided by the same facilitator and for the same amount of time as the guided mindfulness practice which the experimental group engage in. Where the active-control group are instructed to “continue breathing as we sit in meditation” every few minutes, the experimental group are given clear instructions on how to cultivate a state of mindfulness. Therefore, the one key difference between the two groups is the nature of the instructions given regarding how to pay attention (Zeidan, Johnson, Gordon, et al., 2010).

Interventions which focus solely on mindfulness meditation tend to start off with exercises involving focus on the breath, with gradual progress towards paying mindful attention to the body and then everyday activities and bringing a non-reactive approach to this experience (Creswell, 2016). There are various meditative practices which help cultivate these skills of observation and then non-reactivity (Dorjee, 2010). These can be categorised as focused (or concentrative) attention meditation and open-monitoring meditation (Slagter, Davidson, & Lutz, 2011).

Specifically, focused attention meditations usually involve holding a particular stimulus in attention, typically one’s own breath, in each successive moment. When attention moves away from this stimulus, this should be noticed and attention should be shifted back to the target stimulus. As practice of focused attention meditation continues, the practitioner will become better able to monitor for lapses in attention and regulate their attention so that it is sustained on the target stimulus for longer periods of time (Lutz, Slagter, Dunne, & Davidson, 2008).

The development of this monitoring skill provides the foundation for open-monitoring meditation (Davidson & Kasznia, 2015). The focus of attention is broader in this practice with the practitioner encouraged to continuously monitor all internal and external stimuli, rather than any specific object. This is said to lead to a lower tendency towards emotional reactivity as the continuous monitoring detaches experience from emotional elaboration (Lutz et al., 2008). A recent experimental study employing an...
electroencephalographic index of emotional reactivity demonstrated a more
dynamic effect of open-monitoring on emotional reactivity. Initial exposures
to negative emotional images led to higher emotional reactivity in
individuals following open-monitoring meditation compared to a distraction
condition and a control condition – perhaps due to greater engagement with
the stimulus – but later repetitions of these images resulted in lower
emotional reactivity in the open-monitoring condition compared to the
distraction and control conditions (Uusberg, Uusberg, Talpsep, & Paaver,
2016).

Focused attention meditations and open-monitoring meditations have
been shown to have different effects on various aspects of experience and to
interact with levels of mindfulness meditation expertise (Lippelt, Hommel, &
Colzato, 2014). Focused attention meditation leads to less bias of
information processing by irrelevant information than open-monitoring does
(Colzato, van der Wel, Sellaro, & Hommel, 2016). Open-monitoring
meditation has been shown to benefit attention orienting to a greater extent
than focused attention meditation (Tsai & Chou, 2016). Expert meditators
reported being less bothered by painful thermal stimulation than non-
meditators only after open-monitoring meditation. The expert meditators
reported similar levels of discomfort following focused meditation as did the
novices following each type of meditation (Perlman, Salomons, Davidson,
& Lutz, 2010). Given that differences in meditation instructions can lead to
different effects, the fact that there is generally a lack of detail in the
reporting of the exact content of mindfulness interventions is a major
limitation (Davidson & Kaszniaik, 2015; Lippelt et al., 2014). As a result of
this limitation, it is unclear to what extent different mindfulness intervention
studies are comparable (Creswell, 2016; Shonin, Van Gordon, & Griffiths,
2013).

It is important to note that not all studies which claim to assess
mindfulness involve meditation. Apart from meditation, practices such as
yoga (Sauer-Zavala, Walsh, Eisenlohr-Moul, & Lykins, 2012), qi gong
(Tang, Yang, Leve, & Harold, 2012) and tai chi (Schmalzl, Crane-Godreau,
& Payne, 2014) involve non-judgmental, present-moment awareness and
empirical studies have demonstrated increases in mindfulness as a result of these practices.

Apart from the specific limitations of each research design described above, there are some methodological limitations which are common to mindfulness research in general. There is a tendency towards small sample sizes which undermines the power of reported statistical tests. Furthermore, it is rare that mindfulness studies report the carrying out of any a priori power analysis (Chiesa & Serretti, 2009; Sedlmeier et al., 2012; Shonin et al., 2013). Another problem related to samples is that they are usually recruited in a convenient manner. This may create bias as there could be systematic differences between those who would self-select into a mindfulness study and those who would not. There can also be systematic differences within these samples but few experimental studies include a focus on individual differences (Davidson & Kaszniak, 2015). This has limited our knowledge of how other dispositional variables moderate responses to mindfulness manipulations. Similarly, relatively few studies have been designed to identify variables which mediate the effects of mindfulness (Creswell, 2016; Dimidjian & Segal, 2015). Such designs can shed light on the mechanisms underlying mindfulness.

Finally, even when studies are well-powered, employ an adequate sampling approach and take care to include theoretically plausible moderator and mediator variables in their design, the interpretation of results is hindered by the field’s reliance on self-report measures (Rau & Williams, 2016; Siegling & Petrides, 2016). Apart from the issues of construct validity discussed earlier, there are two major sources of bias in using self-report measures of mindfulness. First, these measures rely on the ability to retrospectively report on one’s mental state. There is evidence which suggests that humans are not very good at this – even over a short period of time - from studies which compare objective and subjective measures of attention (Grossman, 2011; Smallwood, McSpadden, & Schooler, 2007). One suggested solution to this problem is to include ecological momentary assessments in mindfulness research, where participants are prompted at random intervals, through a mobile device, to report on their current mental state.
state. Second, there is potential for eliciting socially desirable responding as a result of the wording of mindfulness scale items (Brown & Ryan, 2004; Creswell, 2016). With all self-report instruments, there is the potential for bias as a result of social desirability (van de Mortel, 2008). This problem is exacerbated in mindfulness research, however, because the wording of mindfulness questionnaires mirrors closely the language used in guided meditations and other mindfulness intervention content (Grossman, 2011; Rau & Williams, 2016). The limitations discussed here must be borne in mind when considering the results of mindfulness studies as they are present more often than not.

In summary, the definition and measurement of mindfulness varies according to the theoretical framework underpinning the researcher’s interpretation of mindfulness and this has led to many different instruments being developed with the aim of measuring mindfulness. These definitions and measures have been employed in studies using several types of designs which focus on both expert and novice practitioners and occur over both short and long timespans. Next, the specific effects of mindfulness will be discussed in more detail. The chapter will close with a consideration of what these results mean for the oft-neglected view of mindfulness as a means of cultivating clarity of thought and whether this view deserves more attention, alongside the near-total focus of research on mindfulness as the reduction of suffering.

1.12 Synthesising Research on the Effects of Mindfulness

As previously referred to, research on mindfulness has focused primarily on its effects on health and mental health, with less research focusing on cognitive outcomes such as problem-solving, decision-making and critical thinking. It is difficult to exactly quantify this disparity but a search of systematic reviews and meta-analyses of mindfulness research on the Scopus database supports this claim. Out of 101 systematic reviews found, just two involved cognitive outcomes while the majority focus on health and mental health. This again suggests that mindfulness research has
tested claims regarding the reduction of suffering to a much greater extent than claims related to the clarity of thought and everyday thinking skills.

Still, across the research on mental health, physical health and cognition, there are commonalities that can be identified in the likely mechanisms of mindfulness which can inform theory-building regarding the relationship between mindfulness and critical thinking. Specifically, it appears that enhanced self-regulation may be a key mechanism through which the putative benefits of mindfulness arise for disparate types of behaviour (Lyvers, Makin, Toms, Throberg, & Samios, 2013; Ostafin, 2015; Short et al., 2016; Teper et al., 2013; Tran et al., 2014). This claim should be considered cautiously, however, because the high rate of publication bias in mindfulness research means studies which have failed to support this relationship could exist in researchers’ file drawers (Coronado-Montoya et al., 2016). In addition, relatively few studies directly investigate the mechanisms underlying the benefits of mindfulness (Quaglia et al., 2016).

The effects of mindfulness on physical health-related variables have been studied across a diverse range of health conditions with a particular focus on chronic health conditions. As previously discussed, it was the lack of options for the treatment of chronic health conditions and the psychological distress which accompanies them that inspired Jon Kabat-Zinn to develop the MBSR programme (Jon Kabat-Zinn, 1982; Jon Kabat-Zinn, Lipworth, & Burney, 1985). While the initial focus was on the reduction of stress (Crowe et al., 2016), subsequent research has focused on pain management (Buhrman et al., 2013; Chiesa & Serretti, 2011; Dowd et al., 2015; Schubiner, 2014; Zeidan, Gordon, Merchant, & Goolkasian, 2010), insomnia (Gong et al., 2016), fatigue in recovery from stroke and cancer (Carlson & Garland, 2005; Ulrichsen et al., 2016), quality of life in cancer patients (Altschuler, Rosenbaum, Gordon, Canales, & Avins, 2012), and health behaviours such as weight loss (Olson & Emery, 2015), healthy eating (Kristeller, 2015; Kristeller & Epel, 2014), and exercise (Santos Teixeira & Labisa Palmeira, 2013).
The majority of these studies take an intervention approach by evaluating the effect of mindfulness-based programmes, mostly involving MBSR and some involving MBCT, on physical health outcomes and measures of psychological distress. Since both MBSR and MBCT both involve additional psychoeducational and yoga-based components, it is difficult to isolate a mechanism specific to mindfulness within studies applying these interventions. Evidence for health-related benefits of mindfulness appear to be strongest for pain and stress management and health behaviours related to eating and alcohol intake. Evidence for the effects of mindfulness on other health-related outcomes and behaviours is inconclusive at present (Creswell, 2016).

Focusing on outcomes related to psychological distress, a recent overview of meta-analytic evidence regarding the efficacy of mindfulness in healthcare concluded that acceptance is a common mechanism underlying the reduction of stress, pain, depression and anxiety in patients with physical health problems (Gotink et al., 2015). Each of these are often exacerbated by the amplification of physical symptoms through worrying about their origin and consequences (Ottaviani et al., 2015). As referred to earlier, acceptance works in situations like this because it involves the active inhibition of such elaborative processes (Teper et al., 2013). There is meta-analytic evidence to show that rumination about the past and worry about the future have detrimental effects on a number of physiological indicators of health including diastolic (g = .45) and systolic blood pressure (g = .51), heart rate (g = .28 & g = .20) and its variability (g = .15 & g = .27), and cortisol (g = .36 & g = .32; Ottaviani et al., 2015). Notably, mindfulness practice appears to have a positive effect on each of these physiological health indices (Brown, Weinstein, & Creswell, 2012; Bullis, Bøe, Asnaani, & Hofmann, 2014; Kingston, Chadwick, Meron, & Skinner, 2007; Mankus, Aldao, Kerns, Mayville, & Mennin, 2013). Therefore, many of the benefits of mindfulness in healthcare may be due to the inhibition of elaborative processes and subsequent decreased cognitive and physiological reactivity.
Since the development of MBCT, DBT and ACT in the 1990s, research into the effects of mindfulness-based interventions on various aspects of mental health and wellbeing has proliferated (Eisenlohr-Moul et al., 2015). While the effects of such interventions on depression and anxiety have been studied most frequently, their effects on psychosis (Khoury, Lecomte, Gaudiano, & Paquin, 2013), sleep disturbance (Kim, Park, & Seo, 2016), eating disorders (Wanden-Berghe, Sanz-Valero, & Wanden-Berghe, 2011) and somatization disorders (Lakhan & Schofield, 2013) have also been studied. Currently, the most robust evidence for benefits in relation to mindfulness and mental health can be found in studies on depression relapse (Felder, Dimidjian, & Segal, 2014; Willett & Lau, 2015; Williams et al., 2014). There is also strong evidence for the reduction of cravings and relapse in individuals who have experienced substance use disorders (Creswell, 2016).

In recent years, better evidence has become available regarding the possible mechanisms underlying the effects of mindfulness on aspects of mental health. This has facilitated a meta-analytic study of mediation analyses which showed that there is strong evidence for the reduction of reactivity as a mechanism underlying the clinical benefits of mindfulness (i.e. on stress, anxiety, depression and negative affect) and moderate evidence for decreased rumination and worry and increased dispositional mindfulness as mechanisms (Gu, Strauss, Bond, & Cavanagh, 2015). It should be noted that both worry and rumination are elaborative processes and dispositional mindfulness includes facets related to the inhibition of elaborative processes so there is a connection here again to acceptance and the underlying process of non-reactivity (Desrosiers et al., 2014). Therefore, the results regarding the effects of mindfulness in clinical mental health conditions are consistent with results found in studies on psychological distress associated with physical health conditions.

As discussed above, mindful acceptance involves the inhibition of elaborative and reactive processes which is an act of self-regulation (Teper et al., 2013). Our knowledge regarding these processes has accumulated slowly through research on mindfulness in cognitive psychology, which
began in earnest following Bishop et al.’s (2004) operationalisation of mindfulness in cognitive terms (Chiesa, Calati, & Serretti, 2011). A brief overview of this research is presented next.

Research on mindfulness within cognitive psychology has predominantly focused on various aspects of attention, memory, and, to a lesser extent, executive function. This research has helped clarify mindfulness as a construct in terms of its concomitant mental processes by revealing the role of specific aspects of attention and memory in mindful information processing. The proliferation of positive results in these studies (an average effect of $r = .30$, due in part to publication bias; Eberth & Sedlmeier, 2012) has seen mindfulness referred to by cognitive psychologists as a type of mental training (Lutz et al., 2009), brain state training (Tang & Posner, 2015) or attentional training (Tang & Posner, 2009).

Much of this research has drawn on Posner and Petersen’s (1990, 2012) attentional networks framework which posits three brain networks with distinct cognitive correlates, namely alerting, orienting and executive attention. The alerting network supports the establishment and maintenance of general awareness or vigilance of one’s environment. The orienting network supports the direction of attention to specific stimuli. The executive attention network supports the self-regulation of attention, particularly the prioritisation of external stimuli and internal thoughts and emotions competing for attentional resources. Several different aspects of attention have been examined in this context including the accuracy and flexibility of visual attention (related to the orienting network; Zeidan, Johnson, Diamond, David, & Goolkasian, 2010), the stability of sustained attention (related to the alerting network; Lutz et al., 2009; Mrazek, Smallwood, & Schooler, 2012; Ruocco & Direkoglu, 2013), executive attention (Chambers, Lo, & Allen, 2007), the attentional blink (Slagter, Lutz, Greischar, Nieuwenhuis, & Davidson, 2009) and attentional effort (Jensen, Vangkilde, Frokjaer, & Hasselbalch, 2012) with varying degrees of support existing for the effects of mindfulness on each of these. Among the small pool of randomised controlled experiments in this area, consistent support...
has been found for the positive effects of mindfulness on performance in tasks related to executive attention and sustained attention only (Becerra, Dandrade, & Harms, 2016).

Studies on the effects of mindfulness on working memory have focused on its capacity i.e. the amount of information which can be maintained at any given moment (Morrison & Jha, 2015). This construct is closely related to executive attention as it is an indicator of the processing limits which make executive attention necessary (Kane, Bleckley, Conway, & Engle, 2001). These studies have all reported positive relationships between mindfulness and working memory capacity, though just three involved random assignment to a control group (Jensen et al., 2012; Jha, Stanley, Kiyonaga, Wong, & Gelfand, 2010; Mrazek, Franklin, Phillips, Baird, & Schooler, 2013; Quach, Jastrowski Mano, & Alexander, 2016; Ruocco & Direkoglu, 2013).

Interestingly, the results of an individual differences study of mindfulness, sustained attention and working memory capacity suggested that these constructs are differentially related to the two main facets of mindfulness. Those who reported greater present-moment attention performed better on a sustained attention task, the continuous performance task, and those who reported greater acceptance performed better on a N-back task, an indicator of working memory capacity (Ruocco & Direkoglu, 2013). The significant positive relationship between present-moment attention and sustained attention is perhaps not surprising. One explanation for the relationship found between acceptance and working memory capacity is that the process of inhibiting elaborative processes which underlies acceptance ensures that working memory resources are not used by the elaborative processes which would otherwise automatically occur.

As referred to earlier, the overriding of automatic processes is central to the construct of self-regulation and, in cognitive psychology, the processes underlying self-regulation are referred to as the executive functions (Hofmann et al., 2012). Research on mindfulness and executive functioning is important for elucidating how exactly the cultivation of
mindfulness leads to greater self-regulation. This is possible because sophisticated statistical techniques such as structural equation modelling can be used to identify relationships between facets of mindfulness and specific executive functions such as inhibition, shifting and working memory updating (Gallant, 2016; Noone et al., 2016). Crucially, most of these studies have involved interventions where the only active component is mindfulness meditation (Eberth & Sedlmeier, 2012). A recent review found that positive effects of mindfulness meditation practice on inhibition are consistently reported, while evidence is mixed for shifting and updating (Gallant, 2016).

Executive functioning is central to effective higher-order cognitive processes such as decision-making, problem solving and critical thinking (Evans & Stanovich, 2013; Liberali, Reyna, Furlan, Stein, & Pardo, 2012). Despite this and the frequency of claims regarding the benefits of mindfulness for thinking and decision-making, research on the effects of mindfulness on higher-order thinking skills has been limited. Just a few studies exist which investigate the effects of mindfulness on such outcomes. These studies, which have focused on insight problem-solving (Ostafin & Kassman, 2012), cognitive rigidity (Greenberg, Reiner, & Meiran, 2012), creative thinking (Colzato, Ozturk, & Hommel, 2012; Colzato, Szapora, Lippelt, & Hommel, 2014), and indicators of biased thinking such as the correspondence bias (Hopthrow, Hooper, Mahmood, Meier, & Weger, 2016), and the sunk cost bias (Hafenbrack, Kinias, & Barsade, 2013), will be reviewed in detail in Chapter 2. Considering the fact that there are clearly historical, theoretical and empirical reasons to investigate the relationship between mindfulness and higher-order thinking skills, as demonstrated in this chapter, the relative lack of adequate research on this topic is a considerable oversight.
1.12 Conclusion

Mindfulness, a 3,500-year-old Eastern concept, has become hugely popular in modern western culture. While there has been a tremendous surge in research interest in mindfulness over the last 25 years, these investigations have not kept pace with the claims being made about the supposed benefits of mindfulness for higher-order thinking skills and there are concerns about mindfulness being seen as a panacea. Though conceptualisations of mindfulness in Western science vary, all suggest a role for mindfulness in improving self-regulation of thought, behaviour and emotional and physiological reactivity and the available evidence across different research designs and types of outcomes appears to support this relationship. The vast majority of this research focuses on outcomes related to the reduction of suffering, and appear to support claims regarding the benefits of mindfulness for reducing distress caused by physical and mental health problems. Much less research has focused on outcomes related to another traditional outcome of mindfulness, the clarity of thought. Despite many claims have made regarding the benefits of mindfulness for everyday thinking skills. However, it remains an open question as to whether mindfulness practice enhances thinking skills or not (or even hinders it; Brendel, 2015). The next chapter will focus on claims relating to mindfulness, the clarity of thought and everyday thinking skills, the rationale for operationalising everyday thinking skills as critical thinking, the self-regulation of critical thinking and the arguments for and against mindfulness facilitating effective critical thinking.
Chapter 2

Mindfulness and the Self-Regulation of Critical Thinking

2.1 Chapter Outline

As demonstrated in the previous chapter, many claims have been made which suggest that mindfulness facilitates everyday thinking skills and, despite historical, theoretical and empirical reasons to justify investigation of these claims, few studies have done so. When debate arises over the thinking skills which are of most practical value in society, the set of skills that tends to emerge as most desirable to universities, businesses and governments includes the ability to analyse information, the capacity to evaluate arguments, and the ability to reflect on information in order to make accurate inferences (Halpern, 1998). These are the exact skills to which many of the claims regarding the cognitive benefits of mindfulness refer. Together these skills are generally referred to as critical thinking. This chapter will focus on how critical thinking is defined, approaches to its assessment and determinants of critical thinking performance. It will then address the self-regulation of critical thinking and how mindfulness might relate to the self-regulation of thinking. It will close with a description of the studies presented in this thesis, which were undertaken to test the proposition that mindfulness facilitates critical thinking.

2.2 Why Critical Thinking is Important

Before addressing these issues, it is worth briefly noting why critical thinking skills are so valued in modern society. In a world where we have more information than ever available to us, it is vital to be able to analyse this information, evaluate its quality, relevance, credibility, and logical soundness and apply it in appropriate circumstances (Butler, 2012). Developing these thinking skills is important in order to make the most of the information available to us rather than just passively assimilating it (Dwyer, Hogan, & Stewart, 2014). Conversely, failure to critically analyse information can have extremely negative consequences. For example, on the individual level, failure to probe the evidence underlying treatments for health issues can lead to an exacerbation of symptoms if an inadequate,
pseudoscientific treatment option is chosen (Beyerstein, 2001; Pigliucci & Boudry, 2013). On the societal level, issues such as sustainability and climate change persist in part due to the proliferation and uncritical acceptance of unscientific arguments (Byrnes & Dunbar, 2014; Thomm & Bromme, 2012). Therefore, it is understandable that there is a high level of concern regarding the apparently insufficient levels of critical thinking among many university student populations (Ku, 2009; Niu, Behar-Horenstein, & Garvan, 2013). Clearly, it is important that strategies for improving critical thinking are identified and that claims regarding new ways of doing so are empirically evaluated. One limitation of such research is the diversity in the conceptualisation of critical thinking (Moore, 2013).

2.3 Defining Critical Thinking

Attempts to converge on an operational definition of critical thinking have been far from unanimous (Dwyer, Hogan, & Stewart, 2014). Defining critical thinking has been a challenging and divisive task for researchers across the fields of psychology, philosophy and education (Lai, 2011). From an empirical point of view, one problem common to many of the definitions is the lack of operationalisation. This has resulted in many definitions which are not specific or measurable (Ku, 2009).

One reason for the lack of operational definitions of critical thinking is that many prominent descriptions of critical thinking come from the field of philosophy where measurement is not a key goal (Sternberg, 1986). These definitions focus on describing the skills and attributes of the ideal critical thinker in ideal circumstances rather than the cognitive processes involved in critical thinking under the limitations of everyday circumstances (Lai, 2011; Sternberg, 1986). Perhaps the most prominent of these definitions (see Table 2.1 for a summary) is the American Philosophical Associations consensus definition (Facione, 1990). This definition was developed by a group of academics recognised as experts on critical thinking using the Delphi consensus method. They agreed to define critical thinking as “Purposeful, self-regulatory judgment which results in interpretation, analysis, evaluation and inference, as well as explanation of
the evidential, conceptual, methodological, criteriological or contextual considerations upon which the judgment is based”. Additionally, they describe the ideal critical thinker as someone who is open-minded, cognitively mature, analytic, truth-seeking and self-confident in their thinking (Facione, Facione, & Sanchez, 1994). Some have criticised this definition for being too broad (Niu et al., 2013).

Table 2.1. Summary of Definitions of Critical Thinking

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Definition</th>
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<tbody>
<tr>
<td><strong>Philosophy</strong></td>
<td></td>
</tr>
<tr>
<td>Facione et al. (1990)</td>
<td>Purposeful, self-regulatory judgment which results in interpretation, analysis, evaluation and inference, as well as explanation of the evidential, conceptual, methodological, criteriological or contextual considerations upon which the judgment is based.</td>
</tr>
<tr>
<td>Elder &amp; Paul (1994)</td>
<td>[Critical thinking] is best understood as the ability of thinkers to take charge of their own thinking. This requires that they develop sound criteria and standards for analyzing and assessing their own thinking and routinely use those criteria and standards to improve its quality.</td>
</tr>
<tr>
<td>Chaffee (1988)</td>
<td>[Critical thinking is] our active, purposeful, and organized efforts to make sense of our world by carefully examining our thinking, and the thinking of others, in order to clarify and improve our understanding.</td>
</tr>
<tr>
<td>Lipman (1988)</td>
<td>[Critical thinking is] skillful, responsible thinking that facilitates good judgment because it 1) relies upon criteria, 2) is self-correcting, and 3) is sensitive to context.</td>
</tr>
<tr>
<td><strong>Education</strong></td>
<td></td>
</tr>
<tr>
<td>Norris &amp; Ennis (1989)</td>
<td>Critical thinking is the reasonable and reflective thinking that is focused upon deciding what to believe or do.</td>
</tr>
</tbody>
</table>
Critical thinking typically involves the individual’s ability to do some or all of the following: identify central issues and assumptions in an argument, recognize important relationships, make correct inferences from data, deduce conclusions from information or data provided, interpret whether conclusions are warranted on the basis of the data given, and evaluate evidence or authority.

**Psychology**

**Halpern (1998)**

The term critical thinking refers to the use of those cognitive skills or strategies that increase the probability of a desirable outcome. Critical thinking is thinking that is purposeful, reasoned and goal directed. It is the kind of thinking involved in solving problems, formulating inferences, calculating likelihoods, and making decisions.

**Sternberg (1986)**

[Critical thinking is] the mental processes, strategies, and representations people use to solve problems, make decisions, and learn new concepts.

**Dwyer, Hogan & Stewart (2014)**

Critical thinking is a metacognitive process that, through purposeful, reflective judgement, increases the chances of producing a logical conclusion to an argument or solution to a problem.

**Willingham (2007)**

[Critical thinking is] seeing both sides of an issue, being open to new evidence that disconfirms your ideas, reasoning dispassionately, demanding that claims be backed by evidence, deducing and inferring conclusions from available facts, solving problems, and so forth.
Educational approaches to critical thinking tend to describe it in terms of what is achieved through thinking critically, perhaps due to the importance of identifying learning outcomes in this field (Sternberg, 1986). For example, the most prominent model of learning outcomes, Bloom’s Taxonomy of Educational Objectives (Bloom et al., 1956; Krathwohl, 2002), specifies three higher-order cognitive learning outcomes – analysis, synthesis and evaluation – which are thought to together reflect critical thinking. Both the philosophical and educational approaches to defining critical thinking have been criticised for their reliance on introspection rather than empirical work (Moore, 2013; Sternberg, 1986). While useful for understanding and discussing the standards of thinking to which we should aspire, these approaches do not shed light on the cognitive processes by which this level of thinking is achieved or the variations in the individual ability to think critically. Therefore, further discussion of these definitions is beyond the scope of this thesis.

Conceptualisations of critical thinking in psychology tend to identify the discrete mental processes involved in thinking critically and the dispositions which make individuals more likely to apply critical thinking when required (Stanovich & Stanovich, 2010). Central to many of these is the need to evaluate arguments, evidence and one’s own thinking without bias from pre-existing beliefs (West, Toplak, & Stanovich, 2008). Diane Halpern has described the higher-order thinking skills employed when one is engaged in critical thinking as including verbal reasoning, argument analysis, hypothesis testing, estimating likelihood and dealing with uncertainty, problem solving, and decision-making (Halpern, 1998). However, in her definition of critical thinking, its function is the selection of thinking strategies which increase the probability of a desirable (or rational) outcome (Halpern, 2007). Thus the defining features of critical thinking are not the characteristics of the thinking skills employed but the metacognitive processes of selecting and executing the appropriate thinking skill and the monitor and control of this thinking process (Halpern, 1998; Ku & Ho, 2010b; Kuhn, 2000). Therefore critical thinking involves the thinker’s awareness that a particular thinking skill is required and that the ongoing
execution of the skill is adequate, and the ability to monitor and exert control to change ongoing thinking processes (Hogan, Dwyer, Harney, Noone, & Conway, 2015; Ku & Ho, 2010b; Kuhn, 2000; Magno, 2010). This perspective of critical thinking as the application of metacognition in order to achieve rationality is pervasive in psychology (Dwyer, Hogan, & Stewart, 2014; Ku & Ho, 2010b; Kuhn, 2000; Magno, 2010; Sternberg, 1986) and is consistent with several definitions of critical thinking from philosophy which refer to “thinking about thinking” (Elder & Paul, 1994; Chaffee, 1988; Lipman, 1988).

As referred to above, the execution of critical thinking also depends on the presence of specific dispositions towards thinking. That is, it is not enough to have the ability to think critically, one must also have the inclination to do so (Halpern, 1993; Ku & Ho, 2010a). Therefore, failures to think critically are not necessarily due to a lack of ability but can also be due to the lack of a disposition towards thinking critically (or both; Dwyer, Hogan, Harney, & Kavanagh, 2016). More than 20 different thinking dispositions have been proposed as contributing to effective critical thinking and these vary in their distinctiveness (Tishman & Andrade, 1996). Some include inquisitiveness, fair-mindedness, precision, self-confidence in one’s own reasoning (among others from the Delphi definition; Facione, 1990), systematicity, analyticity, truth-seeking (Facione et al., 1994), tentativeness, scepticism and tolerance of ambiguity (Halonen, 1995) and many others are described across several thinking disposition taxonomies (Sosu, 2013). However, many of the suggested dispositions do not yet have associated measures and so the validity of these taxonomies is unclear (Ku, 2009a; Sosu, 2013). Some thinking dispositions focus on the motivation to think critically (i.e. whether someone tends to maintain the goal of thinking critically; Valenzuela, Nieto, & Saiz, 2011). An example of this type of disposition is need for cognition, a construct which represents the amount of effort an individual tends to put into cognitive activities (Cacioppo & Petty, 1982). Other thinking dispositions focus on the intellectual habits and attitudes which facilitate critical thinking. These tend to describe the manner in which a situation requiring critical thinking is approached (Sosu, 2013).
An example of this type of thinking disposition is *actively open-minded thinking*. This construct represents an individual tendency to avoid dichotomous thinking and seek alternatives and counterevidence to one’s own beliefs (Stanovich & West, 1997). Though most experts on critical thinking agree on the importance of thinking dispositions to critical thinking, there is much debate about whether or not all of the thinking dispositions that have been identified truly facilitate critical thinking. There is also a lack of clarity regarding the relative contributions to critical thinking of those thinking dispositions which have been confirmed as beneficial (Sosu, 2013).

It is important to note that the literature in psychology which explicitly discusses critical thinking is not the only body of psychological literature which focuses on thinking rationally (Stanovich, 2016). The process of thinking in order to achieve a rational outcome is also discussed in research on intelligence and by researchers focusing on judgment and decision-making (Weber & Johnson, 2009). The construct of intelligence is popularly understood to reflect good thinking skills. However, comparisons of intelligence test items and various definitions of intelligence show that while intelligence is often described as including reasonable judgment and adaptive decision-making, the tasks included on intelligence tests do not assess these skills (Legg & Hutter, 2007; Stanovich, 2016; Stanovich & Stanovich, 2010). Intelligence can perhaps be described more accurately as the efficiency with which individuals process abstract information, while critical thinking involves the assessment of the quality of information and one’s own thinking about information in more concrete and specific real-world situations (Halpern, 2006; Stanovich & Stanovich, 2010).

In contrast to intelligence research, judgment and decision-making research focuses directly on rationality (Hastie & Dawes, 2010; Stanovich, 2016). In this research, rationality is often operationalised by reference to the concept of maximising expected utility (Stanovich, 2016). Simply put, expected utility is a mathematically derived indicator of how beneficial a specific choice will be for a decision-maker (Briggs, 2015). Pioneering work by Kahneman, Tversky and others revealed that humans often do not
act according in ways that maximise expected utility (Aczel, Bago, Szollosi, Foldes, & Lukacs, 2015; Ayal, Rusou, Zakay, & Hochman, 2015; Kahneman, 2011; Kahneman & Tversky, 1984). This program of research has led to the identification of a number of ways in which human decision-making typically and systematically leads to irrational outcomes (West et al., 2008). Some of the most researched cognitive biases include confirmation bias, which is the tendency to interpret information in a way that conforms with one’s pre-existing beliefs; the correspondence bias, which is the tendency to focus on personality rather than context in explaining behaviour; and the sunk cost bias, which is the tendency to persist with a decision, despite evidence that better options are available, because of initial investment in the decision (Hafenbrack, Kinias, & Barsade, 2013; Hopthrow, Hooper, Mahmood, Meier, & Weger, 2016; Stanovich & West, 2007).

Tasks designed to be sensitive to cognitive biases allow rationality to be experimentally assessed through observation of the extent to which individuals successfully avoid succumbing to cognitive biases (Stanovich, 2016). While a great number of separate tasks have been developed to assess different cognitive biases, no comprehensive assessment of rational thinking has been validated (though one is in development; Stanovich, 2016). Research focused explicitly on critical thinking, on the other hand, has led to the development of a number of validated measures which reflect the construct as a whole (Ku, 2009a). These measures will be considered next.

2.4 Assessing Critical Thinking Performance

Developing assessments of critical thinking has been a complex process, due to the multi-faceted nature of the construct (Ku, 2009a; Liu, Frankel, & Roohr, 2014). Initial attempts at assessing critical thinking focused solely on the cognitive skills involved (Bensley et al., 2016; Ennis, Millman, & Tomko, 1985; Ennis & Norris, 1990; Facione, 1992; Watson & Glaser, 1980). However, more recent research has determined that variations in the endorsement of particular thinking dispositions independently account for variance in critical thinking performance in addition to the variation
accounted for by cognitive skills (Ku & Ho, 2010a; Macpherson & Stanovich, 2007; Taube, 1997).

A dissociation has been discussed in the types of questions that are sensitive to the skills and dispositions underlying critical thinking. While assessments composed of closed (e.g. multiple choice questions, Likert scale ratings) are thought to accurately reflect levels of cognitive skill in the performance of critical thinking, assessments composed of open-ended questions are said to be more apt for determining the presence of a disposition towards critical thinking (Ku, 2009a). This assumption, held by many critical thinking researchers, is supported by evidence from a study which submitted responses to a number of measures of critical thinking, cognitive skill and thinking dispositions to factor analysis (Taube, 1997). One factor appeared to reflect cognitive ability as the measures which loaded on it significantly included SAT scores, university grade point average, and scores on the Watson-Glaser Critical Thinking Appraisal (Watson & Glaser, 1980; which is composed of multiple-choice questions). Another factor representing dispositions included scores on measures of need for cognition, tolerance of ambiguity and dualistic/relativistic thinking. Crucially, a test of critical thinking which is open in format – the Ennis-Weir Critical Thinking Essay Test (Ennis & Weir, 1985) – loaded significantly on both factors. This suggests that closed questions might only capture levels of cognitive skill while open questions appear to capture both cognitive skill and disposition towards thinking (Taube, 1997).

Another concern with assessments based solely on multiple choice questions is that, by providing the possible answers, critical thinking is elicited by recognition of the correct answer rather than by the thinker’s ability to generate thinking strategies and select the one most likely to provide a rational outcome (Liu et al., 2014). Assessments that employ only multiple choice questions are therefore at odds with the current conceptualisation of critical thinking, both because they are not sensitive to thinking dispositions and because they do not involve the unprompted generation and selection of optimal thinking strategies. One suggested solution was to ensure that measures of critical thinking dispositions are
included in all attempts at assessment. This is a flawed solution as most available thinking disposition measures are self-report in format and it is arguably better to assess the application of thinking dispositions (i.e. in open-ended answers). As a result, measures which employ both open and closed questions are now recommended by researchers (Ku, 2009a).

There are currently seven measures of general critical thinking available (i.e. not restricted in focus to a particular domain of knowledge; Lai, 2011; Liu, Frankel, & Roohr, 2014). These include the Watson-Glaser Critical Thinking Appraisal (WGCTA; Watson & Glaser, 1980), the Ennis-Weir Critical Thinking Essay Test (EWCTET; Ennis & Weir, 1985), the Cornell Critical Thinking Test (CCTT; Ennis et al., 1985), the California Critical Thinking Skills Test (CCTST; Facione, 1992), the Collegiate Assessment of Academic Proficiency Critical Thinking (CAAPCT; CAAP Program Management, 2012), the Minnesota Test of Critical Thinking (MTCT; Edman, Robey, & Bart, 2004), and the Halpern Critical Thinking Assessment (HCTA; Halpern, 2010). In these assessments, scenarios are presented along with relevant questions which target critical thinking skills such as analysis, evaluation and inference-making, though all focus on different thinking skills to different extents and in different ways (Tiruneh, de Cock, Weldeslassie, Elen, & Janssen, 2016).

The WGCTA, CCTT, CAAPCT and the CCTST all consist of multiple choice questions only (Liu et al., 2014). A further limitation of the WGCTA, CCTT and CCTST is the inconsistency in the stability of their factor structures and reliability across studies. The MTCT requires participants to consider 16 scenarios in which judgments are made. After each scenario, a range of arguments are presented and test takers are required to rate their relevance to the judgment on a Likert scale. This format suffers the same weakness as the multiple choice format since critical thinking is prompted. All that is required in both of these formats is the recognition of the quality of arguments, where a more valid approach would require test takers to generate their own arguments and monitor the quality of their own thinking (de Bie, Wilhelm, & van der Meij, 2015; Lai, 2011).
As previously stated, this can be achieved using open-ended questions. The EWCTET consists of one open-ended question which requires test takers to respond to a hypothetical newspaper letter, which includes instances of flawed reasoning, with a letter of their own composition. The test taker is expected to analyse the arguments presented in the hypothetical letter and the quality of their analysis (Ennis & Weir, 1985). A major limitation of this test is that the grading of responses is entirely subjective (de Bie et al., 2015).

Perhaps the most comprehensive critical thinking measure is the HCTA as it employs both open and closed questions (de Bie et al., 2015; Halpern, 2010; Ku, 2009a). This measure presents 25 everyday scenarios which focus on a range of topics including the reporting of science news, the consideration of health information and judging proposed government policies. Each of these scenarios is followed first by an open question which itself is followed by a closed question which requires either a multiple choice, ranking or Likert scale rating response. Five broad categories of thinking skill are assessed in the HCTA including argument analysis (the ability to identify conclusions in arguments and judge the quality of their underlying reasons), hypothesis testing (the ability to accumulate information, while recognising whether information is missing or not generalisable, before forming beliefs and to revise beliefs based on new information), judging likelihood (the ability to accurately consider probabilities of events), problem-solving (the ability to identify different ways of thinking about a problem and to generate criteria for selecting the best solution), and verbal reasoning (the ability to recognise and not be swayed by persuasive but misleading language; Halpern, 2010).

The broad range of thinking skills required in completing the HCTA and the mixed response format enhance its construct validity while the use of familiar situations enhances its ecological validity. In terms of predictive validity, the HCTA is unique among critical thinking measures in its ability to predict life outcomes. Specifically, higher scores on the HCTA have been associated with fewer negative life outcomes (Butler, 2012; Butler et al., 2012). Examinations of the factor structure of the HCTA consistently show
that questions focused on each of the five categories of thinking skill described above load together on two factors representing the open and closed question formats (Halpern, 2010; Hau et al., 2006; Ku & Ho, 2009). Furthermore, aggregate scores of all the questions on the HCTA tend to produce Cronbach’s $\alpha$ values of between .79 and .88 reported, indicating a high level of internal consistency (Butler, 2012; Dwyer, Hogan, & Stewart, 2012; Halpern, 2010). Across a number of studies reported by Halpern (2010), correlations of between .39 and .75 were observed between scores on open and closed questions. This supports the idea that they are measuring something similar but that the responses are generated in different ways (de Bie et al., 2015). A major strength of the HCTA is that all responses are scored according to standardised prompts. This significantly reduces the subjectivity involved in scoring open-ended answers, as is evident in the high levels of inter-rater reliability found in previous applications of the HCTA (Butler, 2012). Overall, the HCTA is the critical thinking measure with the strongest claim for construct validity and the most adequate psychometric properties (Butler, 2012; de Bie et al., 2015; Ku, 2009a).

In summary, critical thinking involves the deliberate consideration application of thinking skills in order achieve a rational outcome. It involves both a dispositional motivation towards critical thinking as well as thinking skill. Individual differences in critical thinking are therefore best measured by taking both critical thinking dispositions and critical thinking skills into account. The next section will describe how critical thinking fits into dual-process accounts of human cognition in order to demonstrate the role of self-regulation in effective critical thinking.

**2.5 How Self-Regulation Supports Critical Thinking**

Critical thinking, as described above, is not an automatic process (Bonnefon, 2016; Facione, 2013; Halpern, 2013). For an individual to think critically, they must voluntarily recognise the need to think critically, select the appropriate thinking strategy, monitor the adequacy of this strategy and, if necessary, exert control to change the thinking strategy (Butler et al., 2012; Ku, 2009b). However, much of the information processing individuals
tend to engage in is automatic because this is less cognitively demanding (Andrzejewska, Dreesmann, Haslbeck, Mechelmans, & Furlan, 2002; Bargh, 1999; Bargh & Ferguson, 2000; Böckenholt, 2012). Through experience we learn associations between stimuli, and between stimuli and their consequences, so that when stimuli are encountered again we will often unconsciously act upon them according to our learned associations (Strack & Deutsch, 2004; Wasserman & Miller, 1997). This distinction between automatic and voluntary modes of information processing has been elaborated upon in the literature on dual-process theories of cognition (Barr, Pennycook, Stolz, & Fugelsang, 2014; De Neys, 2006; Epstein & Pacini, 1999; Evans & Stanovich, 2013a; Handlely & Trippas, 2015; Hofmann, Friese, & Strack, 2009; Kahneman & Frederick, 2005; Sloman, 1996; Stanovich & Toplak, 2012). A common theme in this research is that self-regulation is the mechanism responsible for interrupting automatic processing, allowing voluntary responses, such as critical thinking to occur (De Neys, 2014; Evans, 2007; Hofmann, Gschwendner, Friese, Wiers, & Schmitt, 2008; Pennycook, Fugelsang, & Koehler, 2015).

Dual-process theories posit that cognitive processes can be organised into two categories. Many different types of dual-process theories have been advanced but all share the notion that human thought processes can be described as either fast, intuitive and arising automatically or slow, reflective and occurring voluntarily (Evans, 2008; Evans & Stanovich, 2013a). Across these different theories, various terms are used to describe these two types of information processing. For example, an inexhaustive list of the ways in which the “fast” type of thinking has been described includes intuitive (Hammond, 1996), implicit (Evans & Over, 1996), reflexive (Lieberman, 2003), impulsive (Strack & Deutsch, 2004), heuristic (Chen & Chaiken, 1999; Evans, 2006) and system 1 thinking (Kahneman, 2011; Stanovich, 2009). Some of the descriptions of the “slow” type of thinking include analytic (Evans, 2006; Hammond, 1996), reflective (Lieberman, 2003; Strack & Deutsch, 2004), explicit (Evans & Over, 1996), systematic (Chen & Chaiken, 1999) and system 2 thinking (Kahneman, 2011; Stanovich, 2009). In recognition of the fact that many different types of
cognitive processes fall into each of these categories, and that these different
cognitive processes do not necessarily map on to distinct neurocognitive
systems, the “fast” category of thinking processes will be referred to here as
Type-1 processes and the “slow” category of cognitive processes will be
referred to as Type-2 processes, as recommended by Evans and Stanovich
(2013).

The defining feature of Type-1 processes is that they occur by
default in response to stimuli due to either innate (e.g. our general aversion
to heights) or learned tendencies, whether learned implicitly (e.g. stereotypes) or explicitly (e.g. swerving to avoid a collision while driving; Stanovich & Toplak, 2012). Coming to a decision by way of Type-1 processes has the feeling of an intuition or what is sometimes referred to as a “gut feeling”. As a result, individuals are usually unable to report how they
came to their response when it was generated by a Type-1 process
(Bonnefon, 2016). This may have to do with the way in which information
accessed by Type-1 processes is stored. This information is assumed to be
stored in an associative network in which concepts, conditioned affective
responses and behavioural schemata are represented as nodes which are
linked together (Ostafin, 2015; Strack & Deutsch, 2004). The strength of the
link between any two nodes is determined by an individual’s past experience
of their spatial or temporal co-occurrence. This allows responses to be
generated quickly as the triggering stimulus automatically activates related
nodes, proportionally to the strength of their link, through a spreading of
activation (Strack & Deutsch, 2004). These default processes occur in
response to their triggering stimuli without the attention of the individual
being directed to the decision-making process and therefore do not involve
the operation of working memory since it receives no input (Evans, 2008).
Since there is no need to attend to or maintain information regarding the
operation of Type-1 processes or their triggering stimuli in working
memory, their overall impact on cognitive resources is small (Evans &
Stanovich, 2013a; Toplak, West, & Stanovich, 2014). As a result, Type-1
processes are an extremely economic form of information processing. The
extent to which humans rely on default responses which are generated
automatically and without the involvement of working memory resources has led to the view of humans as “cognitive misers” (Toplak, West, & Stanovich, 2011; Toplak et al., 2014).

Type-1 processes are useful in familiar contexts where the optimal response has been learned to the point of being automatic. For example, studies on decision-making by individuals considered to be experts in their field show that they tend to make many decisions based on their immediate recognition of the characteristics of the current situation rather than a deliberative analysis (Lipshitz, Klein, Orasanu, & Salas, 2001). Similarly, many of the heuristics referred to earlier are acquired because they do in fact lead to accurate responses much of the time. However, in novel contexts for which an individual has no learned responses (such as experimental decision-making paradigms), Type-1 processes have a high probability of generating inadequate responses (Evans & Stanovich, 2013a). In these circumstances, it is more adaptive to generate alternative options for responses and reflect on which response might lead to the best outcome. To achieve this, Type-2 processes must be engaged.

Type-2 processes are defined by their reliance on working memory resources to deliberately maintain the mental representation and comparison of hypothetical models of the world – a process referred to as decoupling (Evans, 2012; Larue, Poirier, & Nkambou, 2013; Pennycook et al., 2015; Stanovich & Toplak, 2012). For decoupling to be initiated, when an individual is presented with a given stimulus or situation, they must first successfully override responses generated by Type-1 processes. Then, different cognitive simulations of possible actions are compared to test their appropriateness, before the individual acts according to their preferred response (Larue et al., 2013; Pennycook et al., 2015; Stanovich & Stanovich, 2010). It has been suggested that these simulations are represented as propositions with a truth value (representing the probability that the proposition is true; Ostafin, 2015; Strack & Deutsch, 2004). Individuals tend to be able to recall the different propositions generated by Type-2 processes and to explain how they arrived at their response. It has been argued that in most situations (i.e. those where the processes have not
been automatised through experience), all higher-order thinking skills can be considered as Type-2 processes. Accordingly, several authors have concluded that critical thinking involves Type-2 processes. This is plausible as critical thinking is deliberate and involves the ability to reflect upon, evaluate and explain one’s thinking (Bonnefon, 2016; Facione, 2013; Halpern, 2013).

Evidence for the distinction between Type-1 and Type-2 processes comes from studies on reaction times in reasoning tasks, the effects of experimental manipulations of task structure, time to respond and cognitive load on responses to reasoning tasks, and from studies on how individual differences in cognitive ability and thinking dispositions relate to responses to reasoning tasks (Evans & Stanovich, 2013). These reasoning tasks are typically presented in such a way that a tempting but wrong answer (typically referred to as a heuristic response) should spring to mind intuitively. Further reflection, through the engagement of Type-2 processes, is required in order to identify that this heuristic response is in conflict with the correct answer (De Neys, 2015; Stanovich, 2016). See Table 2.2 for an example.

Distinct reaction time profiles for Type-1 and Type-2 processes are found when the structure of reasoning tasks is manipulated to either include a tempting incorrect option (usually referred to as a “conflict” condition) or not (in which case the tempting option is also the correct option – usually referred to as a control condition; see Table 2.2). These studies show that all participants respond very rapidly to the reasoning and with very high levels of accuracy tasks in the control condition. While in the conflict condition, reaction times for incorrect responses are significantly faster than those for correct responses (De Neys & Franssens, 2009; De Neys & Glumicic, 2008). However, some argue that this demonstrates that more information processing is required, rather than a qualitatively different type of processing (Kruglanski, 2013).
Evidence for a qualitative difference in types of processing comes from the study of experimental manipulations which theoretically should prevent Type-2 processes from initiating. Manipulations of time pressure and cognitive load have been successful in eliciting the heuristic responses associated with Type-1 processes (Evans & Stanovich, 2013). For example, when the amount of time allowed to respond on a reasoning task like this is constrained to a very brief period (e.g. 10s), the number of heuristic responses jumps significantly in comparison to an unlimited time condition as there is not enough time available for Type-2 processes to occur (Andrzejewska et al., 2002; Villejoubert, 2009). Again, this may just be the result of interrupting the extra processing required to arrive at a correct answer. However, similar effects are found when cognitive load is increased by requiring participants to complete a second task (which requires working memory resources) alongside the reasoning tasks. This suggests that it is not the amount of processing which affects performance, but rather whether working memory resources are available to support Type-2 processes (Franssens & De Neys, 2009; Johnson, Tubau, & De Neys, 2016).

Furthermore, it has been argued that these constraints cannot be simply increasing the difficulty of the reasoning tasks and inducing guessing, as this would be reflected by chance-level responding (Evans & Stanovich, 2013).
Studies of individual differences in cognitive ability have consistently shown selective associations between the extent to which Type-2 processing is engaged and competence in tests of working memory (De Neys & Bonnefon, 2013). The ability to recruit working memory resources appears to explain much of the variation in responses to many different types of reasoning tasks typically used in studies on heuristics and biases (Gilinsky & Judd, 1994; Schmiedek, Oberauer, Wilhelm, Süß, & Wittmann, 2007; Stanovich, 1999). Similar relationships have been found between individual differences in working memory capacity and the influence of Type-1 and Type-2 processes on real-world behaviours. A series of studies by Hofmann and colleagues (2008) showed that when observing situations related to sexual interest behaviour, the consumption of tempting food and the expression of anger in a provoking situation, the relationship between responses to implicit association tests related to these outcomes and the actual observed behaviour was much stronger for individuals who were low in working memory capacity than those with high working memory capacity. These studies also showed that responses to explicit measures of attitudes and self-regulatory goals relevant to the behaviours observed were only predictive of actual behaviour in individuals with high working memory capacity (Hofmann et al., 2008). In summary, there appears to be convergent evidence across different methods of investigation and measures of behaviour for the notion that there are broadly two distinct types of cognitive processing available to humans, as posited by dual-process theories. While much of the research on dual-process theory has focused on what distinguishes Type-1 and Type-2 processes, and the conditions in which they respectively lead to adequate responses, only recently has research begun to investigate the question of how we switch from using Type-1 processes to using Type-2 processes.

Dual-process theories differ in how they conceptualise the joint operation of Type-1 and Type-2 processes (De Neys, 2014; Evans, 2007; Travers, Rolison, & Feeney, 2016). Competitive models assume that Type-1 processes occur in parallel with Type-2 processes and that if there is a conflict between the possible responses generated, then self-regulation is
required to override the response generated by Type-1 processing (Evans & Stanovich, 2013a; Sloman, 1996; Travers et al., 2016). However, this implies that Type-1 processes must “wait” for Type-2 processes to generate a response and check for conflict before action is taken (Evans & Stanovich, 2013). The results from studies which manipulate the presence of conflict (by including or removing a tempting but incorrect, as referred to earlier) show that even when there is conflict present, Type-1 processes occur much faster than Type-2 processes (De Neys, 2014; Pennycook et al., 2015). In addition, the competitive perspective is unable to explain why increases in cognitive load do not interfere with conflict detection but do interfere with reasoning. In competitive models, conflict detection is considered to be a Type-2 process and therefore should require working memory resources (Evans & Stanovich, 2013).

Default interventionist models, on the other hand, are serial in nature. They assume that Type-1 processes are triggered automatically and that they must be overridden in order for Type-2 processes to initiate (Evans, 2007; Handley & Trippas, 2015; Travers et al., 2016). Current evidence appears to support the default interventionist perspective as opposed to the competitive perspective. The strongest evidence for this comes from an eye-tracking analysis of performance on reasoning tasks similar to those described in Table 2.2. This study showed that even when the correct response is eventually chosen, individuals are first attracted to the tempting incorrect answer, and that when the tempting incorrect answer is chosen, neither the correct option nor the obviously incorrect options are considered. This suggests that there is an initial response generated by Type-1 processes which, on trials where a correct response was eventually given, is overridden to allow the engagement of Type-2 processes (Travers et al., 2016). This begs the question of how the override of Type-1 processes is triggered. This question has been the source of great debate among dual-process theorists and the lack of clarity regarding its answer is often pointed to by critics of dual-process theories (Evans, 2007). While Evans and Stanovich, argued that it is the intervention of executive functioning which allows the engagement of Type-2 processes, they did not specify how
executive functioning itself is triggered (Evans & Stanovich, 2013). However, progress has recently been made towards identifying the mechanism by which a switch from Type-1 processing to Type-2 processing is engaged.

There are currently two dual-process models of reasoning which are default interventionist in nature and which attempt to specify how the override of Type-1 processes is triggered: the intuitive logic model (De Neys, 2014) and the three-stage dual-process model of analytic engagement (Pennycook et al., 2015).

The intuitive logic model (see Figure 2.1), assumes that when Type-1 processes are cued in situations requiring reasoning, two types of Type-1 process are activated: one sensitive to information stored in associative memory and another sensitive to normative principles (e.g. logical rules, mathematical rules) which have been internalised (De Neys, 2014). When such conflicts are noticed, individuals will still act according to the response generated by Type-1 processes, unless they are overridden. Only when Type-1 processes are overridden can Type-2 processes be initiated. Therefore, the engagement of Type-2 processing depends on both successful conflict detection and the subsequent successful override of Type-1 processes (De Neys, 2015). A number of studies have suggested that individuals routinely offer biased responses in reasoning tasks despite apparently having successfully detected the presence of a conflict between their response and intuitive logic. These studies have demonstrated that participants often gave the tempting but wrong answer to a reasoning problem which involved conflict but also showed increased reaction time, arousal, and activity of the anterior cingulate cortex in comparison to their performance on no-conflict reasoning tasks (Ball, Phillips, Wade, & Quayle, 2006; Bonner & Newell, 2010; De Neys, 2010; De Neys, Vartanian, & Goel, 2008; Thompson & Johnson, 2014). This was interpreted as successful conflict detection followed by lapses in self-regulation. These results were taken as support for the idea that biased responses tend to happen as a result of failures to override Type-1 processing. This model can also account for heuristic (but incorrect) responses on traditional reasoning tasks taking
longer than correct responses on control versions of these tasks by attributing the extra processing time to successful conflict detection which is then followed by a failure to override the prepotent Type-1 response.

*Figure 2.1. The Intuitive Logic Model*

The three-stage dual-process model of analytic engagement (See Figure 2.2; Pennycook, Fugelsang, et al., 2015) also specifies a conflict detection mechanism. However, this model does not assume that any Type-1 processes are sensitive to an intuitive logic. Rather, in Stage 1 of this model, Type-1 processes draw on associative memory and may generate several possible responses, in order of the fluency with which they come to mind. The fluency with which these responses come to mind is dependent on the strength of their association with the triggering stimulus. Stage 2 involves the monitoring of Type-1 responses and it has been suggested that probability of successfully detecting a conflict between Type-1 responses is a function of the fluency with which these responses come to mind. So, if two different possible responses spring to mind quickly, it is relatively easy for one to notice the conflict between them. The greater the distance in time between the generation of possible responses, the lower the likelihood of successful conflict detection. If conflict detection is not successful, the
response which came to mind most fluently is carried out. If conflict
detection is successful, then the urge to carry out the most fluently generated
Type-1 response must be overridden. This allows Type-2 cognitive
simulation processes to be engaged in order to compare the possible
responses and generate alternative responses. Occasionally Type-2 processes
do not have sufficient information to draw on (whether in the environment
or from declarative memory) to form an alternative to the initial response
(Stanovich & Stanovich, 2010).

*Figure 2.2. The Three-Stage Dual-Process Model of Analytic Engagement*

It can also be the case that an individual is not motivated to seek out
alternatives to the initial response (as reflected by the concept of thinking
dispositions discussed earlier). In these cases, the engagement of Type-2
processes results in rationalisation of the initial response (Bonnefon, 2016;
Pennycook et al., 2015). This is perhaps the most comprehensive default
interventionist model of higher-order cognition as it integrates results from
many different strands of dual-process research in a coherent manner and
specifies mechanisms for how conflict monitoring operates.
While there are differing opinions on which specific default interventionist model is the most accurate, the role of self-regulation in allowing the engagement of Type-2 processes like critical thinking is constant across each model (De Neys, 2015; Evans & Stanovich, 2013; Pennycook et al., 2015). In each model, Type-1 processes occur by default and must be overridden in order for the response generated by Type-2 processes to be enacted (Bonnefon, 2016). Furthermore, though failure to detect conflict can also lead to bias, evidence is accumulating in favour of failures to override Type-1 responses being the main source of bias observed in experimental studies (De Neys, 2014; Pennycook et al., 2015). As discussed in Chapter 1, the override of automatic responses requires self-regulation (Hofmann, Schmeichel, & Baddeley, 2012). Examinations at the level of executive functions show that the sub-process of inhibition is particularly important in overriding Type-1 processes (Böckenholt, 2012; Liberali, Reyna, Furlan, Stein, & Pardo, 2012). This is unsurprising as inhibition is, by definition, the process by which prepotent responses and habitual behaviours are overridden, thus allowing for other responses to occur (Hofmann et al., 2012; Miyake et al., 2000; Miyake & Friedman, 2012). Other executive sub-processes underlying self-regulation are involved in supporting Type-2 processes. Once Type-1 processes have been inhibited, the other executive sub-processes, updating and shifting, support the effective operation of working memory and thereby facilitate Type-2 processes (Hofmann et al., 2008, 2012). In line with this, individual differences in executive functioning tend to account for a significant share of the variance in higher-order thinking skill (Del Missier et al., 2010; Toplak, Sorge, Benoit, West, & Stanovich, 2010; Toplak et al., 2011). Given that all default interventionist accounts of higher-order cognition posit that the initiation of Type-2 processes depends on effective conflict monitoring and self-regulation, it is reasonable to propose that critical thinking, as a Type-2 process, requires these too (Bonnefon, 2016).
In summary, many models of human cognition posit that cognitive processes can be categorised into two different types. Type-1 processes occur by default in response to triggering stimuli and are useful in situations for which we have learned adequate responses. However, many situations require going beyond our intuitive response. To think critically about a situation requires voluntary recognition of the need to think critically, conscious selection of the appropriate thinking strategy and monitoring and control of the thinking process. This implies that critical thinking is a Type-2 process and therefore requires self-regulation in order to inhibit Type-1 processes and then maintain, revise and switch between working memory representations. As referred to earlier, the purpose of critical thinking is to “increase the probability of a desirable outcome” (Halpern, 1998). Failures to generate a desirable outcome can be the result of: (1) failures to notice conflicts between intuitive responses (i.e. going with one’s first response which comes to mind with a sense of certainty, despite its inadequacy), (2) failures to inhibit the intuitive response (i.e. going with one’s first response which comes to mind despite feeling that it may be inadequate), and (3) failures to support decoupling processes with access to relevant information (i.e. selecting an inadequate response due to a lack of relevant knowledge or experience, or access to resources from which relevant information can be synthesised to simulate alternative responses) which can lead to either a sub-optimal alternative response or rationalisation of an initial intuitive response. In the next section, we will see how mindfulness may facilitate both conflict detection and successful self-regulation following the detection of a conflict between intuitive responses.

2.6 How Mindfulness Supports Self-Regulation

In Chapter 1, it was shown that mindfulness can be conceptualised as the operation of two distinct processes: present-moment attention and non-reactivity to experience (Bishop et al., 2004; Tran, Glück, & Nader, 2013). It was noted that these processes are thought to work together to enhance one’s ability to notice affective signals and inhibit our natural tendency to cognitively elaborate upon affective signals (Teper, Segal, & Inzlicht, 2013). Evidence was presented for the inhibition of elaborative processing as a key
mechanism underlying the facilitative effects of mindfulness on the self-regulation of behaviours related to physical and mental health (Gotink et al., 2015; Gu, Strauss, Bond, & Cavanagh, 2015). However, engaging in mindfulness may have an even broader effect on self-regulation. This section will elaborate upon the account of mindfulness by Teper and colleagues (2013) presented briefly in Chapter 1. This will show how present-moment attention and non-reactivity to experience respectively may enhance the executive functions which underlie self-regulation – updating, inhibition and shifting – and thereby facilitate not just the inhibition of elaborative processing, but the engagement of Type-2 processes more generally.

Let us first consider how present-moment attention contributes to enhanced self-regulation and the specific executive sub-processes which may be related to this enhancement. In Chapter 1, present-moment attention was described as full attention to all internal and external stimuli at any given moment (Bishop et al., 2004). When internal and external stimuli are observed and brought into awareness, affective cues, which are normally overlooked, are more likely to be noticed (Teper et al., 2013). Affective cues (sometimes referred to as transient affects) can be understood as somatic precursors to longer lasting affective experiences such as emotions and moods. They occur very quickly, directly after sensory processing, and often without conscious awareness (Zajonc, 1980). For example, the conscious experience of negative affective cues has been described as the feeling of immediate “pangs” in response to events (e.g. an initial aversive feeling of arousal when one makes a mistake; Teper et al., 2013).

Many studies have suggested that mindful attention to the present moment enhances awareness of the somatic sensations which characterise affective cues. For instance, in a randomised controlled experiment, participants who were required to follow a 15-minute guided meditation every day for five days showed a significantly greater improvement in sensitivity on a somatic signal detection task (which involves distinguishing perceptual noise from real tactile feedback) than those assigned to an audiobook condition (Mirams, Poliaikoff, Brown, & Lloyd, 2013). Expert
mindfulness practitioners also perform better on this task than novices (Fox et al., 2012). Brief inductions of mindfulness have also been shown to increase awareness of breath and heartbeat (Kerr, Sacchet, Lazar, Moore, & Jones, 2013; Levinson, Stoll, Kindy, Merry, & Davidson, 2014; Melloni et al., 2013). More direct evidence of greater awareness of affective cues as a result of mindfulness has come from a study where implicit and explicit affective reactions to negatively valenced stimuli were measured in participants assigned to either a mindfulness, rumination or distraction group. Participants in the mindfulness group showed significantly greater coherence between their implicit and explicit reports of negative affect than those in the rumination and distraction conditions. This suggests that by cultivating a state of mindfulness through meditation, these participants were better able to notice their affective reactions and report them accurately (Remmers, Topolinski, & Koole, 2016). The relationship between greater awareness of affective cues and enhanced self-regulation becomes clearer when affective cues are thought of as information regarding an individual’s current situation (Inzlicht, Bartholow, & Hirsh, 2015).

From this point of view, the function of negative affective cues is to indicate that an individual’s current state is inconsistent with their goal state. The process of comparing one’s current state to one’s goal state is referred to as conflict monitoring and conflict has been defined in this context as “any disagreement or discrepancy between mental representations, response tendencies, or actual behaviour” (Inzlicht et al., 2015, p. 127). This perspective suggests the presence of conflict is accompanied by a negative affective cue and that this is the information used to signal whether an individual should engage in self-regulation. This view is supported by studies in which the variation in control exerted is predicted by the variation in negative affect experienced (see Inzlicht, Bartholow, & Hirsh, 2015 for a review). It also suggests that greater awareness of negative affective cues – such as that which is gained through sustained present-moment attention – may lead to greater sensitivity regarding when to engage in self-regulation. Evidence supporting this claim comes from studies showing positive
associations between present-moment attention and awareness of conflict-related negative affect (Teper et al., 2013).

Current evidence suggests that an electroencephalographic event-related potential (ERP) known as the error-related negativity (ERN) can act as an indicator of conflict-related negative affect (Aarts, De Houwer, & Pourtois, 2013; Hajcak & Foti, 2008). The ERN is routinely observed as a negative deflection in the ERP within 100ms of an error being made on a task (Yeung, Botvinick, & Cohen, 2004). A recent study focused on the relationship between awareness of affective cues, conflict-related negative affect (measured as ERN amplitude) and performance on an executive control task (Saunders, Rodrigo, & Inzlicht, 2016). Participants provided baseline data on a Go/NoGo task—a standard measure of inhibition—and were subsequently randomised to either an emotion-focused or a thought-focused guided meditation condition. The emotion-focused guided meditation instructed participants to pay attention to their affective experience. The thought-focused meditation instructed participants to consider what they were thinking about at any given moment. When changes in performance on the Go/NoGo task from baseline to post-meditation were analysed, it was found that those in the emotion-focused condition showed greater ERN amplitude increases than those in the thought-focused condition and this was suggested to indicate greater awareness of conflict-related negative affect. Furthermore, while the thought-focused group responded faster and committed more errors at post-test compared to baseline, the emotion-focused group responded slower following the meditation and maintained their accuracy, suggesting a more controlled approach to the task (Saunders et al., 2016).

Apart from facilitating the initial engagement of self-regulation, it has also been suggested that present-moment attention might specifically facilitate the executive functions responsible for the updating of working memory and switching between working memory representations (Gallant, 2016). Maintaining attention to the present moment should lead to continuous updating of the thought-action representations which make up the contents of working memory as greater attention to current experience
should result in the noticing (and mental representation) of events which may have been overlooked previously (Bishop et al., 2004). Shifting is also an important part of maintaining present-moment attention as this process must be engaged to redirect attention when the mind wanders away from current experience (Teper & Inzlicht, 2013). Few studies examine both mindfulness and executive functioning at the facet-level in order to determine the specific relationships between them so there is currently no strong evidence to support these specific claims. However, there have been studies which have focused on mindfulness as a higher-level unitary construct and its relation to both updating and shifting.

Studies on the relationship between mindfulness and the ability to shift between thought-action representations in working memory have had mixed results. Chambers, Lo and Allen (2007) examined the effects of self-reported increases in mindfulness following a 10-day mindfulness retreat and found that improvement in switching performance was significantly correlated with increases in the tendency to employ mindful attention. Compared to a control condition, this experimental group showed improvement on the Internal Switching task, which measures shifting between responding to positive and negative affective words (Chambers, Lo, & Allen, 2007). Using the Attention Network Task, Jha and colleagues (2007) found that participants in a MBSR course showed improved attention shifting ability compared to those in a waitlist control group. Hodgins and Adair (2010) found that participants in a mindfulness training group performed better than those in a control group on a task requiring participants to shift between visual perspectives. However, null findings have been reported in other studies. For example, Lykins, Baer and Gottlob (2010) found no differences between novice and experienced meditators on the Color Trails test, and Anderson and colleagues (2007) found that participants randomised to an 8-week Mindfulness-Based Stress Reduction course did not show any greater improvement in shifting performance than a waitlist control group did.
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Fewer studies have focused on the effects of mindfulness on working memory updating. In a study that compared mindfulness training with an active control-group, working memory capacity showed improvement in the mindfulness group, as indexed by both the forward/backward digit span of the Wechsler Adult Intelligence Scale and the n-back task (Zeidan, Johnson, Diamond, David, & Goolkasian, 2010). Other studies have focused on the effects of mindfulness on the related construct of working memory capacity - an indicator of the amount of information an individual can maintain in working memory, which reliably contributes to effective updating (Ecker, Lewandowsky, Oberauer, & Chee, 2010). One study compared military personnel who received mindfulness training to both military and civilian control groups on an operation span task which assesses the limits of working memory capacity (Jha, Stanley, Kiyonaga, Wong, & Gelfand, 2010). On average, both of the military groups decreased significantly in their performance compared to the civilian control group, in which performance remained stable. However, evidence was presented for an improvement in working memory capacity for those in the mindfulness group who were considered to have engaged in a “high” amount of practice (based on a median split) in comparison to the “low” practice group and the military control group (Jha et al., 2010).

A study by Mrazek and colleagues (2013) provides more rigorous evidence that present-moment attention in particular may facilitate greater operation span performance. Participants were randomised to either a mindfulness training condition or an active-control condition which consisted of classes about nutrition. Both groups attended the same amount of classes over the course of two weeks. Before and after the intervention, participants completed an operation span task and a retrospective self-report measure of whether their attention was focused on the task or not. Those in the mindfulness group were found to have improved their operation span performance to a greater extent than those in the control group and to have also maintained their attention on the task to a greater extent. Mediation analyses showed that the improved operation span performance for the mindfulness group could be accounted for by their increase in task-relevant
thought, which suggests a direct relationship between attention to the present moment and working memory operation (Mrazek, Franklin, Phillips, Baird, & Schooler, 2013).

To briefly summarise, there is support for the idea that present-moment attention facilitates the initial engagement of self-regulation and, potentially, the operation of the underlying processes of working memory updating and shifting. However, greater awareness of affective signals can also have negative outcomes. For example, anxious individuals tend to pay close attention to the present moment and demonstrate keen awareness of affective cues (Eysenck, Derakshan, Santos, & Calvo, 2007). In turn, this can lead to elaborative processes such as worry and rumination (Watkins, 2008). To gain a fuller understanding of how mindfulness relates to self-regulation, the cognitive processes involved in cultivating a non-reactive orientation to experience must be considered.

When engaging in mindfulness, cultivating an orientation of non-reactivity to experience involves learning to “create a space between thoughts and reactions to them” (Anicha et al., 2012, p. 257). In terms of cognitive processes, this requires the override of automatic urges to cognitively elaborate upon the somatic features of affective experience and therefore specifically involves the engagement of inhibition (Bishop et al., 2004; Desrosiers, Vine, Curtiss, & Klemanski, 2014). This means that in order to be accepting of our experience, it is necessary to interrupt our natural tendency to challenge, suppress or elaborate upon our feelings. In the terminology of self-regulation research, the “goal” of this component of mindfulness is the acceptance of sensations, thoughts and emotions. This goal conflicts with our automatic tendency towards cognitive reactivity in response to thoughts and other stimuli which provoke an affective response (Ostafin, 2015). When an individual engaging in mindfulness notices this conflict, then this should act as a signal to inhibit the prepotent reactivity response (Lee & Chao, 2012). This allows a more open and receptive orientation to experience as cognitive resources are not used up by elaborative processes. This may in turn support the maintenance of present-moment attention as attention can be directed towards ongoing experience.
and affective cues rather than elaborative processes (Teper et al., 2013). Evidence to support this view was put forward by Teper and Inzlicht (2013) in a study which again focused on the ERN. Teper and Inzlicht (2013) found that expert meditators exhibited significantly greater ERN amplitudes and fewer errors (indicating better inhibitory control) than novice meditators during performance on a Stroop task. They also found a significant positive correlation between the tendency towards an accepting orientation to experience and ERN amplitude. Based on further mediation analyses, the authors concluded that experience with meditation led to a more accepting orientation to experience and that the extent to which this orientation was applied accounted for individual differences in inhibitory control (Teper & Inzlicht, 2013).

The distinction between the specific effects of present-moment attention and non-reactivity to experience on self-regulation, and its underlying executive functions, and the importance of their interaction has been linked to dual-process theories of cognition by Desrosiers and colleagues (2014). They suggest considering the difference between engaging in reactive present-moment attention and engaging in non-reactive present-moment attention. They suggest that people who react immediately (i.e. through Type-1 processes) to whatever they have just paid attention to are more likely to elaborate upon this reaction. This is similar to the rationalisation process described in the Three-stage Model of Analytic Engagement (Pennycook et al., 2015) presented earlier. For example, if someone immediately responds to an event with a feeling of anxiety, they are likely to explore the reasons which justify their anxiety – an elaborative process that can be simply referred to as worry (Mathews, 1990; Watkins, 2008). On the other hand, a person who engages in non-reactive present-moment attention, is likely to pause after noticing the initial pang of anxiety (i.e. noticing the signal of need for self-regulation and engaging inhibition of elaborative processing) which opens the possibility for alternative responses (i.e. as provided through Type-2 cognitive simulation processes; Desrosiers et al., 2014). This interpretation of the relationship between mindfulness and self-regulation has not been widely tested but is supported by individual
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differences studies which have examined the interaction between tendencies towards present-moment attention and tendencies towards non-reactivity. For example, in a clinical sample, higher levels of observing predicted fewer symptoms of depression and anxiety only in those who also were high in non-reactivity. Furthermore, conditional indirect effects were found such that these decreases in depression symptoms were attributed to decreases in rumination while the decreases in anxiety symptoms were attributed to decreases in rumination and worry (Desrosiers et al., 2014). This suggests that, through their tendency towards non-reactivity, these individuals inhibited these elaborative processes (Bishop et al., 2004; Tran et al., 2013).

It has been suggested that regularly inhibiting automatic responses while engaging in mindfulness may translate into a general enhancement of inhibitory capacity (Gallant, 2016). As mentioned in Chapter 1, in research on how mindfulness relates to the executive functions, the most consistent positive relationships are found between mindfulness and inhibition. For example, mindfulness practice over a 6 week period improved performance on a backward inhibition task (Greenberg, Reiner, & Meiran, 2012b) and 8 sessions of mindfulness-based cognitive therapy improved performance on the Hayling task (Heeren et al., 2009). Studies employing the Stroop task have found better performance in experienced meditators than novices (Chan & Woollacott, 2007), after a 15 minute mindfulness meditation (Wenk-Sormaz, 2005) and following a 6-week mindfulness training (Allen et al., 2012). However, one study reported no improvement in Stroop performance after an 8-week Mindfulness-based Stress Reduction program (Anderson et al., 2007).

In summary, the component processes of mindfulness, present-moment attention and non-reactivity to experience, each contribute to the enhancement of self-regulation through their respective relations to the engagement of executive control and the operation of specific executive functions (see Figure 2.3 for a graphical representation). These relationships are consistent with dual-process theories of cognition and suggest that mindfulness may facilitate the engagement of adaptive Type-2 processes.
The next section will consider whether mindfulness might facilitate the application of critical thinking in a similar way.

![Figure 2.3. Theoretical model of relationships between facets of mindfulness and the executive functions which underlie self-regulation](image)

**2.7 Mindfulness and Critical Thinking**

The aim of this thesis is to examine claims made by researchers, practitioners, commercial and non-profit organisations and governments regarding the supposed beneficial effects of mindfulness practice to the execution of everyday thinking skills. Chapter 1 summarised the history, nature and currently known effects of mindfulness and in doing so demonstrated a dearth of research examining claims that cultivating mindfulness improves thinking skills. Chapter 2 has focused on how we can operationalise everyday thinking skills as critical thinking and measure this, how self-regulation supports critical thinking and how cultivating mindfulness may in turn support self-regulation. This implies a theoretical framework of the relationships between mindfulness, self-regulation and critical thinking which can be tested. For example, Figure 2.4 displays how mindfulness and self-regulation can be connected to the Three-stage model of Analytic Engagement. Unfortunately, there have been no studies directly testing the effects of mindfulness on critical thinking to date. This section will review the limited amount of studies which have examined the effects of mindfulness on thinking skills related to critical thinking. These studies have produced mixed results. Therefore, suggestions that mindfulness may hinder (or at least not affect) critical thinking must be borne in mind.
Figure 2.4. Theoretical model of the relationships between mindfulness, the executive functions which underlie self-regulation and critical thinking.
While no studies have directly assessed the effect of mindfulness to responses on critical thinking measures, the relationships between mindfulness and related higher-order thinking skills have been examined. These related outcomes include cognitive rigidity (Greenberg, Reiner, & Meiran, 2012a) insight problem-solving (Ostafin & Kassman, 2012), creative thinking (Lebuda, Zabelina, & Karwowski, 2016), and biased thinking (Hafenbrack et al., 2013; Hopthrow et al., 2016). These outcomes are related to critical thinking insofar as they also involve choosing the correct thinking strategy to perform well on their respective measures and each can be considered to rely on Type-2 processing due to their reliance on working memory resources. In line with the theoretical model presented in Figure 2.4, several studies found positive effects of mindfulness on the thinking skills outlined above and their authors suggested the inhibition of automatic thinking processes as a possible underlying mechanism, without directly testing this hypothesis.

Thus far, claims suggesting that cultivating mindfulness leads to improved thinking skills have been given the benefit of the doubt. Before considering in detail the studies that have focused on the relationships between mindfulness and various higher-order thinking skills related to critical thinking, it is important to emphasise that it is an open question as to whether mindfulness facilitates critical thinking or not. In fact, some suggest that cultivating mindfulness may even be a hindrance to effective critical thinking. This is due to the emphasis placed on developing skill in acceptance and non-elaborative, or non-reactive, processing in learning mindfulness (Brendel 2015). Critical thinking fundamentally involves not accepting information without question (Facione, 1990). It is currently unclear whether or not the kind of accepting orientation to experience developed while cultivating mindfulness leads to a tendency to accept information without question. As discussed earlier, the cognitive processes underlying the mindful accepting of experience involve the inhibition of elaborative processes. It is assumed that it is the elaboration of affective information alone which is inhibited (Teper et al., 2013). However, if the elaboration of more complex information (e.g. Type-1 responses through
cognitive simulation) is also inhibited, then critical thinking may be hindered as a result.

Studies of the relationship between mindfulness and creative thinking have focused on three different aspects of creativity: cognitive rigidity, insight problem-solving and divergent (as opposed to convergent) thinking. Cognitive rigidity refers to the tendency to persevere with behavioural strategies which have proven useful in the past even when they are no longer useful in current circumstances. Rigidity tends to prevent individuals from considering better alternative behavioural strategies (Ostafin, 2015). This is sometimes referred to as the Einstulling effect (Greenberg et al., 2012a). A study by Greenberg and colleagues (2012a) examined whether expert mindfulness practitioners differed from novices in cognitive rigidity and whether novices who had just completed an 8-week mindfulness training program differed from novices in a waitlist-control group. Rigidity was assessed using a water jar task where participants had to use three differently sized (and hypothetical) jars to obtain a specific quantity of water. On initial trials a complex formula had to be followed to complete the task. On random later trials, a simpler solution was possible. On these critical trials, expert meditators were found to have persisted with the complex approach to a lesser extent than novices, with a large effect size found. As discussed in Chapter 1, it is impossible to ensure that any difference between expert and novice practitioners of mindfulness is solely due to their differing amount of practice. There may be other individual differences that contribute to both the amount of mindfulness practice individuals have engaged in and the outcome of interest (Davidson & Kaszniak, 2015). This problem was addressed to an extent by Greenberg and colleagues’ test of the effects of an 8-week mindfulness training intervention on cognitive rigidity in novice mindfulness practitioners in comparison to those of a waitlist control condition. A significant group difference of medium effect size was found. Lower rigidity scores were observed for those in the training group in comparison to those in the control group. However, it must be noted that comparisons to waitlist control groups tend
to produce an exaggerated effect size as non-specific intervention effects are not controlled for (Furukawa et al., 2014).

Insight problem-solving tasks are similar to those focusing on cognitive rigidity since they involve the presentation of situations where the solution is actually blocked by past experience. These problems require restructuring and because they tend to produce a solution that appears suddenly in consciousness, they are said to be experienced as insights. Ostafin and Kassman (2012) found that dispositional mindfulness, as assessed by the Mindful Attention Awareness Scale which focuses solely on the present-moment attention facet of mindfulness, was positively related to insight problem-solving ability across two separate samples. Participants from one of these samples were randomly assigned to a mindfulness condition, consisting of a short guided meditation focusing on bodily sensations, or a control condition in which they listened to an audio excerpt about history. This experiment showed that the mindfulness group performed better on average than the control group and that this effect was partially mediated by increases in state mindfulness. This benefit of increased state mindfulness for insight problem-solving was later replicated (Walsh, 2013). Interestingly, neither trait nor state mindfulness was found to improve performance on two analytic problem-solving tasks which were also presented (Ostafin & Kassman, 2012). These tasks did not require generating a non-obvious way of structuring the problem as they could be solved in a linear, logical manner. Nonetheless they are analytic problems which would have depended on working memory resources (Schooler, Ohlsson, & Brooks, 1993). This result suggests that mindfulness may facilitate the inhibition of Type-1 responses in tasks which are structured so that the Type-1 response is dominant (i.e. where a habitual response is hindering performance) but might not be useful in solving analytic problems which do not trigger a strong pre-potent response (i.e. where there is no habitual response to influence performance).

Studies on divergent thinking focus on the extent to which individuals are able to generate many ideas in response to situations where many different responses can be correct. Problems for which there is just
one correct answer are said to require convergent thinking. A pair of studies by Colzato and colleagues focused on how different types of meditation influence convergent and divergent thinking. In a within-subjects design, participants were asked to follow a guided focused attention meditation – which focuses on present-moment observation of bodily sensations and breath – and a guided open-monitoring meditation – which focuses on considering thoughts and emotions in a non-reactive manner (Colzato, Ozturk, & Hommel, 2012). They then completed the alternate uses task, which measures divergent thinking by asking participants to name as many ways of using a common object as possible, and the remote associates task, which requires participants to find the one word which connects three seemingly disparate words. Following the focused attention guided meditation, performance on the divergent and convergent thinking tasks did not differ from baseline performance. Significantly better performance was observed following the open-monitoring meditation for the divergent thinking task in compared to the baseline and focused attention meditation conditions. However, open-monitoring meditation did not appear to affect convergent thinking (Colzato et al., 2012). A later study followed the same design with the addition of also investigating whether meditation expertise moderated the effects. The same pattern of results was found and it was stable across both novice and expert meditator groups (Colzato, Szapora, Lippelt, & Hommel, 2014). The authors suggested that open-monitoring meditation facilitated what they called a “distributed” state of executive control which allowed a broad search of associative memory when completing a divergent thinking task. This interpretation suggests that a mindfulness meditation which focused on cultivating non-reactivity to experience led to a weaker state of executive control than was present at baseline. The authors supported this assertion with data showing that, after open-monitoring meditation, expert meditators self-reported relying significantly more on intuition in the convergent thinking task (Colzato et al., 2012, 2014).
While these results do show that more alternate responses are generated by participants following an open-monitoring, it is difficult to infer exactly why that may be. Recent evidence has countered the idea that divergent thinking relies on weak executive control and has suggested that divergent thinking relies on working memory and cognitive simulation processes, in a similar way to analytic thinking but with a different goal in terms of the information searched for in declarative memory (Atchley, Strayer, & Atchley, 2012; Barr, Pennycook, Stolz, & Fugelsang, 2015; Beaty & Silvia, 2012; Nusbaum & Silvia, 2011). A similar view of insight problem-solving is emerging (Gilhooly & Fioratou, 2009; Macchi & Bagassi, 2012).

As referred to earlier in this chapter, one approach to assessing rationality in participants is to present them with tasks which are designed to elicit known cognitive biases and assess whether they can avoid thinking in a biased manner. Just four studies have examined the effects of mindfulness on cognitive biases in healthy participants. Three of these studies focused on cognitive biases which affect social judgments. These included intergroup bias (Tincher, Lebois, & Barsalou, 2016), correspondence bias (Hopthrow et al., 2016), implicit race bias and implicit age bias (Lueke & Gibson, 2015). Each of these studies demonstrated a lower tendency towards biased responding in groups which followed a brief guided meditation in comparison to control conditions. Another study focused on the sunk-cost bias, which is more directly linked to critical thinking (Butler, 2012; West et al., 2008). The sunk-cost bias refers to the tendency to persist with a course of action, despite the availability of better options, due to previous investment of resources (e.g. time, money, effort). Hafenbrack and colleagues hypothesised that mindfulness meditation should reduce the sunk-cost bias through the inhibition of elaborative process regarding the past and future (and a subsequent reduction in negative affect; Hafenbrack et al., 2013). Those who fall prey to the sunk-cost bias give undue weight to the loss of resources previously committed and to the regret they anticipate in relation to abandoning their current actions. They fail to reflect on their situation, weigh up the evidence regarding their options and decide to act in
the way which will provide the most desirable outcome. In this way, it is a failure of critical thinking (Stanovich & West, 2008). Across three experiments, participants who followed brief guided mindfulness meditations showed lower tendencies to commit the sunk-cost bias when presented with relevant situations than participants who followed a mind-wandering induction. Evidence was also found for a reduction in thoughts about the past or future (as directly self-reported by participants) and a reduction in negative affect, both of which mediated the relationship between assignment to the mindfulness condition and avoiding the sunk-cost bias (Hafenbrack et al., 2013). It should be no surprise then that when claims regarding mindfulness and thinking skills are made, this study tends to be cited most often.

To sum up, since the components of mindfulness appear to facilitate the conflict monitoring processes which initiate self-regulation and the executive sub-processes which underlie self-regulation, it is possible that mindfulness may facilitate Type-2 processes which depend on effective self-regulation, including critical thinking. While many claims have been made to this effect, no studies have directly examined the relationship between mindfulness and critical thinking. Surveying the limited studies available which focus on whether mindfulness facilitates higher-order cognitive processes related to critical thinking reveals a mixture of positive and negative findings. However, since there is considerable heterogeneity in the research designs employed and the types of measures used to assess higher-order cognition, it would be unwise to infer anything except that research directly assessing claims regarding mindfulness and critical thinking is needed. The next section describes a series of studies carried out in order to address this need.
2.8 An Overview of the Studies in the Present Thesis

The following studies were conducted in order to examine claims regarding the supposed benefits of mindfulness for critical thinking.

Study 1

In this study, 178 university students were asked to complete measures of dispositional mindfulness, executive function and critical thinking. In order to gain a fine-grained analysis of the relationships between these constructs, structural equation modelling was employed. Specifically, this study focused on how individual differences in dispositions towards present-moment attention and non-reactivity to experience related to variation in performance on behavioural tasks assessing aspects of executive functioning (i.e. working memory updating, shifting and inhibition) and critical thinking. Structural equation modelling was the ideal analytic approach as it allowed the use of latent variables to reduce measurement error and the test of a multiple mediation model which represented hypotheses regarding indirect effects of the components of mindfulness on critical thinking through the executive functions. For a full description of this study and its results, see Chapter 3.

Study 2

This study focused on the effects of a single brief guided mindfulness meditation on executive functioning and critical thinking, in comparison to those of an active-control condition. 56 university students were randomly assigned to either listen to a 10-minute guided meditation focusing on mindfulness of the breath or a 10-minute sham meditation which did not give any specific instruction regarding how to pay attention. This experiment had a mixed factorial design such that changes in performance on the executive function and critical thinking tasks from baseline to follow-up were examined as a function of group assignment using 2 X 2 mixed ANOVAs. Mediation analyses examined whether there was an indirect effect of assignment to the mindfulness group on critical thinking through performance on the executive functioning task. Moderation analyses explored whether individual differences in dispositional
mindfulness and thinking dispositions (actively open-minded thinking and need for cognition) modulated the effects of group assignment on critical thinking. For a full description of this study and its results, see Chapter 4.

Study 3

This study was a pre-registered randomised-controlled trial of the effects of an online mindfulness intervention on executive function, thinking dispositions (actively open-minded thinking and need for cognition) and critical thinking. 91 university students were randomly allocated following screening to either a mindfulness meditation group or a sham meditation group. Both the researchers and the participants were blind to group allocation. The intervention content for both groups was delivered through the Headspace online application, an app which provides guided meditations to users. Both groups were requested to complete 30 guided meditation sessions across a 6-week period. Primary outcome measures assessed mindfulness, executive functioning, critical thinking, actively open-minded thinking and need for cognition. Secondary outcome measures assessed wellbeing, positive and negative affect, and real-world outcomes. Measures were completed before and after the intervention and changes across time and group were assessed using a series of 2 X 2 mixed ANOVAs. In addition, mediation analyses assessed whether there was an indirect effect of group assignment on critical thinking through performance on the executive functioning task. Moderation analyses examined whether the effect of the intervention depended on baseline thinking dispositions. For a full description of this study and its results, see Chapter 5.
Chapter 3

Study 1: Structural Relations between Mindfulness, the Executive Functions and Critical Thinking

3.1. Introduction

As described in Chapter 2, mindfulness can be conceptualised as consisting of two component processes: present-moment attention and non-reactivity. Furthermore, each of these processes relate to the executive functions underlying self-regulation – updating, inhibition and shifting – in specific ways. These executive functions are necessary for the successful engagement of Type 2 processes. Mindfulness has shown some positive associations with other higher-order thinking skills which also depend on executive functioning such as insight problem-solving (Ostafin & Kassman, 2012), creative thinking (Colzato, Ozturk, & Hommel, 2012; Colzato, Szapora, Lippelt, & Hommel, 2014) and avoidance of the sunk-cost bias (Hafenbrack, Kinias, & Barsade, 2013). Each of these studies emphasised the non-automatic orientation to experience that mindfulness brings and which is characteristic of the engagement of executive functioning and Type-2 processing but they did not examine whether executive functioning mediated the effect of mindfulness on these cognitive outcomes.

As a first step towards addressing this gap in the research, this study tested whether executive functioning mediates the relationship between dispositional mindfulness and critical thinking in the context of a cross-sectional individual differences design. The current study focused on university students and examined the relationship between dispositional mindfulness as measured using a short form of the Five Factor Mindfulness Questionnaire (Bohlmeijer, ten Klooster, Fledderus, Veehof, & Baer, 2011), performance on executive functioning tasks assessing updating, inhibition and shifting (Del Missier et al., 2010; Miyake et al., 2000), and critical thinking performance assessed using the Halpern Critical Thinking Assessment (Halpern, 2010).
In light of the available evidence, several specific predictions can be made about how components of mindfulness, executive functioning and critical thinking are related. The current study adopted a multiple indicator individual differences study approach to test the following hypotheses using structural equation modelling:

1. First, it is hypothesised that the measurement model for mindfulness will support the two-component conceptualisation of mindfulness with observing representing present-moment awareness and non-reactivity representing non-reactive monitoring of one’s ongoing experience.

2. Second, it is hypothesised that the measurement model for executive functioning will support the three-component unity/diversity model which proposes that updating, inhibition and shifting are related but distinct components of executive functioning.

3. Third, it is hypothesised that present-moment awareness and non-reactivity will be positively associated with critical thinking performance. Notably, present-moment mindful awareness, often referred to as observing, has been associated with an enhanced ability to pick up relevant information (Carson & Langer, 2006), whereas non-reactivity has been shown to interrupt the biasing of information processing by both emotional state (Kiken & Shook, 2011) and temperament (Feltman et al., 2009). Using appropriate information free from bias is vital for effective critical thinking (West et al., 2008). Therefore, we predict that higher scores on self-reported measures of both observing and non-reactivity will predict higher critical thinking performance.

4. Fourth, it is hypothesised that self-reported observing or present-moment attention will be positively related to the ability to a) update the contents of working memory, b) shift between different working memory representations, and c) inhibit prepotent responses. Notably, previous research has linked greater skills of observation with better inhibitory control performance (Schmertz, Anderson, & Robins, 2009)
and with better performance on tasks requiring participants to switch flexibly from one thought to another (Chambers et al., 2007). Higher self-reported observation skills have also been found to predict better performance on measures of working memory updating (Anicha et al., 2011).

5. Fifth, it is expected that non-reactivity will be positively related to inhibition and shifting. Non-reactivity has been associated with both behavioural and electrophysiological indicators of inhibition (Teper & Inzlicht, 2013) and greater cognitive flexibility (Anicha et al., 2011).

6. Sixth, it is expected that updating, shifting and inhibition will be positively related to critical thinking. Critical thinking may be most effective when information held in working memory is efficiently updated as new information is presented, when switching from one perspective to another is efficient, and when heuristic and biased responses and distractions are inhibited (Sanz de Acedo Lizarraga et al., 2012; West et al., 2008).

7. Finally, it is expected that the relationship between mindfulness and critical thinking will be mediated by executive functioning. To date no research has investigated the mechanisms by which mindfulness might facilitates critical thinking skills. In light of theoretical work in the dual-processing tradition and research on mindfulness, self-regulation and higher-order thinking skills, executive functioning is proposed as a key mechanism driving this relationship. Establishing a mediational relationship between mindfulness, executive functioning and critical thinking is necessary in order to support this proposition that the engagement of executive functioning is a mechanism through which mindfulness facilitates critical thinking performance (Hayes, 2014).
Figure 3.1. Hypothesised structural model of the relationships between facets of mindfulness, executive functions and critical thinking.
3.2 Methods

Participants

178 university undergraduate psychology students (Mean age = 21.04; SD = 5.77; 39 males; 139 females) attending the National University of Ireland, Galway, participated in the study. A priori calculations using Soper's (2014) Structural Equation Modelling sample size calculator suggested a minimum sample size of 156 was required for analysis to yield adequate power to detect model structure and a sample size of 403 was needed to detect effects of a small-medium size (.2). This was based on a model including 6 latent predictor variables, 20 observed variables and a desired power level of .8 at a probability level of .05. Participants were recruited by email and an online participant recruitment system. They were awarded credit as part of their course requirement. Participant were over 18 and were required to have English as their first language or university level English (i.e. equivalent to 80 on the Test of English as a Foreign Language (TOEFL) or 6.5 on the International English Language Testing System (IELTS); both are recognised tests of English as a foreign language). Exclusion criteria included those with alcohol and drug dependency (including prescribed sedation medications) and those with visual and hearing impairments not corrected to normal (as required for the computer tasks). This study was given ethical approval by the NUIG Research Ethics Committee.

Study Design

The study employed a cross-sectional, individual differences design to examine the relationships between the observing and non-reactivity components of mindfulness, the updating, shifting and inhibition components of executive functioning and critical thinking skills. Structural Equation Modelling (SEM) was used to test the model of specified relations between mindfulness, executive functioning and critical thinking. SEM allows for multiple hypotheses to be tested simultaneously. SEM is best suited to test hypotheses patterns of
direct and indirect relationships between theoretical concepts which contain observed and latent variables (MacCallum & Austin, 2000). In assessing executive functioning, a latent variable approach is best as it resolves the task impurity problem. This is a problem inherent in using individual executive functioning tasks where non-executive processes contaminate the examination of executive processes (Miyake & Friedman, 2012; Miyake et al., 2000). The latent variable approach allows identification of how performance on multiple exemplar tasks is statistically shared (in this case the executive process), thus giving a truer measure of the construct underlying these tasks which can then be related to a target manifest variable, in this case critical thinking (Del Missier et al., 2010). This means that two tasks for each of updating, switching, and inhibition were used in this study in order to compute latent variables for each executive function. This approach has been used previously, for example, to investigate the role of in executive functioning in decision-making (Del Missier et al., 2010) and fluid intelligence (Friedman, Miyake, Corley, Young, & DeFries, 2006).

**Measures**

All computer tasks were conducted on a Dell computer with a 15in LCD monitor. The executive functioning tasks were administered using the MATLAB software programme which recorded reaction times and error commission.

Five Facet Mindfulness Questionnaire short form (FFMQ-SF; Bohlmeijer et al., 2011)

The FFMQ-SF is a 24 item measure consisting of five subscales (observing, describing, acting with awareness, non-judging of inner experience, and non-reactivity to inner experience). The FFQM-SF employs a 5-point Likert scale (e.g. 1 = never or very rarely true; 5 = very often or always true). For the purpose of the current study, the scores obtained for the observing and non-reactivity facets were the main focus. This multi-facet scale includes four
observing items (e.g. “I pay attention to sounds, such as clocks ticking, birds chirping, or cars passing”) and five non-reactivity items (e.g. “I perceive my feelings and emotions without having to react to them”). The current study used non-reactivity and observing sub-scales to measure mindfulness, as these are the most widely agreed upon components of mindfulness analysed in the empirical literature (Anicha et al., 2011). The non-reactivity sub-scale showed good reliability ($\alpha = .72$) as did the observing sub-scale ($\alpha = .71$).

**Executive functions measures**

Six executive tasks were administered to all participants to assess the three core components of EFs; *Shifting*, *Updating* and *Inhibition*. For all tasks, participants were asked to respond as quickly and accurately as possible. The dependent variables for each task were the proportions of accurate responses. We followed Miyake and colleagues (2000) in using these dependent measures for all but the switching tasks. While switch costs are often examined in terms of reaction time, it is not uncommon to examine accuracy costs in terms of the proportion of accurate responses on switch trials (Sy, Elliott, & Giesbrecht, 2013). This method was chosen to avoid any potentially unique variance that could be attributed to reaction time and in light of evidence that reaction time switch costs may not necessarily reflect executive processes (Logan & Bundesen, 2003).

The following two tasks were used to measure *Shifting*:

**Plus-minus task:** The plus-minus task (Jersild, 1927; Spector & Biederman, 1976; adapted by Miyake et al., 2000) consists of 3 blocks in which 30 two-digit numbers are presented. In the first block participants are required to add 3 to each number. In the second block they are required to subtract 3 from each number. In the final block participant are required to alternate between adding 3 and subtracting 3 from each number (i.e. add 3 from the first number, subtract 3 from the next number and so forth). The proportion of accurate responses on switch trials was the dependent variable.
**Number-letter task:** The number-letter task (Miyake et al., 2000) is presented in 3 blocks. In the first block (32 trials), number-letter pairs are presented in the top two quadrants of a square grid on a computer screen. The participant is instructed to indicate whether the number is odd or even. In the second block (32 trials), the number-letter pair is presented in the bottom quadrants of the grid. In this block, the participants are instructed to indicate whether a letter is vowel or consonant. In the final block, number-letter pairs are presented in all quadrants of the grid. When they appear in the top quadrants, participants have to indicate whether the number is odd or even, and when they appeared in the bottom quadrants they had to indicate if a letter is a vowel or a consonant. Therefore, in the third block, half of the trials require the participant to shift between the two types of categorisation. The dependent measure was the proportion of accurate responses on switch trials.

The following two tasks were used to measure *Updating:*

**Tone monitoring task:** In the tone monitoring task (Miyake et al., 2000) participants are presented with 25 tones of low, middle and high frequency which are delivered over four trial blocks. The tones are presented for 500ms each with an interval of 2500ms. Each trial block consist of 8 high-pitched tones (880Hz), 8 medium-pitched tones (440Hz) and 8 low-pitched tones (220Hz), with the addition of 1 tone selected randomly from the other three for a total of 25. There were 4 blocks and 6 potential correct answers per block. Whenever one of the tones was played for the fourth time, the participant had to respond by pressing the corresponding key - 1 for low, 2 for medium and 3 for high - while maintaining a count of the occurrences of the other tones in working memory. In order to avoid the impact of momentary mental lapse on task performance the tone count for each pitch automatically resets to 0 after incorrect responses. A different error tone would be heard on this occurrence. The dependent measure was the proportion of correct responses.
**Letter-memory task:** The letter-memory task (Miyake et al., 2000) involves constantly updating a series of letters in working memory. A series of letters are presented in succession in each trial for the duration of 2000ms per letter. Participants are required to rehearse the last 4 letters presented in the list, and then report the last four letters in the series at the end of each trial. The number of letters presented (5, 7, 9, or 11) varied randomly across trials to avoid habituation to trial length. The dependent measure is the proportion of correctly recalled letters.

The following two tasks were used to measure *Inhibition:*

**Anti-saccade task:** The anti-saccade task (Kane, Bleckley, Conway, & Engle, 2001) requires participants to detect a sudden-onset visual cue and use that cue to direct their attention to a specific location that will contain a target stimulus. In the first block the cue appears in the same location as the target. In the second block the cue appears on the opposite side to the target. In this block when the cue predictably signals a location that does not contain the target, participants must voluntarily redirect their gaze from the cue to the target, ignoring the salient cue, and respond to the target. Participants must therefore maintain their goal (i.e. response to target) despite interference. The dependent measure was the proportion of correctly identified targets.

**Stop-signal task:** The stop-signal task (Miyake et al., 2000) requires inhibition of a learned response. This task is presented in two blocks. In the first block participants are presented with 24 words one-by-one (e.g. duck, gun), they are instructed to indicate if the word was an animal or not by means of button presses (i.e. left = animal, right = not). In the second block participants were instructed not to respond when they heard a tone. If no tone was played they were required to respond as they did in the first block. In all trials a fixation point appears on the screen 500ms prior to the presentation of the stimulus and participants are given up to 1500ms to make their response. The dependent measure was the proportion of correctly withheld responses for the stop trials.
Halpern Critical Thinking Assessment (Halpern, 2010)

The Halpern Critical Thinking Assessment (HCTA) assesses thinking in everyday, easy to relate to scenarios. It taps both the motivational and behavioural parts of critical thinking by including both open-ended and forced choice questions (Ku, 2009). The assessment consists of 25 everyday situations that the participant must analyse and critique. Following these situations are 25 open-ended questions followed by 25 specific questions that assess the reasoning behind each answer. Across these questions five sub-categories of thinking skills must be applied including argument analysis skills, verbal reasoning skills, hypothesis testing skills, likelihood and uncertainty judgment skills and decision making/problem solving skills. There are 5 items for each sub-category of critical thinking with the maximum points possible for each sub-category varying. Scoring of the HCTA was carried out by three trained graders. The scoring guide provides answers for forced-choice questions while open-ended questions are graded according to specific grading prompts. Greater scores are awarded to more accurate and comprehensive answers and total scores can range from 0 to 194 (Halpern, 2010). The internal reliability of the HTCA was found to be adequate with a Cronbach’s alpha coefficient of .79 in this study which corresponds to robust reliability found in other samples.

Both types of question (open-ended and forced choice) included in the HCTA require type-2 processing to produce responses warranting high scores. This is because the description of each situation presented in the HCTA suggests obvious answers, which will result in lower scores. For open-ended questions, participants are rewarded for evidence of having reflected appropriately upon the given question. A high scoring open-ended answer will demonstrate that the participant (1) noticed the conflict between the simple “obvious” answer and later-occurring alternative responses, (2) sustained inhibition of the intuitive response (i.e. the obvious answer) and (3) used relevant knowledge and rules to generate an appropriate response (Bonnefon, 2016; Halpern, 2010). These are the essential stages of the three-stage model of
analytic engagement (Pennycook et al., 2015). Forced choice questions do not require the generation of alternative responses, as a range of possible responses are presented. However, conflict detection and sustained inhibition of the intuitive response are still required in order to identify and respond with the correct answer.

Procedure

All participants first completed the HCTA and the FFMQ-SF questionnaire online at a separate location (e.g. home or campus computers). The online questionnaires were administered using Survey Gizmo. At a later date, within a month of online testing, all participants were administered 6 computerized executive functioning tasks in a laboratory cubicle at the School of Psychology building at NUI Galway. Here participant consent was again obtained (following provision of informed consent online). A pseudo-random counterbalancing strategy was applied to the task order, involving 6 orders with no two orders repeating the order of consecutive pairs of tasks. This was done to keep any executive function depletion or fatigue effects constant across tasks and participants. At the end of each task participants were prompted to call the researcher, the researcher then applied the specified order when initiating the next task. The laboratory session took approximately 1 hour to complete for each participant.

Analytic Approach

The approach to analysis consisted of four stages. First, a series of measurement models were used to evaluate the mindfulness and executive functioning constructs. Second, a structural model of executive functioning and critical thinking was evaluated. Third, a structural model of dispositional mindfulness, executive functioning and critical thinking was evaluated based on the structural model established in the second stage. Finally, a multiple mediator analysis was carried out by examining the direct and indirect effects between the mindfulness factors of observing and non-reactivity, the executive
functioning factors of updating, inhibition and shifting and critical thinking in order to determine the nature of any mediation/non-mediation present.

Descriptive statistics, correlation analyses, reliability analyses and EM substitution were all carried out using SPSS 20 (IBM Corp., 2011). The fits of all CFA models and SEMs were evaluated in AMOS using the maximum likelihood technique and using fit indices recommended by Byrne (2010) and Kline (2005). The indices employed included the chi-square, the Tucker-Lewis index (TLI), comparative fit index (CFI), and the incremental fit index (IFI). A non-significant chi-square and values greater than 0.90 for the TLI, CFI, and IFI reflect acceptable fit and values above .95 suggest good fit (Byrne, 2010; Kline, 2005). In addition, the Root-mean-square-error-of-approximation (RMSEA) with 90% confidence intervals is reported, where values less than .08 reflect adequate fit with values less than .06 indicating good fit (Byrne, 2010; Kline, 2005). Akaike information criteria (AIC) is also reported when comparing two models, with smaller values representing a better fit (Byrne, 2010).

3.3 Results

A summary of the descriptive statistics for variables representing the facets of mindfulness, performance on the executive functioning tasks and critical thinking performance can be seen in Table 3.1 along with correlations between them. Most variables had relatively low values for skewness and kurtosis except for the Number-Letter, Letter Memory and Anti-saccade tasks. Arc Sin transformations, which are often employed with proportional measures, were successful in achieving acceptable kurtosis and skewness values for these measures. Due to computer program malfunctions, some participants (N = 7) did not have scores for specific executive functioning tasks. Expectation-Maximisation substitution was carried out in order to treat missing data since each of these participants only had missing scores for one particular task out of the 6 completed. The amount of missing data for each individual task was 1.1% or lower. Reliability for all measures was assessed using Cronbach’s alpha and
was adequate for all except the Stop Signal task. Correlations among the variables were consistent with previous studies (Del Missier et al., 2010; Friedman et al., 2009; Miyake et al., 2000).

Measurement Models

**Mindfulness**

The two factor model of the FFMQ-SF using sub-scales of non-reactivity and observing indicated good model fit. The chi-square test was non-significant (33.12, p = .16) with TLI (.97), IFI (.98) and CFI (.98) values all above .95 and a RMSEA value of .04 [.00 - .08]. Furthermore, all factor loadings ranged between .46 and .85. Notably, it was a much better fit than a one factor model for which the chi-square test was significant (200.161, p <.001), the TLI (.22), IFI (.43) and CFI (.42) values were all below .45 and the RMSEA value was above .08 (.19 [.00 - .08]).

Table 3.1. Descriptive statistics and correlations for mindfulness, executive functions and critical thinking

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<td>1. Non-reactivity</td>
<td>14.01</td>
<td>3.13</td>
<td>.72</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Observing</td>
<td>13.35</td>
<td>2.96</td>
<td>.71</td>
<td>.09</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Tone Monitoring</td>
<td>.29</td>
<td>.25</td>
<td>.86</td>
<td>.14</td>
<td>.24**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Stop Signal</td>
<td>.76</td>
<td>.17</td>
<td>.55</td>
<td>.00</td>
<td>.12</td>
<td>.25**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Plus Minus</td>
<td>.67</td>
<td>.32</td>
<td>.96</td>
<td>.02</td>
<td>.06</td>
<td>.35**</td>
<td>.09</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Number-Letter</td>
<td>.91</td>
<td>.13</td>
<td>.95</td>
<td>.08</td>
<td>.07</td>
<td>.28**</td>
<td>.24**</td>
<td>.20**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Letter Memory</td>
<td>.66</td>
<td>.18</td>
<td>.75</td>
<td>-.04</td>
<td>-.05</td>
<td>.17*</td>
<td>.08</td>
<td>.12</td>
<td>.06</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Anti-saccade</td>
<td>.86</td>
<td>.13</td>
<td>.91</td>
<td>-.09</td>
<td>.12</td>
<td>.42**</td>
<td>.28**</td>
<td>.27**</td>
<td>.26**</td>
<td>-.05</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

1 Means and standard deviations for untransformed variables are presented while correlations presented are between transformed variables
2 Cronbach’s alpha
Executive Function

Confirmatory Factor Analysis (CFA) was used to compare models with one, two, three or no related factors. This was done by first testing the full three-factor model and then testing the alternative models nested within the full model, achieved by fixing specific correlations among the latent variables in the following ways – for the one factor models, all correlations were fixed to 1.0, for the two factor models, the correlation between the various pairs of unitary latent variables was fixed to 1.0 while the other two were allowed to vary freely and for the model with no relationships among the three factors (i.e. independence), all correlations were fixed to zero. It was expected that the full three factor model would provide the best fit to the data. Of these possibilities, a nested 2 factor model with the covariance between the Shifting and Updating factors constrained to 1 provided the most adequate fit to the data. However, given the low factor loadings of the Plus-Minus and Number-Letter tasks on the Shifting factor, it was decided to drop the Shifting factor from further analyses. The resulting model demonstrated adequate fit with a non-significant chi-square test (3.83, p = .05), and IFI and CFI values of .95 (although the TLI value was an inadequate .67). This model had an AIC value of 21.83 and AIC values for the competing models were all worse, ranging from 36.20 for the nested 2 factor model described above to 124.23 for the 3 independent factors model.

Structural Models

Executive Function and Critical Thinking

Following Miyake and colleagues (2000), this stage involved adding critical thinking performance as a manifest variable to the executive functioning model supported in the previous stage. Potential paths from the latent variables to the critical thinking manifest variable were evaluated. Models with either two or one path(s) (i.e., paths from both inhibition and updating, or paths from either inhibition or updating) to the critical thinking manifest variable were compared to determine the paths necessary to provide the best fit to the
observed data. The two-path model fit the observed data best (see Table 3.2) and demonstrated a strong significant relationship between updating and critical thinking ($\beta = 3.25, p = .04$). In order for this model and the one-path model connecting updating and critical thinking to identify, the error variance of critical thinking was fixed to .001. This is acceptable in cases where a model will not identify due to negative error variance provided that the estimate of negative error variance is not statistically significantly different from 0 as was the case in this instance (Dillon, Kumar, & Mulani, 1987).

Table 3.2. Fit indices for structural models of executive functions and critical thinking

<table>
<thead>
<tr>
<th>Model</th>
<th>df</th>
<th>$\chi^2$</th>
<th>$p$</th>
<th>IFI</th>
<th>CFI</th>
<th>TLI</th>
<th>RMSEA</th>
<th>AIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. One Path - Inhibition</td>
<td>4</td>
<td>7.59</td>
<td>.11</td>
<td>.95</td>
<td>.95</td>
<td>.87</td>
<td>.07 [.00 - .15]</td>
<td>29.59</td>
</tr>
<tr>
<td>3. One Path - Updating</td>
<td>5</td>
<td>41.02</td>
<td>.00</td>
<td>.52</td>
<td>.49</td>
<td>-.02</td>
<td>.20 [.15 - .26]</td>
<td>61.02</td>
</tr>
</tbody>
</table>

Mindfulness, Executive Function and Critical Thinking

This stage involved adding the observing and non-reactivity facets of dispositional mindfulness as manifest variables to the model supported in the previous stage. A model with the hypothesised paths was compared against two reference structural models with one assuming no relation between both mindfulness facets and the three latent executive functioning variables and one assuming that each facet is related to each executive function. For the hypothesised model to be supported, it needed to demonstrate a better fit to the data than the model assuming no relations and the fit had to be no worse than the full path model. This analysis strategy is similar to that employed by Del Missier et al. (2010). To achieve the best possible fit, the error variances for the Tone Monitoring scores and the Letter Memory scores respectively were allowed to co-vary with the error variance for the Anti-saccade task, as suggested by the modification indices. Examination of the model fit indices demonstrated that the hypothesised model was supported (see Table 3.3).
Parameter estimates revealed a significant positive relationship between observing and inhibition and a weak but significant negative relationship between non-reactivity and critical thinking (see Table 3.4).

Table 3.3. Fit indices for structural models of mindfulness, executive functions and critical thinking

<table>
<thead>
<tr>
<th>Model</th>
<th>df</th>
<th>$\chi^2$</th>
<th>$p$</th>
<th>IFI</th>
<th>CFI</th>
<th>TLI</th>
<th>RMSEA</th>
<th>AIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Hypothesised</td>
<td>8</td>
<td>13.62</td>
<td>.09</td>
<td>.94</td>
<td>.93</td>
<td>.82</td>
<td>.06 [.00 -.12]</td>
<td>53.62</td>
</tr>
<tr>
<td>2. No paths</td>
<td>12</td>
<td>31.58</td>
<td>.002</td>
<td>.79</td>
<td>.76</td>
<td>.59</td>
<td>.10 [.06 -.14]</td>
<td>63.58</td>
</tr>
<tr>
<td>3. Full path</td>
<td>7</td>
<td>13.52</td>
<td>.06</td>
<td>.93</td>
<td>.92</td>
<td>.76</td>
<td>.07 [.00 -.13]</td>
<td>55.52</td>
</tr>
</tbody>
</table>

Multiple Mediation Model

In order to investigate whether the effects of the observing and non-reactivity facets of dispositional mindfulness on critical thinking were mediated by executive functioning, a multiple mediation analysis (MacKinnon, Fairchild, & Fritz, 2007) was carried out. Figure 3.2 displays the model which was examined. The first step in the multiple mediation analysis involved quantifying the direct effects of mindfulness on both executive functioning and critical thinking respectively. More specifically, it required examining the paths leading directly from the dispositional mindfulness facets of observing and non-reactivity to the executive functioning latent variables, and from both the mindfulness and executive functioning factors to critical thinking. Then the specific indirect effects were quantified. These are defined as the effects leading from a mindfulness factor via each executive functioning factor to critical thinking performance. Following this, the total indirect effects were calculated by summing the specific indirect effects. Lastly, the direct effect of each mindfulness factor (i.e. observing and non-reactivity respectively) on critical thinking and their corresponding specific indirect effect were summed to find the total effects. These effects were estimated, along with their 95% Confidence Intervals (CI), using bias corrected bootstrapping with 5,000 draws specified, as recommended (see Table 3.4; Kline, 2011).
The different patterns of mediation/non-mediation present can be described using an approach developed by Zhao and colleagues (Zhao, Lynch Jr., & Chen, 2010). The significance of both the indirect and direct effects were examined to determine whether meditation is present and, if it was, whether it was complementary (where both indirect and direct effects are significant and the multiplication of their estimates is positive), competitive (where both indirect and direct effects are significant and the multiplication of their estimates is negative) or indirect only (where there is no significant direct effect but the indirect effects is significant – full mediation in Baron and Kenny’s (1986) terms). It was found that for the path leading from non-reactivity to critical thinking through inhibition that there was evidence for competitive mediation since the direct effect of non-reactivity on critical thinking was significant but negative while its specific indirect effect through inhibition was significant and positive. For the path from observing to critical thinking through inhibition, evidence for indirect-only mediation was present as this specific indirect path was significant and positive but the direct path from observing to critical thinking was not significant. Since the indirect path from observing to critical thinking through updating was not significant either, updating cannot be considered a mediator of the relationship between observing and critical thinking in this model. Overall, the model explained 36.3% of the variance in critical thinking performance.
Figure 3.2. Multiple mediation model of mindfulness facets, executive functions and critical thinking with standardised direct effects and 95% Confidence Intervals (CI), using bias corrected bootstrapping for indirect effects. *$p < .05$; **$p < .01$; ***$p < .001$. 
Table 3.4. Estimates in the multiple mediation model

<table>
<thead>
<tr>
<th>Type of effect</th>
<th>$b$</th>
<th>$SE$</th>
<th>$\beta$</th>
<th>BC 95% CI</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Direct effects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Observing $\rightarrow$ Updating</td>
<td>.44</td>
<td>.53</td>
<td>.04</td>
<td>[-.33, 1.81]</td>
<td>.26</td>
</tr>
<tr>
<td>Observing $\rightarrow$ Inhibition***</td>
<td>1.77</td>
<td>.57</td>
<td>.23</td>
<td>[.65, 2.85]</td>
<td>.001</td>
</tr>
<tr>
<td>Observing $\rightarrow$ Critical Thinking</td>
<td>-.06</td>
<td>1.17</td>
<td>-.01</td>
<td>[-1.85, 1.30]</td>
<td>.92</td>
</tr>
<tr>
<td>Non-reactivity $\rightarrow$ Inhibition</td>
<td>.87</td>
<td>.53</td>
<td>.12</td>
<td>[-.11, 2.01]</td>
<td>.08</td>
</tr>
<tr>
<td>Non-reactivity $\rightarrow$ Critical Thinking*</td>
<td>-.91</td>
<td>.58</td>
<td>-.17</td>
<td>[-2.13, -.07]</td>
<td>.04</td>
</tr>
<tr>
<td>Updating $\rightarrow$ Critical Thinking***</td>
<td>.82</td>
<td>.61</td>
<td>1.47</td>
<td>[.37, 2.40]</td>
<td>.000</td>
</tr>
<tr>
<td>Inhibition $\rightarrow$ Critical Thinking**</td>
<td>.31</td>
<td>.60</td>
<td>.43</td>
<td>[.03, 1.69]</td>
<td>.009</td>
</tr>
<tr>
<td><strong>Specific indirect effects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-reactivity $\rightarrow$ Inhibition $\rightarrow$ Critical Thinking*</td>
<td>.27</td>
<td>.46</td>
<td>.05</td>
<td>[.01, 2.35]</td>
<td>.04</td>
</tr>
<tr>
<td>Observing $\rightarrow$ Inhibition $\rightarrow$ Critical Thinking**</td>
<td>.55</td>
<td>.99</td>
<td>.10</td>
<td>[.04, 2.97]</td>
<td>.009</td>
</tr>
<tr>
<td>Observing $\rightarrow$ Updating $\rightarrow$ Critical Thinking</td>
<td>.36</td>
<td>.57</td>
<td>.07</td>
<td>[-.31, 1.48]</td>
<td>.25</td>
</tr>
<tr>
<td><strong>Total indirect effects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-reactivity $\rightarrow$ Inhibition $\rightarrow$ Critical Thinking*</td>
<td>.27</td>
<td>.46</td>
<td>.05</td>
<td>[.01, 2.35]</td>
<td>.04</td>
</tr>
<tr>
<td>Observing $\rightarrow$ Inhibition + Updating $\rightarrow$ Critical Thinking</td>
<td>.91</td>
<td>1.14</td>
<td>.16</td>
<td>[-.22, 2.82]</td>
<td>.12</td>
</tr>
<tr>
<td><strong>Total effects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-reactivity $\rightarrow$ Inhibition</td>
<td>-.64</td>
<td>.38</td>
<td>-.12</td>
<td>[-1.40, .10]</td>
<td>.09</td>
</tr>
<tr>
<td>Critical Thinking</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-reactivity $\rightarrow$ Critical Thinking</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Observing $\rightarrow$ Inhibition + Updating $\rightarrow$ Critical Thinking</td>
<td>.85</td>
<td>.42</td>
<td>.15</td>
<td>[.05, 1.69]</td>
<td>.04</td>
</tr>
<tr>
<td>Critical Thinking $\rightarrow$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Note:</strong> $p &lt; .05$ ** $p &lt; .01$ *** $p &lt; .001$</td>
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</tbody>
</table>
3.4. Discussion

This study sought to investigate whether individual differences in dispositional mindfulness are associated with variation in critical thinking performance. Additionally, this study examined whether performance on executive functioning tasks assessing updating, inhibition and shifting mediates the relationship between the two facets of dispositional mindfulness and critical thinking. Relations between the observing and non-reactivity facets of mindfulness, the executive processes of updating, shifting and inhibition, and critical thinking performance were examined using SEM. This analysis revealed a number of interesting findings in relation to the specified hypotheses.

Our first hypothesis stated that the two-component model of mindfulness would be found to be a better fit than a one-factor solution. This conceptualisation made use of the observing and non-reactivity subscales of the Five Factor Mindfulness Questionnaire. These subscales represent the most supported operational definition of mindfulness and have been found to have dissociable cognitive correlates (Anicha et al., 2011). Consistent with our first hypothesis, the two-component model of mindfulness was supported and used in the subsequent SEMs.

Our second hypothesis concerned the structure of executive functions. Specifically, consistent with Miyake’s (2001) unity and diversity model of executive functioning and subsequent research supporting this (Del Missier et al., 2010; Miyake & Friedman, 2012), it was hypothesised that the measurement model for executive functioning would support a three-factor model structure which proposes that updating, inhibition and shifting are related but distinct components of executive functioning. Executive functioning was assessed using a battery of tasks measuring the skills of updating, inhibition and switching to which a latent variable analysis was applied. A two-factor solution was found to be optimal in the current study, with the updating and inhibition factors retained as the inclusion of the shifting tasks led to problems in identifying a positive definite covariance matrix. This may have been due to the ceiling effects found
for the shifting tasks in the current sample. Factor loadings were in the range reported in previous studies (Del Missier et al., 2010; Miyake et al., 2000).

The third hypothesis focused on the direct effects of mindfulness on critical thinking. It was expected that both observing and non-reactivity would be positively related to critical thinking. Results indicated no direct effect of observing on critical thinking. However, there was a positive, indirect effect of observing on critical thinking that was mediated by inhibition, suggesting that observing influences executive functioning which in turn influences critical thinking ability. This indirect effect is discussed in more detail below in regard to our final hypothesis. Converse to this hypothesis, non-reactivity was found to be significantly negatively related to critical thinking. This is an interesting finding which suggests the possible existence of mediators not accounted for by the model which may have a debilitating effect on critical thinking performance. Potential candidates include worry and repetitive thought, emotional regulation and positive mood, and non-elaborative processing. For example, mindfulness has been shown to reduce habitual worry and evidence suggests that a key mechanism underlying this is the negative relationship between non-reactivity and repetitive thought (Evans & Segerstrom, 2011). Furthermore, responsibility to continue thinking, a process underlying habitual worry, has been shown to be important for effective critical thinking (Sugiura, 2013). It is possible that in reducing repetitive thought and worry, non-reactivity could indirectly impair critical thinking performance. Similarly, as regards the possible role of emotional regulation, non-reactivity is thought to require executive control to inhibit the elaboration of acute affective cues (Teper et al., 2013), and this has been shown to result in the down-regulation of negative affect and increases in positive affect (Chambers, Gullone, & Allen, 2009). However, this pattern of emotional regulation may result in sub-optimal conditions for critical thinking performance since negative affect tends to facilitate the engagement of executive functioning and positive affect increases the probability of intuitive thinking (Bolte, Goschke, & Kuhl, 2003; Fiedler, Nickel, Asbeck, & Pagel, 2010; Inzlicht, Bartholow, & Hirsh, 2015; Teper et al., 2013). It is also possible
that the measure of non-reactivity used in the current study captures a tendency for non-elaborative processing beyond just affective cues. The questionnaire items used to assess non-reactivity focus on the ability to “let go” soon after the experience of distressing thoughts, rather than persisting with the thoughts. This dispositional tendency may lead to less cognitive effort being engaged when thinking in stressful, problem situations, which a test such as the Halpern Critical Thinking Assessment could be considered to be. Cognitive effort is vital for effective critical thinking performance (Stanovich, 2011) and it is possible that high levels of non-reactivity are associated with low levels of cognitive effort in some situations. It is possible that any one of these factors, or a combination, could account for the negative relationship found between non-reactivity and critical thinking in the current study. However, further research is needed to replicate the findings observed in the current study and examine these and other explanatory mechanisms in more detail.

The fourth hypothesis specified direct relations between observing and the executive functioning components. It was expected that observing would be positively related to updating, inhibition and shifting. Observing was not found to predict updating in the current study, and it was not correlated with shifting performance, but observing did predict inhibition as hypothesised. Much previous research has linked mindfulness skill with enhanced inhibition (Greenberg, Reiner, & Meiran, 2012b; Heeren, Van Broeck, & Philippot, 2009; Sahdra et al., 2011). Predictions of a link between observing and inhibition were based on process descriptions of mindfulness, which emphasise the inhibition of elaborative processing in order to keep one’s attention focused on observing the present-moment (Bishop et al., 2004). This is an important finding as the proposed relationship between mindfulness and inhibition is often invoked in explaining how mindfulness disrupts automatic thinking across studies of the outcomes of mindfulness (e.g. Frewen, Evans, Maraj, Dozois, & Partridge, 2007; Kang, Gruber, & Gray, 2012; Ostafin, Kassman, et al., 2013; Ostafin & Kassman, 2012). Studies have also suggested the benefits of mindfulness practice for working memory operation and the link between
observing and working memory updating has been theorised previously (Anicha et al., 2011; Jha et al., 2010; Mrazek, Franklin, Phillips, Baird, & Schooler, 2013; van Vugt & Jha, 2011). The lack of a direct relationship between observing and updating in the current study may reflect the approach the study adopted. Most studies focusing on the effects of mindfulness on working memory have involved training interventions and the only finding of a positive relationship between observing and working memory updating from a dispositional perspective may have been due to perceptual rather than executive benefits (Anicha et al., 2011). It is possible that specific mindfulness training is required in order for individual differences in working memory updating to emerge in relation to skills in observing.

The fifth hypothesis, concerning the relationship between non-reactivity and inhibition was not supported, contrary to previous findings from mindfulness training studies (Anicha et al., 2011; Teper et al., 2013). Regarding the relationship between non-reactivity and shifting, no significant relationships were observed. It is surprising to find no direct effects of non-reactivity on any component of executive functioning since the engagement of executive control to suppress the elaboration of affective cues is considered to be central to non-reactive information processing (Teper & Inzlicht, 2013). However, a recent study found a significant but small negative effect of non-reactivity on self-reported behaviour regulation, which includes items related to inhibition and shifting (Short et al., 2015). Non-reactivity skills have been shown to take longer to develop than observing skills in training studies (Lilja et al., 2012) and perhaps more explicit guidance and practice are needed to demonstrate significant links between non-reactivity and executive functioning. Furthermore, the self-report of non-reactivity outside of mindfulness training contexts may be different to the self-report of this ability after some exposure to mindfulness practices, and thus relations between mindfulness dispositions and executive functioning may differ across different study contexts (Van Dam, Earleywine, & Danoff-Burg, 2009).
The sixth hypothesis stated that the executive functioning components would each exert significant direct, positive effects on critical thinking. Consistent with our hypothesis, both updating and inhibition were significantly and positively associated with critical thinking in the final SEM model. The effect of updating on critical thinking was stronger than that of inhibition. One possible explanation for this pattern of findings is that updating is more important for sustained high level performance on the Halpern task. For instance, once the initial intuitive response to a situation in the Halpern Critical Thinking Assessment is inhibited, updating is continuously engaged as the contents of working memory are manipulated and revised and as more information is gleaned from the question. Another possibility is that the low reliability for the Stop Signal task contributed to the weaker effect of inhibition. Importantly, this is the first study to demonstrate a relationship between specific executive functions and critical thinking performance. This finding aligns with previous research suggesting the importance of working memory for effective critical thinking (Dwyer et al., 2014) and is in line with dual-process theories which emphasises the necessity of working memory operations for Type-2 processes such as critical thinking (Evans & Stanovich, 2013).

Finally, it was hypothesised that the relationship between mindfulness and critical thinking would be mediated by executive functioning. Using SEM to conduct a multiple mediation analysis, it was found that there was evidence for inhibition mediating the relationships between critical thinking and both observing and non-reactivity. The relationship between observing, inhibition and critical thinking is considered to be indirect-only mediation (or full mediation in Baron and Kenny’s (1986) terms) since no direct effect of observing on critical thinking was found. This finding suggests that the entirety of the effect of present-moment mindful observation on critical thinking is due to it being positively related to inhibition. Evidence for competitive mediation was found for the relationship between non-reactivity, inhibition and mindfulness. This means that while there was a negative direct effect of non-reactivity on critical thinking, there was a positive indirect effect of non-
reactivity on critical thinking that was mediated by inhibition. This positive indirect effect makes sense considering the fact that non-reactivity has been assumed to reduce automatic responding and promote more reflective responses (Peters, Eisenlohr-Moul, & Smart, 2015). This competitive relationship suggests the presence of additional mediators not accounted for by the model, as discussed above, which act independently of the positive indirect relationship (Zhao et al., 2010). The observation that inhibition acts as a mediator of both components of mindfulness in this model provides evidence for inhibition as a core mechanism of the effect of mindfulness on critical thinking. This mechanism has been suggested in several previous studies showing facilitative effects of mindfulness on higher-order cognition but has never been explicitly demonstrated before. This finding ties the relationship between mindfulness, executive functioning and critical thinking closely to default interventionist dual-process theories of higher-order cognition, which posits that it is through the inhibition of the prepotent tendency to accept the outcomes of Type 1 processes that Type 2 higher-order cognitive processes such as critical thinking are engaged (Stanovich & Toplak, 2012).

This study had several strengths. Methodologically speaking, it employed objective behavioural measures of both executive functioning and critical thinking. The use of SEM also accounted for the task impurity problem in the measurement of executive functioning and allowed multiple mediation to be examined. While previous research has suggested that mindfulness can facilitate higher-order thinking skills in general, its effect on critical thinking specifically had not been examined and no attempts had been made to identify the mechanisms driving this relationship. This study also sheds light on the extent to which particular executive processes are implicated in critical thinking. By identifying links between literature on mindfulness and self-regulation, and studies on the self-regulation of higher-order cognition it was hypothesised that executive functioning would mediate the effect of mindfulness on critical thinking. Consistent with default interventionist dual process theories of higher-order cognition, it appears that mindfulness may be
enabling the engagement of Type-2 processing as a result of its positive effects on the inhibition component of executive functioning. This study adds to the very few studies that have focused on the effects of dispositional mindfulness in psychologically healthy individuals (Petrocchi & Ottaviani, 2015) and increases our knowledge regarding the mechanisms by which mindfulness might enhance higher-order cognition.

However, there are weaknesses to this study. As with any cross-sectional study, caution must be taken in interpreting these findings as causal. However, as the model fit was good, the hypothesised causal relations can be said to be plausible (Bollen & Pearl, 2013) and can be used as the basis for further experimental work that examines causal hypotheses in controlled settings. Additional caution must be taken in interpreting the results due to the failure to recruit a sample size large enough to ensure 80% power for the estimation of relationships in the SEM. The use of a self-report measure to assess dispositional mindfulness and the use of non-practitioners of mindfulness mean that further research is needed before the results of the current study can be generalised to the practice of mindfulness. Furthermore, debate continues regarding the validity of self-report measures of dispositional mindfulness. While investigations involving the FFMQ suggest that the non-reactivity facet represents its corresponding aspect of mindfulness well, divergent views exist regarding how best to measure the present-moment attention aspect with some studies supporting the acting with awareness facet (Rau & Williams, 2015) and others supporting the observing facet (Anicha et al., 2011). It is clear that further refinement of the FFMQ is required to increase its validity (Petrocchi & Ottaviani, 2015). As regards the measurement of executive functioning, despite adequate piloting, many participants found the switching tasks too easy which produced a ceiling effect. This led to low factor loadings on the shifting factor and much better fit when this factor was dropped, thus not supporting the common conceptualisation of the unity/diversity model of executive functioning. Also relevant to the measurement of executive functioning is the fact that any speed-accuracy trade-off advantage, sometimes observed in more
mindful individuals (van Vugt & Jha, 2011), would not have been captured by the proportional accuracy dependent variables employed here. However, this has only been observed in individuals trained in mindfulness and thus may not have had an effect in the current study. Finally, the measures of executive functioning employed in this study were purely performance based. It has been suggested that including both self-reported measures of executive functioning and self-regulation and performance-based measures is important for increasing ecological validity (Toplak et al., 2013). Future investigations could include measures such as the Behaviour Rating Inventory of Executive Functions which has been shown recently to mediate the relationship between mindfulness and both positive and negative affect independently of and to a greater extent than performance-based executive functioning tasks (Short et al., 2015).

In summary, dispositional mindfulness appears to facilitate, albeit weakly, critical thinking performance and this effect is mediated by the inhibition component of executive functioning. However, this relationship is complex as the non-reactivity facet of mindfulness appears to have a competing negative effect on critical thinking through as yet unidentified mediators. These findings suggest many possibilities for future research. In order to support the claim that mindfulness can improve critical thinking in educational settings (Shapiro et al., 2011), careful intervention research will be needed. However, it is important to first continue investigations of the basic relationships between mindfulness and higher-order cognitive skills in typically developing individuals and the mechanisms underlying any significant relationships found.
Chapter 4

Study 2: Effects of a Brief Guided Mindfulness Meditation on executive Function and Critical Thinking

4.1 Introduction

Study 1 is the only study to date which has focused specifically on examining the effects of mindfulness on critical thinking (Noone et al. 2016). However, this study was cross-sectional in nature so experimental studies are needed to confirm the relationships observed in it. There have been experiments which have focused on the effect of mindfulness on cognitive outcomes related to critical thinking such as cognitive rigidity (Greenberg et al., 2012), insight problem-solving (Ostafin & Kassman, 2012), and creative thinking (Colzato et al., 2012; Colzato et al., 2014). These studies all highlighted, but did not specifically investigate, the inhibition of automatic thinking processes as a possible mechanism underlying the positive effects of mindfulness on thinking skills. These studies together do appear to support the view that mindfulness might facilitate the self-regulation of thinking. This study was designed to examine whether the cultivation of a mindfulness state through a brief meditation facilitates critical thinking and whether improvements in executive functioning mediates this relationship.

While there has been some experimental research into the effects of mindfulness on executive functions (for a recent systematic review, see Gallant, 2016), there have been few experiments focusing on mindfulness and behaviours related to critical thinking and fewer which attempted to identify the mechanism(s) by which mindfulness exerts an effect on these behaviours. This study seeks to address this significant gap in the literature by examining whether individuals randomised to a mindfulness meditation condition improve in their performance on tasks assessing critical thinking and executive function to a significantly greater extent than individuals randomised to an active control condition, following baseline assessment.

Experiments in mindfulness research can generally take one of two forms – interventions (i.e. more than 1 session of mindfulness practice) and brief mindfulness inductions (i.e. 1 session of mindfulness practice). While
an advantage of interventions is that they may be more reflective of the effects of the regular practice of mindfulness, they are resource intensive, can be difficult to control in a rigorous manner and are often subject to significant sample attrition (Davidson & Kaszniak, 2015). Brief mindfulness inductions lack this ecological validity but require far less resources and can be tightly controlled as it is easier to manage expectation effects and demand characteristics and to include an active-control condition. They are also more amenable to direct replication. A further distinction is that while intervention studies operate by attempting to manipulate the tendency to engage in a mindful state, or dispositional mindfulness, brief mindfulness inductions focus on the direct manipulation of state mindfulness and thus any effects found can be attributed to this state, given appropriate experimental design.

It is important to note that the manipulation of state mindfulness cannot be assumed to affect different individuals to the same degree (Farias & Wikholm, 2016). Therefore, it is important to include, where possible, baseline measures of task performance in the experimental designs employed and to take relevant traits or dispositions into account. In this study, dispositional mindfulness, actively open-minded thinking and need for cognition were the dispositions of interest. Dispositional mindfulness was measured because there is evidence to suggest that a greater general tendency to engage in a mindful state (i.e., higher scores on dispositional mindfulness scales) can boost the effect of brief mindfulness inductions – even in novice mindfulness practitioners. These positive moderation effects have been observed in studies on state mindfulness and postural balance (Kee, Chatzisarantis, Kong, Chow, & Chen, 2012), emotional regulation (Huffziger & Kuehner, 2009), and physiological stress responses (Laurent, Laurent, Nelson, Wright, & De Araujo Sanchez, 2015). Need for cognition reflects an individual disposition to enjoy engaging in effortful cognitive activity: it is strongly associated with critical thinking and also, to a much lesser extent, significantly related to mindfulness (Brown & Ryan, 2003; Ritchie & Bryant, 2012; West, Toplak, & Stanovich, 2008). Previous discussion of mindfulness interventions suggested that those with a higher need for cognition would be more likely to engage with mindfulness as it is
a cognitively demanding activity and for this reason it was expected that the effectiveness of the mindfulness induction would be moderated by levels of need for cognition (Chatzisarantis & Hagger, 2007). *Actively open-minded thinking* refers to the tendency to process information in a flexible manner and remain open to revising one’s beliefs (Stanovich & West, 1997). This disposition is highly predictive of effective critical thinking and has been associated with openness to experience (Oyer, Gillespie, Issah, & Fasko, 2012). It was predicted that this would also moderate the effectiveness of the mindfulness induction such that more open-minded individuals would engage with the meditation to a greater extent and demonstrate greater gains in critical thinking.

In summary, this study was designed to test the effects of a brief mindfulness meditation on executive function and critical thinking against those of a sham meditation. In addition, mediation analyses were planned to assess whether engaging in a brief mindfulness meditation increased critical thinking performance indirectly through its effect on executive function. Finally, moderation analyses were planned to investigate whether the direct and indirect effects mentioned above are conditional on individual differences in dispositions towards mindfulness, need for cognition and actively open-minded thinking. The specific hypotheses are outlined in Table 4.1.

**Table 4.1. Hypotheses for Study 2**

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Variables</th>
<th>Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1 Greater increase in executive control for experimental group</td>
<td>DVs= (a) 2 Back D’ (b) 2 Back Accuracy (c) 2 Back reaction time (RT); IVs = Time, Group</td>
<td>2x2 Mixed ANOVAs</td>
</tr>
<tr>
<td>1.2 Greater increase in critical thinking for experimental group</td>
<td>DVs= Shortened Halpern Critical Thinking Assessment; IVs = Time, Group</td>
<td>2x2 Mixed ANOVA</td>
</tr>
<tr>
<td>1.3 Executive control mediates effect of experimental manipulation on critical thinking</td>
<td>DV = Time 2 Shortened Halpern Critical Thinking; IV = Group</td>
<td>PROCESS, Model 4</td>
</tr>
<tr>
<td></td>
<td>MV = (a) 2 Back D’ (b) 2 Back Accuracy (c) 2 Back RT at Time 2</td>
<td></td>
</tr>
</tbody>
</table>
Chapter 4 – Study 2

Secondary

2.1 Increase in critical thinking for experimental group is conditional on level of need for cognition

DV = Time 2 Shortened Halpern Critical Thinking;
IV = Group
ModV = Need for Cognition;
CV = Time 1 Shortened Halpern Critical Thinking

PROCESS, Model 1

2.2 Increase in critical thinking for experimental group is conditional on level of Actively Open-Minded Thinking

DV = Time 2 Shortened Halpern Critical Thinking;
IV = Group
ModV = Actively Open-Minded Thinking;
CV = Time 1 Shortened Halpern Critical Thinking

PROCESS, Model 1

2.3 Greater increase in executive control for experimental group if they are high in observing and non-reactivity

DV = a) 2 Back D’ (b) 2 Back Accuracy (c) 2 Back RT at Time 2;
ModVs = Observing, Non-reactivity sub-scales;
CV = a) 2 Back D’ (b) 2 Back Accuracy (c) 2 Back RT at Time 1

PROCESS, Model 2

2.4 Greater increase in critical thinking for experimental group if they are high in observing and non-reactivity

DV = Time 2 Shortened Halpern Critical Thinking;
IV = Group
ModVs = Observing sub-scale, Non-reactivity sub-scale;
CV = Time 1 Shortened Halpern Critical Thinking

PROCESS, Model 2

2.5 Executive control mediates effect of experimental manipulation on critical thinking in those with high dispositional mindfulness

DV = Time 2 Shortened Halpern Critical Thinking;
IV = Group
MedV = a) 2 Back D’ (b) 2 Back Accuracy (c) 2 Back RT at Time 2
ModV = Observing, Non-reactivity sub-scales;
CV = Time 1 Shortened Halpern Critical Thinking

PROCESS, Model 10
Manipulation Checks

3.1 Greater increase in mindfulness for experimental group
   DV = Mindful Attention and Awareness Scale; IVs = Time, Group
   2x2 Mixed ANOVA

3.2 No difference in adherence to instructions
   DV = Following of instructions; IV = Group
   Bayesian Independent T-test

3.3 No difference in understanding of instructions
   DV = Understanding of instructions; IV = Group
   Bayesian Independent T-test

3.4 No differences in application of induced attentional state to tasks
   DV = Application of induced attentional state to each task; IV = Group
   Bayesian Independent T-test

Note: IV = Independent variable, DV = Dependent variable, CV = Covariate, ModV = Moderator variable, MedV = Mediator variable.

4.2 Methods

Participants

A total of 65 participants completed this study, while one participant withdrew during the procedure. 73.8% of participants were female (N= 48). A majority of participants were Irish (89.3%) and all were students of the National University of Ireland, Galway in either the 1st or 2nd year of their undergraduate studies (Mean age = 21.09, SD = 5.46). First year and second year psychology students were awarded course credit for participating. 95.4% of the participants reported no experience with meditation. The remaining 4.6% had not experienced formal training or practiced regularly but had attended once-off events related to meditation. Therefore, no analyses regarding previous experience with mindfulness were conducted.

The statistical program G*Power was used to conduct a power analysis a priori. With 2 groups, 2 measurements, an assumed correlation among repeated measures of 0.3 (typically low in such research; Rossi, 2012) as well as a medium effect size ($r = 0.3$, again typical in research on the cognitive effects of mindfulness; Chiesa et al., 2011) and a power of 0.8, the recommended sample size for repeated measures ANOVA was 60. In
order to allow for possible participant exclusions or withdrawals, data was collected until the break in the semester. No interim data analyses were conducted before this time. University students over the age of 18 were invited to participate. Only participants with English as first language or university level English (i.e. equivalent to 80 on TOEFL or 6.5 on IELTS) were included.

Ethics

Ethical approval for this study was granted by the NUI Galway Research Ethics Committee. While informed consent was sought before participation in the study began, this information was not complete in order to reduce demand characteristics and ensure expectation effects were equal across groups. Rather participants were informed that the study focused on the effects of relaxation on attention and critical thinking and both conditions presented as a break during the experimental procedure to relax with a guided meditation. This type of deception is typical in psychological research and is an important control in mindfulness research (e.g. Mrazek, Smallwood, & Schooler, 2012). The word “Mindfulness” was not mentioned in any recruiting or experimental materials. There was a full debriefing regarding the purpose of the study and the purpose of the deception following each lab session.

Study Design

A mixed factorial design was employed to assess the effects of both experimental condition (mindfulness meditation vs. sham meditation; between subjects) and time (pre-manipulation vs post-manipulation; within subjects). Covariates measured included dispositional mindfulness, actively open-minded thinking and need for cognition. Manipulation checks assessed state mindfulness, understanding of and adherence to the experimental manipulation and the extent to which the type of attention cultivated during the experimental manipulation was applied to the post-manipulation tasks.
**Experimental Manipulation**

Participants were randomized to one of two experimental conditions which respectively involved mindfulness meditation and a sham meditation. Randomisation was achieved using Sealed Envelope (Sealed Envelope Ltd., 2015) with a block size of 4. This resulted in 31 participants being assigned to the mindfulness meditation condition and 34 participants being assigned to the sham meditation condition. These groups did not significantly differ on age, gender or baseline measures of dispositional mindfulness, thinking dispositions, state mindfulness, N-back performance and critical thinking, indicating that randomisation was successful.

A brief mindfulness meditation was used to induce a state of mindfulness. Out of 36 studies reviewed in the development of this study (see Table 4.2), only 3 studies using this mindfulness induction approach have been published which did not show evidence of a successful increase in state mindfulness. However, no meta-analytic evaluation of this technique has been attempted so it is unclear to what extent this is due to publication bias. Furthermore, manipulation checks are rarely used. Where measures of state mindfulness were employed as a manipulation check, effect sizes varied considerably from small to large.

Of these 33 studies which reported successful manipulations of state mindfulness, the most commonly employed method was a guided meditation based on a sitting meditation developed by Jon Kabat-Zinn as part of the Mindfulness-Based Stress reduction program. This meditation is focused on cultivating mindful awareness of the breath. It was initially employed as an experimental manipulation of state mindfulness by Arch and Craske (2006) and was compared to a control condition in which participants listened to a recording of equal length which encouraged them to let their minds wander.

It was decided to employ the guided meditation scripts kindly provided by Arch and Craske (2006) due to their extensive previous use (see Appendices D and E). These were re-recorded in a professional-level studio by a therapist with an Irish accent to facilitate the engagement of the participants.
Table 4.2. Methodological details of previous studies which employed brief mindfulness manipulations.

<table>
<thead>
<tr>
<th>Study</th>
<th>Typical Adult Population</th>
<th>Length (mins)</th>
<th>Focus</th>
<th>Nature of Induction</th>
<th>Active Control</th>
<th>Manipulation Check</th>
<th>Effect Size</th>
<th>Reported Effectiveness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arch &amp; Craske (2006)*</td>
<td>Yes</td>
<td>10</td>
<td>Breath</td>
<td>Audio</td>
<td>Mind-wandering induction</td>
<td>No</td>
<td>Not reported</td>
<td>Effective</td>
</tr>
<tr>
<td>Carlin &amp; Ahrens (2014)</td>
<td>Yes*</td>
<td>15</td>
<td>Breath</td>
<td>Audio</td>
<td>Mind-wandering induction</td>
<td>No</td>
<td>Not reported</td>
<td>Effective</td>
</tr>
<tr>
<td>Cassin &amp; Rector (2011)</td>
<td>Individuals with DSM-IV Generalized Social Phobia</td>
<td>Not reported</td>
<td>Sensations, thought, emotions</td>
<td>Audio</td>
<td>Distraction</td>
<td>No</td>
<td>Not reported</td>
<td>Effective</td>
</tr>
<tr>
<td>Diaz (2011)</td>
<td>Musicians</td>
<td>15</td>
<td>Body scan</td>
<td>Audio</td>
<td>No</td>
<td>Between Groups - Self-reported attention</td>
<td>Not reported</td>
<td>Effective</td>
</tr>
<tr>
<td>Dickenson et al. (2013)*</td>
<td>Yes</td>
<td>4 X 50s</td>
<td>Breath</td>
<td>Text</td>
<td>Mind-wandering induction</td>
<td>No</td>
<td>Not reported</td>
<td>Effective</td>
</tr>
<tr>
<td>Gilbert &amp; Gruber (2014)</td>
<td>Yes</td>
<td>5</td>
<td>Sensations, thought, emotions</td>
<td>Audio</td>
<td>Guided rumination induction</td>
<td>No</td>
<td>Not reported</td>
<td>Effective</td>
</tr>
<tr>
<td>Grant et al. (2013)</td>
<td>Family history of hypertension</td>
<td>Not reported</td>
<td>Breath</td>
<td>Audio</td>
<td>Harry Potter Audiobook</td>
<td>No</td>
<td>Not reported</td>
<td>Effective</td>
</tr>
<tr>
<td>Hafenbrack, Kinias, &amp; Barsade (2013)</td>
<td>Yes</td>
<td>15</td>
<td>Breath</td>
<td>Audio</td>
<td>Mind-wandering induction</td>
<td>No</td>
<td>Not reported</td>
<td>Effective</td>
</tr>
<tr>
<td>Heppner et al. (2007)*</td>
<td>Yes</td>
<td>Not reported</td>
<td>Eating</td>
<td>Verbal</td>
<td>Waiting in room</td>
<td>No</td>
<td>Not reported</td>
<td>Effective</td>
</tr>
</tbody>
</table>

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121
<table>
<thead>
<tr>
<th>Study</th>
<th>Participants</th>
<th>Participants</th>
<th>Condition</th>
<th>Task</th>
<th>Instructions</th>
<th>Attention Instructions</th>
<th>MAAS</th>
<th>Effectiveness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hesser, Molander, Jungermann, &amp; Andersson (2013)</td>
<td>Yes</td>
<td>5</td>
<td>Breath</td>
<td>Audio</td>
<td>Watched documentary</td>
<td>No</td>
<td>Not reported</td>
<td>Effective</td>
</tr>
<tr>
<td>Hilt &amp; Pollak (2012)</td>
<td>Young teenagers</td>
<td>8</td>
<td>Breath</td>
<td>Audio</td>
<td>Guided distraction and problem solving</td>
<td>No</td>
<td>Not reported</td>
<td>Effective</td>
</tr>
<tr>
<td>Hooper, Davies, Davies, &amp; McHugh (2011)*</td>
<td>Spider-fearful participants</td>
<td>9</td>
<td>Breath</td>
<td>Audio</td>
<td>Guided thought suppression and unfocused attention.</td>
<td>No</td>
<td>Not reported</td>
<td>Effective</td>
</tr>
<tr>
<td>Huffziger &amp; Kuehner (2009)</td>
<td>Participants with Depression</td>
<td>8</td>
<td>Sensations, thought, emotions</td>
<td>Text</td>
<td>Guided rumination and distraction</td>
<td>No</td>
<td>Not reported</td>
<td>Effective</td>
</tr>
<tr>
<td>Huffziger et al. (2013)</td>
<td>Yes</td>
<td>3</td>
<td>Breath</td>
<td>Text</td>
<td>Guided rumination induction</td>
<td>No</td>
<td>Not reported</td>
<td>Effective</td>
</tr>
<tr>
<td>Kee et al. (2012)</td>
<td>Yes</td>
<td>6</td>
<td>Hands in water</td>
<td>Audio</td>
<td>No attention instructions</td>
<td>No</td>
<td>Not reported</td>
<td>Effective</td>
</tr>
<tr>
<td>Kee, Chaturvedi, Wang, &amp; Chen (2013)</td>
<td>Yes</td>
<td>6</td>
<td>Breath</td>
<td>Audio</td>
<td>No attention instructions</td>
<td>Between Groups - MAAS - State</td>
<td>$d = .76$</td>
<td>Effective</td>
</tr>
<tr>
<td>Keune, Bostanov, Hautzinger, &amp; Kotchoubey (2013)</td>
<td>Participants with recurrent Depression</td>
<td>4</td>
<td>Sensations, thought, emotions</td>
<td>Text</td>
<td>Guided rumination</td>
<td>No</td>
<td>Not reported</td>
<td>Effective</td>
</tr>
<tr>
<td>Kiken &amp; Shook (2011)*</td>
<td>Yes</td>
<td>15</td>
<td>Breath</td>
<td>Audio</td>
<td>Mind-wandering induction</td>
<td>Between Groups - MAAS - State</td>
<td>Not reported</td>
<td>Effective</td>
</tr>
<tr>
<td>Kuehner, Huffziger, &amp; Liebich (2009)</td>
<td>Yes</td>
<td>Not reported</td>
<td>Sensations, thought, emotions</td>
<td>Text</td>
<td>Guided rumination and distraction</td>
<td>No</td>
<td>Not reported</td>
<td>Effective</td>
</tr>
<tr>
<td>Lakey, Berry, &amp; Sellers (2013)*</td>
<td>Yes</td>
<td>6</td>
<td>Breath</td>
<td>Audio</td>
<td>Unguided relaxation</td>
<td>No</td>
<td>Not reported</td>
<td>Effective</td>
</tr>
<tr>
<td>Study</td>
<td>Participants/Condition</td>
<td>No.</td>
<td>Task Type</td>
<td>Main Induction</td>
<td>Data Collection</td>
<td>Effectiveness</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Lalot, Delplanque, &amp; Sander (2014)</td>
<td>Participants with Temporal Brain Injury</td>
<td>10</td>
<td>Breath</td>
<td>Audio</td>
<td>No</td>
<td>Not reported</td>
<td>Effective</td>
<td></td>
</tr>
<tr>
<td>McHugh &amp; Wood (2013)*</td>
<td>Participants with Temporal Brain Injury</td>
<td>10</td>
<td>Breath</td>
<td>Audio</td>
<td>No</td>
<td>Not reported</td>
<td>Effective</td>
<td></td>
</tr>
<tr>
<td>McHugh et al. (2012)</td>
<td>Participants with Temporal Brain Injury</td>
<td>15</td>
<td>Breath</td>
<td>Verbal</td>
<td>Mind-wandering induction</td>
<td>No</td>
<td>Not reported</td>
<td>Effective</td>
</tr>
<tr>
<td>McHugh, Simpson, &amp; Reed (2010)*</td>
<td>Older adults</td>
<td>10</td>
<td>Breath</td>
<td>Verbal</td>
<td>Mind-wandering induction</td>
<td>No</td>
<td>Not reported</td>
<td>Effective</td>
</tr>
<tr>
<td>Murphy &amp; MacKillop (2014)</td>
<td>Heavy drinkers</td>
<td>Not reported</td>
<td>Cravings</td>
<td>Audio</td>
<td>No</td>
<td>Not reported</td>
<td>Not effective</td>
<td></td>
</tr>
<tr>
<td>Ortner &amp; Zelazo (2014)</td>
<td>Participants with Temporal Brain Injury</td>
<td>10</td>
<td>Breath</td>
<td>Audio</td>
<td>Between Groups - Toronto Mindfulness Scale</td>
<td>Not reported</td>
<td>Effective</td>
<td></td>
</tr>
<tr>
<td>Paul et al. (2013)</td>
<td>Participants with Temporal Brain Injury</td>
<td>Not reported</td>
<td>Breath</td>
<td>Verbal</td>
<td>Stress induction</td>
<td>Average salivary cortisol and heart rate</td>
<td>Not reported</td>
<td>Effective</td>
</tr>
<tr>
<td>Pepping, O'Donovan, &amp; Davis (2014)</td>
<td>Participants with Temporal Brain Injury</td>
<td>15</td>
<td>Breath</td>
<td>Audio</td>
<td>Listened to story about Venus fly-trap plants.</td>
<td>Between Groups - MAAS - State</td>
<td>ηp² = .06</td>
<td>Effective</td>
</tr>
<tr>
<td>Petter et al. (2014)</td>
<td>Adolescents</td>
<td>10</td>
<td>Breath</td>
<td>Audio</td>
<td>Read magazines</td>
<td>Between Groups - MAAS - State</td>
<td>Not reported</td>
<td>Effective</td>
</tr>
<tr>
<td>Remmers, Topolinski, &amp; Michalak (2014)</td>
<td>Participants with Temporal Brain Injury</td>
<td>8</td>
<td>Sensations, thought, emotions</td>
<td>Text</td>
<td>Guided rumination and distraction</td>
<td>No</td>
<td>Not reported</td>
<td>Not effective</td>
</tr>
<tr>
<td>Study</td>
<td>Participants</td>
<td>Intervention</td>
<td>Condition</td>
<td>Measured Outcomes</td>
<td>Between Groups</td>
<td>Effect Size</td>
<td>Effect</td>
<td></td>
</tr>
<tr>
<td>-------</td>
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<td></td>
</tr>
<tr>
<td>Reynolds, Lin, Zhou, &amp; Consedine (2014)</td>
<td>Yes</td>
<td>10</td>
<td>Breath</td>
<td>Audio</td>
<td>Listened to a radio recording about the public service</td>
<td>Between Groups - Toronto Mindfulness Scale</td>
<td>$\eta_p^2 = .09$</td>
<td>Effective</td>
</tr>
<tr>
<td>Sanders &amp; Lam (2010)</td>
<td>Participants with Dysphoria</td>
<td>Not reported</td>
<td>Sensations, thought, emotions</td>
<td>Text</td>
<td>Guided rumination</td>
<td>No</td>
<td>Not reported</td>
<td>Effective</td>
</tr>
<tr>
<td>Sauer &amp; Baer (2012)</td>
<td>Participants with Borderline Personality Disorder</td>
<td>Not reported</td>
<td>Not reported</td>
<td>Guided rumination</td>
<td>Not reported</td>
<td>Not reported</td>
<td>Effective</td>
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<td>Sensations, thought, emotions</td>
<td>Audio</td>
<td>Progressive muscle relaxation</td>
<td>Between Groups - Toronto Mindfulness Scale</td>
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<td>Audio</td>
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<td>Breath</td>
<td>Audio</td>
<td>Worry induction</td>
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* Used adaptation of Kabat-Zinn’s sitting meditation
Table 4.4. Bivariate correlations between the primary and secondary measures

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<td>-.02</td>
<td>-.05</td>
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<td>-.04</td>
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<td>* .22</td>
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<td>2-Back Accuracy – Time 1</td>
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<td>12.</td>
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<td>-.23</td>
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<td>.27</td>
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<tr>
<td>14.</td>
<td>Critical Thinking – Time 2</td>
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<td>.27</td>
<td>*</td>
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</table>

* p < .05, ** p < .01, *** p < .001
The mindfulness meditation condition required participants to listen to a guided meditation for 10 minutes. This guided meditation focused on observing one’s breath in a non-judgmental manner and included instructions such as “Focus on the actual sensations of your breath entering and leaving your body”, “There is no need to think about the breath – just experience the sensations of it” and “Bring this sense of allowing to the rest of your experience. There is nothing to be fixed, no particular state to be achieved.”.

The mind-wandering control condition used by Arch and Craske (2006) was presented as if it was a guided meditation (and is therefore referred to as the sham meditation condition). Participants were instructed to follow their thoughts wherever they took them with statements such as “simply think about whatever comes to mind. Let your mind wander freely without trying to focus on anything in particular”. Variants of these instructions were repeated every 30 – 60 seconds for 10 minutes. This acted as an active control and was intended to simulate an everyday thinking state as we tend to mind-wander for up to 30% of our waking hours (Kane et al., 2007). It therefore has high ecological validity and is a closer match than other active-control methods (e.g. reading, listening to educational material). Following the guided meditations, participants were instructed to apply the state of attention cultivated to the executive function and critical thinking tasks.

Primary Measures

N-Back

The N – Back task is a commonly used measure of executive function and working memory (Baddeley, 2003). In this version of the task, participants viewed letters successively presented on a screen. In the 2-back condition, participants responded to a letter as a target when it was identical to the letter presented two trials earlier. The letters were presented for 500ms followed by a 2000ms inter-stimulus interval during which the letter was replaced by a fixation cross. In all conditions, 33% of letters were targets. A number of indicators of performance have been used in studies involving the N-back including reaction time (RT), accuracy (i.e. correctly
identified targets and correctly rejected non-targets) and D’, an indicator introduced from work on Signal Detection Theory. D’ is the difference between the Z transforms of the Hit rate and the False Alarm rate, where the Hit rate is the proportion of correct responses to targets and the False Alarm rate is the proportion of incorrect responses when there is no target. As there is no preferred dependent variable (DV) used in studies employing the N-back, and in the interest of transparency, results for each indicator of performance are reported and a Bonferroni correction is applied to correct for the 3 outcomes ($p = .017$).

**Halpern Critical Thinking Assessment (Halpern 2010)**

The Halpern Critical Thinking Assessment (HCTA) assesses thinking in everyday, easy to relate to scenarios and is sensitive to both the motivational and behavioural aspects of critical thinking. This is achieved by including both open-ended and multiple choice questions (Ku 2009). The Halpern Critical Thinking Assessment was adapted to produce two short forms in order to measure critical thinking performance before and after the experimental manipulation as using the same items before and after would see the participants’ memory confound their critical thinking performance. These shortened versions of the HCTA were validated using an item parcelling strategy. It was found that these two item parcels loaded significantly on overall critical thinking performance and demonstrated greater factor loadings to 3 parcels containing items randomly assigned from the remaining questions (Parcel A $\beta = .73$, Parcel A $\beta = .68$, CFI = .95, IFI = .95, TLI = .96, RMSEA = .07 95% CI .01 to .12). This was achieved using data from a previous study where the full HCTA was employed (Noone et al., 2016). A paired-samples t-test suggested that on average participants performed slightly better on Parcel B ($M = 9.82$) than Parcel A ($M = 8.63$; $t(177) = -4.38$, $p < .001$). Pilot testing showed that this shortened version of the HCTA could be completed in 10 mins. The shortened HCTAs were administered in a counter-balanced order (i.e. half the cohort received A at pre-manipulation while the other half received B at pre-manipulation, and *vice versa* post-manipulation), in order to control for any potential difference in difficulty level. A total of 20 points were available in each
version and these points were awarded to answers based on a standardized prompt-based scoring system. The DV employed was the total score for each participant at each time. Scale reliability was assessed using the Scale Diagnosis function from the UserFriendlyScience package in R (Peters, 2014). This showed moderately adequate reliability across the items (Cronbach’s $\alpha = .45$, $\omega = .64$, Greatest Lower Bound = .72).

Secondary Measures

Five Facet Mindfulness Questionnaire - short form (Bohlmeijer et al. 2011)

The Five Facet Mindfulness Questionnaire - short form (FFMQ-SF) is a 24 item measure consisting of five subscales which assesses the observing, describing, acting with awareness, non-judging, and non-reactivity facets of dispositional mindfulness. The FFQM-SF employs a 5-point Likert scale (e.g. 1 = never or very rarely true; 5 = very often or always true). For the purposes of the current study, the observing and non-reactivity facets were the main focus. This multi-facet scale includes four observing items and five non-reactivity items. The DVs employed were the total scores for the observing and non-reactivity subscales respectively. Moderate reliability for the observe subscale (Cronbach’s $\alpha = .53$, $\omega = .80$, Greatest Lower Bound = .65) and adequate reliability for the non-reactivity subscale (Cronbach’s $\alpha = .75$, $\omega = .82$, Greatest Lower Bound = .83) was found.

Need for Cognition – short form (Cacioppo, Petty, & Kao, 1984)

The Need for Cognition – short form is an 18 item measure which measures the extent to which individuals tend to engage in effortful cognitive activity (Cacioppo et al., 1984). The scale includes 18 items which are rated on a 5-point Likert scale (e.g. 1 = extremely uncharacteristic of me; 5 = extremely characteristic of me). It has been extensively validated as unifactorial and has been found to have adequate reliability (Tolentino, Curry, & Leak, 1990). The total score for each participant was used as the DV. This scale showed excellent reliability in this study (Cronbach’s $\alpha = .87$, $\omega = .90$, Greatest Lower Bound = .96).
Actively Open-minded Thinking Scale (Stanovich & West, 1997)

The Actively Open-minded Thinking Scale assesses the extent to which individuals tend to approach information in an open and flexible way. The scale includes 41 items and these are rated on a 6-point Likert scale (e.g. 1 = strongly agree; 6 = strongly disagree). Again the total score for each participant was used as the DV. Scale diagnosis demonstrated good reliability (Cronbach’s α = .80, ω = .86, Greatest Lower Bound = .85).

Manipulation Checks
Mindful Attention and Awareness Scale – State (Brown & Ryan, 2003)

The Mindful Attention and Awareness Scale– State Version (MAAS-State) assesses participants’ level of mindfulness during a particular moment in time. The scale includes 5 items which are rated on a 7-point Likert scale (e.g. 0 = not at all, 6 = very much). The DV was the average score across the 5 items and adequate reliability was found for item scores before (Cronbach’s α = .46, ω = .83, Greatest Lower Bound = .73) and after the experimental manipulation (Cronbach’s α = .58, ω = .79, Greatest Lower Bound = .72).

Understanding, Adherence to and Application of Instructions

Following the experimental manipulation, participants were asked to rate their understanding of the guided instructions and the extent to which they followed them on a 7-point Likert scale. After each of the post-manipulation tasks, participants were asked to rate their own application of the instructions to their attention during the tasks on a 7-point Likert scale.

Procedure

All study participants attended the School of Psychology labs at NUI Galway for a single two-hour study session. Participants first completed informed consent and a demographics sheet. They then completed the MAAS-State, FFMQ-SF, NFC-SF and AOT. Next, the behavioural tasks were counterbalanced so that participants then either completed the N-Back task or the Critical Thinking task. After these tasks the participants either listened to the mindfulness meditation or a sham meditation audio guide.
Participants then indicated the extent to which they understood the induction instructions and the extent to which they attempted to follow them. Then participants completed the MAAS-State version questionnaire again as a manipulation check. Again, the tasks were counterbalanced so participants either completed the N-Back task or the Critical Thinking Task. Following each task participants indicated the extent to which they were able to apply the quality of attention cultivated during the induction of the task. Finally, participants were debriefed. The procedure is summarised in Figure 4.1.

Figure 4.1. Summary of procedure for Study 2

<table>
<thead>
<tr>
<th>Step 1</th>
<th>Informed Consent and Demographic Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 2</td>
<td>Dispositional &amp; State Measures</td>
</tr>
<tr>
<td>Step 3</td>
<td>Baseline Behavioural Measures</td>
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<td>Step 4</td>
<td>Mindfulness Meditation Sham Meditation</td>
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<td>Step 5</td>
<td>Manipulation Checks</td>
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<td>Step 6</td>
<td>Outcome Behavioural Measures</td>
</tr>
<tr>
<td>Step 7</td>
<td>Debrief</td>
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Analytic Approach

A number of analyses were carried out to ascertain the effects of the experimental manipulation of state mindfulness, evaluate whether greater executive control mediated any effects and identify the conditions, in terms of levels of mindfulness and thinking dispositions, under which these effects occur. These analyses and their associated hypotheses are summarised in Table 4.1. These analyses were completed using SPSS 22 (IBM Corp., 2013), the PROCESS macro (Hayes, 2013) and JASP (JASP Team, 2016).
### Table 4.3. Descriptive statistics

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<tr>
<th>Variable</th>
<th>Mindfulness Meditation</th>
<th>Sham Meditation</th>
<th>Mindfulness Meditation</th>
<th>Sham Meditation</th>
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<td>SD</td>
<td>Skewness</td>
<td>Kurtosis</td>
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</table>
4.3 Results

Descriptive Statistics and Data Inspection

Means, standard deviations and values for skewness and kurtosis are presented in Table 4.3. Bivariate correlations between primary and secondary measures are displayed in Table 4.4. On visual inspection of Q-Q plots and histograms, each variable was found to be approximately normally distributed. Most variables were found to have acceptable levels of skewness and kurtosis. There was no missing data. Two extreme scores were identified in post-experimental manipulation N-back reaction time (RT) but re-analysis with winsorised scores produced very similar results so the original analyses were retained. No problematic outliers were found in other variables on inspection of box plots and z scores.

Primary Analyses

Hypothesis 1.1 stated that there would be a greater increase in performance of the executive functioning task from before the guided meditations to after for those who received the mindfulness instructions rather than the sham instructions. This was tested using a series of 2 x 2 mixed analysis of variance tests (ANOVAs) to examine whether a significant time by group interaction was present for three indicators of performance in the N-back – RT, accuracy and D’. The use of three outcomes for N-back performance was controlled for using a Bonferroni correction which adjusted the significance criterion to .017. While there was a main effect of time for RT \((F(1, 63) = 26.61, p < .001, \eta_p^2 = .30)\), such that RT was faster for both groups after the experimental manipulation \((M = 615ms)\) than before \((M = 693ms)\), no significant main effect for group was found \((F(1, 63) = .19, p = .67, \eta_p^2 = .003)\) and crucially the interaction effect was not significant either \((F(1, 63) = .75, p = .39, \eta_p^2 = .01)\). The accuracy of performance did not significantly differ according to experimental group \((F(1, 63) = .72, p = .40, \eta_p^2 = .01)\) or time \((F(1, 63) = 2.21, p = .14, \eta_p^2 = .03)\) and again no significant interaction was observed \((F(1, 63) = .27, p = .61, \eta_p^2 = .004)\). Finally, there were no significant difference across time \((F(1, 63) = .25, p = .62, \eta_p^2 = .004)\) or group \((F(1, 63) = .001, p = .98, \eta_p^2 = .01)\) for D’.
scores and the interaction effect was not statistically different from zero ($F(1, 63) = .72, p = .40, \eta^2_p = .01$).

Hypothesis 1.2 stated that there would be a greater increase in performance of the critical thinking task for the experimental group following the experimental manipulation in comparison to the control group. A 2 x 2 mixed ANOVA showed no differences across time ($F(1, 63) = .70, p = .41, \eta^2_p = .01$) or group ($F(1, 63) = .04, p = .84, \eta^2_p = .001$) and revealed a non-significant interaction between these ($F(1, 63) = 2.63, p = .11, \eta^2_p = .04$).

Hypothesis 1.3 stated that executive function, indicated by performance on the N-back task, would mediate the effect of the experimental manipulation on critical thinking. A simple mediation model (Model 4) was run using the PROCESS macro for SPSS with critical thinking performance before the experimental manipulation entered as a covariate. This was run for all 3 indicators of N-back performance. No significant direct or indirect effects were found for either RT (Direct effect = 1.03, 95% CI -.62 to 2.69; Indirect effect = .12, 95% CI -.27 to .68), accuracy (Direct effect = 1.19, 95% CI -.56 to 2.94; Indirect effect = -.04, 95% CI -.44 to .32) or D’ (Direct effect = 1.14, 95% CI -.58 to 2.86; Indirect effect = .01, 95% CI -.16 to .50). Confidence intervals were bias-corrected.

Secondary Analyses

Hypothesis 2.1 stated that improvement in critical thinking performance would depend on levels of need for cognition. This was tested using a simple moderation model specified with the PROCESS macro (Model 1). In this model, group assignment (coded as 0 for sham meditation and 1 for mindfulness meditation), need for cognition, their interaction (to test for moderation) and baseline critical thinking performance (to control for individual differences) were entered as predictors of post-manipulation critical thinking performance. The model accounted for 22% of the variance in post-manipulation critical thinking performance ($F(4, 60) = 4.16, p = .005$). As can be seen in Table 4.5, each of these predictors had a significant effect on post-manipulation critical thinking performance. Since the
interaction between group assignment and need for cognition was significant, this moderation effect was probed using the Johnson-Neyman technique to identify regions of significance (as shown in Figure 4.2a; Hayes 2013). This revealed that there was a significant positive effect for those in the mindfulness meditation group with need for cognition scores below 57, an effect which was increasingly strong for lower scores. This applied to 40% of the sample. Overall, the inclusion of this moderation effect in the model led to a $R^2$ change of 11% ($F(1,60) = 8.61, p = .005$).

While there was also a significant negative effect for those in the MM group with need for cognition scores above 79, this was disregarded because it did not make substantive sense as it only applied to 1.5% of cases.

Hypothesis 2.2 stated that improvement in critical thinking performance would be conditional on levels of actively open-minded thinking. Again this was tested by running a simple moderation model with the PROCESS macro (Model 1). In this model, group assignment, actively open-minded thinking, their interaction and baseline critical thinking performance were entered as predictors of post-manipulation critical thinking performance. This model accounted for 29% of the variance in post-manipulation critical thinking performance ($F(4, 60) = 6.09, p = .0003$). As can be seen in Table 4.5, each of these predictors had a significant effect on post-manipulation critical thinking performance except baseline critical thinking. Since the interaction between group assignment and actively open-minded thinking was significant, this moderation effect was probed using the Johnson-Neyman technique. Again, this allows the identification of regions of significance and how the size of the effect of the experimental manipulation differs according to levels of actively open-minded thinking (as shown in Figure 4.2b). This revealed that there was a significant positive effect for those in the MM group with actively open-minded thinking scores below 182 - which applies to 51% of cases - and this effect was increasingly strong for lower scores. Overall, the inclusion of this moderation effect in the model led to a $R^2$ change of 9% ($F(1,60) = 7.22, p = .009$).
Figure 4.2. Moderation of Experimental Effect by (a) Need for Cognition and (b) Actively Open-minded Thinking. Horizontal line at 0 indicates no effect. A significant effect is present when this line does not fall between the 95% CI lines.

Table 4.5. Models of Moderation of Experimental Effect by Need for Cognition and Actively Open-minded Thinking

<table>
<thead>
<tr>
<th>Hypothesis 2.1</th>
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<th>t</th>
<th>p</th>
<th>LLCI</th>
<th>ULCI</th>
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</thead>
<tbody>
<tr>
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<td>.03</td>
<td>.01</td>
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<td>.005</td>
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<td>.005</td>
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<td>.0002</td>
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<td>.52</td>
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Hypothesis 2.3 stated that the direct effect of the mindfulness manipulation on executive function would depend on dispositional levels of mindfulness. This was tested by using the PROCESS macro to run a model in which this direct effect was moderated by the observing and non-reactivity sub-scales of the FFMQ-SF separately (Model 2). In this model, group assignment, observing and non-reactivity sub-scales, their interactions with group assignment and baseline N-back performance were entered as predictors of post-manipulation N-back performance (in terms of RT, accuracy and D’). Neither the interaction of group and level of observing (RT: \( b = .003, 95\% \text{ CI} \) - .02 to .01; Accuracy: \( b = -.23, 95\% \text{ CI} \) -.60 to .13; D’: \( b = .06, 95\% \text{ CI} \) -.13 to .24) nor the interaction between group and level of non-reactivity (RT: \( b = .002, 95\% \text{ CI} \) -.01 to .02; Accuracy: \( b = -.12, 95\% \text{ CI} \) -.42 to .18; D’: \( b = -.01, 95\% \text{ CI} \) -.16 to .15) were significant for any indicator of N-back performance.

Hypothesis 2.4 stated that the direct effect of the mindfulness manipulation on critical thinking would depend on dispositional levels of mindfulness. Again the PROCESS macro was used to run a model in which this direct effect was moderated by the observing and non-reactivity sub-scales of the FFMQ separately (Model 2). In this model, group assignment, observing and non-reactivity sub-scales, their interactions with group assignment and baseline critical thinking performance were entered as predictors of post-manipulation critical thinking performance. Group assignment did not significantly interact with either observing (\( b = -.47, 95\% \text{ CI} \) -.99 to .34) or non-reactivity (\( b = .29, 95\% \text{ CI} \) -.29 to .87). These conditional direct effects remained insignificant when AOT and NFC were entered as covariates (Observing: \( b = -.32, 95\% \text{ CI} \) -1.14 to .21; Non-reactivity: \( b = .22, 95\% \text{ CI} \) -.34 to .79).

Hypothesis 2.5 stated that the indirect effect of the mindfulness manipulation on critical thinking through N-back performance would depend on dispositional levels of mindfulness. This was tested by specifying a moderated mediation model in PROCESS (Model 10). This model included group assignment, post-manipulation N-back performance, observing and non-reactivity sub-scales, their interactions with group
assignment and post-manipulation N-back performance and baseline critical thinking performance. No interaction effects or conditional indirect effects were found in the models which included accuracy or $D'$ as indicators of N-back performance. However, the model which employed RT as an indicator of N-back performance showed evidence for an interaction between non-reactivity and group assignment ($b = -53.37$, 95% CI 5.71 to 52.68). This interaction was probed further by examining the bootstrapped confidence intervals (95%, bias-corrected) of the conditional indirect effect of group assignment on critical thinking through N-back performance at the 10th, 25th, 50th, 75th and 90th percentiles of the distributions of non-reactivity and observing. This revealed that when non-reactivity is very low (10th percentile) or low (25th percentile) and observing is either moderate, high or very high, there was a significant, negative conditional indirect effect. These effects pertain to 18.46% of the sample. The nature of these effects, which were small in size, was such that assignment to the MM condition led to poorer critical thinking task performance in comparison to the control group which was mediated by increased RT on the N-back task (see Figure 4.3).

![Figure 4.3](image)

**Figure 4.3.** Size of Conditional Indirect Effect of Group Assignment on Critical Thinking through N-back performance as a Function of Observing at Very Low (a) and Low (b) Levels of Non-reactivity. Horizontal line at 0 indicates no effect. A significant effect is present when this line does not fall between the 95% CI lines.
Manipulation Checks

Hypothesis 3.1 stated that state mindfulness would increase significantly more in the MM group in comparison to the SM group following the experimental manipulation. This was tested using a mixed ANOVA to test the interaction between the between-subjects factor, group assignment (MM vs SM), and the within-subjects factor, time (pre-manipulation vs. post-manipulation). While there was a significant main effect of time \( F(1, 63) = 16.51, p = .0002, \eta^2_p = .20 \) which indicated that state mindfulness increased for both groups following the experimental manipulation, there was no significant difference between the groups \( F(1, 63) = .78, p = .38, \eta^2_p = .01 \) and crucially no interaction between group and time \( F(1, 63) = .70, p = .41, \eta^2_p = .01 \).

Hypotheses 3.2 and 3.3 respectively stated that there would be no difference due to group assignment in the extent to which participants reported following and understanding the experimental manipulation instructions. Hypothesis 3.4 stated that there would be no difference due to group assignment in the extent to which participants reported applying the state of attention cultivated during the experimental manipulation to each behavioural task. These hypotheses were tested using Bayesian Independent Samples t-tests with Cauchy prior widths of 1, as recommended by Rouder and colleagues (Rouder, Speckman, Sun, Morey, & Iverson, 2009), which were run using JASP to allow for support for the null hypothesis to be identified. On average the experimental manipulation instructions were followed to a slightly greater but non-significant extent in the MM group \( (M = 6.29) \) as compared to the SM group \( (M = 5.94; t(63) = -1.71, p = .09) \). The corresponding Bayes factor \( (null/alternative; BF_{01}) \) indicated that the data were 1.43 times more likely under the null hypothesis. No significant difference was found between the MM group \( (M = 6.45) \) and the SM group \( (M = 6.38; t(63) = -0.327, p = .74) \) in terms of understanding of the experimental manipulation instructions. There was support for the acceptance of the null hypothesis as the \( BF_{01} \) indicated that the data were 5.07 times more likely under it than under the alternate hypothesis. Similarly strong support was found for the hypothesis of no difference between the
Chapter 4 – Study 2

MM group (N-back M = 4.82; HCTA M = 4.94) and the SM (N-back M = 4.84; HCTA M = 4.81) group in the extent to which the attentional state cultivated during the experimental manipulation was applied to each behavioural task (N-back: $t(63) = .04, p = .97, BF_{01} = 5.32$; HCTA: $t(63) = -.39, p = .70, BF_{01} = 4.98$).

4.4 Discussion

The aim of this study was to experimentally examine the effects of a brief mindfulness meditation on executive function and critical thinking and to investigate the extent to which these would interact with dispositions towards thinking and engaging in mindfulness. The results of this study suggest that, for naïve meditators at least, the effects of mindfulness meditation on executive function and critical thinking are complex. While no simple direct or indirect effects were found, conditional direct effects and conditional indirect effects were found which have interesting implications for theories and applications of mindfulness.

The first primary hypothesis stated that performance on the executive function task would improve more, from before the experimental manipulation to after it, for those in the MM group compared to those in SM group. Since the interaction between time and group assignment was not significant for any indicator of executive function performance, this hypothesis was rejected. There was evidence for a ceiling effect on the executive function task, in terms of accuracy, as participants in both groups only made, on average, 2 mistakes in each block. Therefore, the task may not have been difficult enough to elicit individual differences in executive function. By contrast, there was a much greater range of RTs which may be indicative of individual differences in executive function, or the speed with which executive operations are executed. Overall, it is inconclusive as to whether the experimental manipulation failed to affect executive function or if the task failed to accurately reflect executive function. Past studies using brief mindfulness meditations have shown positive effects on the Stroop task and the Flanker task (Wenk-Sormaz, 2005; Chan and Woollacott, 2007). However, these tasks focus primarily on inhibition while the N-back
assesses working memory operation more generally. A review of past literature on the effects of mindfulness on N-back performance reveals positive effects in individual differences and intervention designs (Ruocco & Direkoglu, 2013; Zeidan et al., 2010). However, a more recent study with a similar design showed that performance on a N-back task was not sensitive to a single brief mindfulness meditation (Johnson, Gur, David, & Currier, 2013) and the results here appear to replicate this finding.

The second primary hypothesis focused on whether performance on the critical thinking task would improve, from before the experimental manipulation to after it, to a greater extent for those in the MM group compared to those in the SM group. This hypothesis was not supported as the interaction between time and group assignment was not significant. This would seem to indicate that engaging in a brief mindfulness meditation is no better than a sham meditation at improving critical thinking performance. However, in secondary analyses, a main effect of group assignment was found when controlling for baseline critical thinking performance and each thinking disposition measured. Controlling for critical thinking dispositions may be particularly important since critical thinking is conceptualised as being determined by both thinking dispositions (i.e., reflecting the value placed on thinking and motivation to put effort into effective thinking), and cognitive components (i.e. skill in carrying out the mental operations required for effective thinking; Ku, 2009). By controlling for variations in critical thinking dispositions, the current study suggests that the experimental manipulation may have been successful in specifically enhancing the cognitive aspects of critical thinking.

The third primary hypothesis concerned testing whether mediation was present in the relationship between mindfulness, executive function and critical thinking. Results provided no evidence for executive function mediating the relationship between mindfulness and critical thinking, contrary to the findings of Study 1, though these focused on dispositional mindfulness. This null finding may have been due to the task not being difficult enough as discussed above. Another possibility is that though the task employed, the N-back, is a recognised measure of executive function, it
may not rely heavily enough on the process of inhibition to have benefited from the mindfulness meditation – in Study 1, inhibition was found to be the specific aspect of executive function which meditated the relationship between mindfulness and critical thinking. Notably, the only indicator of performance on the N-back which significantly correlated with critical thinking at the .05 alpha level was RT. However, this correlation does not remain significant following the application of the Bonferroni correction accounting for the use of three different outcomes. This suggests that an executive function task with a stronger relationship to critical thinking could have been chosen.

The first secondary hypothesis stated that the effect of the mindfulness meditation on critical thinking performance would be conditional on individual levels of need for cognition. Need for cognition is a strong determinant of critical thinking performance and has previously been shown to be modestly but significantly related to mindfulness (Brown and Ryan, 2003; Ritchie & Bryant, 2013). Furthermore, it has been suggested that mindfulness interventions may be more beneficial to those higher in need for cognition due to their higher likelihood to engage with the approach considering the cognitive demand involved (Chatzisarantis & Hagger, 2007). In the current study, the mindfulness meditation involved a much greater cognitive demand than the sham meditation so it was expected that those with a greater need for cognition would benefit more from engaging in it. Results revealed an effect in the opposite direction. Individuals high in need for cognition did not benefit from the mindfulness meditation, possibly because their level of cognitive engagement during both testing occasions was already such that they were performing at their peak. The mindfulness meditation did have beneficial effect on critical thinking performance for those lower in need for cognition and this effect was greater in size as levels of need for cognition decreased. This suggests that a brief mindfulness meditation may help overcome a tendency to put little effort into critical thinking. This parallels previous research on the potential of mindfulness to decrease engagement in maladaptive habits of thinking (Vago, 2014). This has been demonstrated
empirically in studies focusing on the effects of mindfulness on habitual worry and cognitive rigidity (Greenberg et al., 2012; Verplanken & Fisher, 2013). It was found that need for cognition was negatively correlated with N-back RT which suggests that those who are higher in need for cognition are also higher in their executive function performance compared to those who are lower in need for cognition. It is possible that the mindfulness meditation only benefited those who were lower in need for cognition because they were the only participants who were not performing at their optimum level of executive functioning.

The next secondary hypothesis concerned whether the effect of the mindfulness meditation on critical thinking performance would also depend on individual levels of actively open-minded thinking. It was thought the extent to which an individual had an open-minded disposition would positively influence their willingness to process the instructions given during the guided meditation in a flexible manner. The results demonstrated a similar pattern to those found in the previous analysis. The mindfulness mediation was only beneficial for critical thinking to those lower in actively open-minded thinking and this effect became stronger as levels of actively open-minded thinking decreased. Actively open-minded thinking was positively correlated with baseline critical thinking and therefore those lower in this thinking disposition had more room to improve in their critical thinking performance. This relationship interacted with the experimental manipulation such that for those less inclined to approach information in a flexible manner, engaging in the mindfulness meditation enhanced critical thinking performance whereas those already inclined to process information in a flexible manner did not experience any extra benefit due to the mindfulness meditation. People who are low in actively open-minded thinking tend to rely overly on their biases (Price, Ottati, Wilson, & Kim, 2015). The moderation effect found here connects to research on how engaging in mindfulness practice can reduce biased thinking as has been demonstrated in studies on the sunk cost bias (Hafenbrack et al., 2014) and the correspondence bias (Hopthrow et al. 2016). Furthermore, a single brief mindfulness meditation has been shown to reduce an objective behavioural
indicator of closed-mindedness - specifically, in a task involving a game of trust with partners of different races, where the mindfulness group demonstrated significantly less bias towards their own race than the control groups (Lueke & Gibson, 2016).

The third secondary hypothesis examined whether the direct effect of the experimental manipulation on executive function depended on dispositional tendencies to engage in present-moment attention and non-reactivity. This was investigated as previous studies had demonstrated that the effects of mindfulness inductions can be conditional on dispositional levels of mindfulness (Huffziger & Kuehner, 2009; Kee et al., 2012; Laurent et al., 2015) and observing and non-reactivity have been shown to be associated with aspects of executive function (Anicha et al., 2012; Noone et al., 2016). No evidence for a conditional direct effect was found in the current study.

The fourth secondary hypothesis stated that the direct effect of the experimental manipulation on critical thinking would depend on individual dispositions towards observing and non-reactivity. Again, it was expected that those higher in these mindfulness dispositions would benefit to a greater extent than others from the mindfulness meditation. Results provided no evidence to suggest that either observing or non-reactivity moderated the effect of the mindfulness meditation on critical thinking, even when thinking dispositions were controlled for. Further research is needed to clarify the relationship between dispositional mindfulness, state mindfulness and critical thinking.

The final secondary hypothesis focused on the presence of a conditional indirect effect dependent on dispositional mindfulness in the relationship between mindfulness meditation, executive function and critical thinking. It was expected that for those with higher levels of observing and non-reactivity, engaging in the mindfulness meditation would enhance their critical thinking performance and that this could be accounted for by improvements in the executive function task. While this exact relationship was not found, there was a finding which corresponds to it. Specifically, it
was found that, for low (25\textsuperscript{th} percentile) and very low (10\textsuperscript{th} percentile) levels of non-reactivity, engaging in the mindfulness meditation had a significant negative effect on critical thinking and that this was accounted for by an increase in RT on the executive function task. This was true for participants who exhibited at least a moderate level of observing (i.e. above 25\textsuperscript{th} percentile) but no such effect was seen for lower levels of observing. This tendency towards present-moment observation coupled with a reactive disposition is characteristic of anxious individuals (Anicha et al., 2012). Therefore, it’s possible that the mindfulness meditation elicited anxiety in these participants which impaired their executive functioning, and ultimately their critical thinking also. This finding is extremely tentative as the effects were small, affected less than 20\% of the sample and were only found for one indicator of N-back performance.

This study was designed to avoid the methodological weaknesses present in previous studies involving brief mindfulness meditations. This was achieved through the management of demand characteristics and expectation effects, effective randomisation, the inclusion of an active control condition and the \textit{a priori} calculation of the sample size required. In addition, understanding of, adherence to, and application of the experimental manipulation instructions did not appear to differ according to group assignment. This methodological rigour was coupled with a fine-grained and sophisticated statistical approach to test a range of hypotheses derived from an extensive review of research and theory in the area.

This study was not without weaknesses. While the moderation effects found appear to demonstrate the successful manipulation of state mindfulness, the mindfulness state measure employed did not show any evidence for an effect of mindfulness meditation over a sham condition. This suggests that either this measure is not sensitive enough to detect change following a brief mindfulness meditation, or is perhaps prone to social desirability. Both are likely as the measure of state mindfulness employed, the MAAS – State, attempts to assess the extent to which an individual has cultivated a state of mindfulness by using items which address different forms of attentional lapses (Brown & Ryan, 2003). The
high scores on the MAAS – State reported by both groups could be considered evidence of social desirability. Future studies should consider comparing the available measures of state mindfulness in response to different configurations of brief mindfulness meditations. Currently, there is scant empirical information regarding the best way to manipulate and measure state mindfulness. For example, brief mindfulness meditations vary in their length, focus, and method of delivery and there is not much consistency in the control conditions to which they are compared. This is a serious limitation to mindfulness research.

Another way of improving this study would be to employ a more difficult or complex executive functioning task or one which specifically targets inhibition, as this aspect of executive functioning was shown to be a specific mediator of the relationship between mindfulness and critical thinking in Study 1. Finally, replication with a larger sample is warranted in order to test the reliability of these findings. While the sample size provided adequate power for most of the analyses conducted, some of the more complex secondary analyses involving moderation must be acknowledged as underpowered as the sample size only allowed the detection of medium to large moderation effects with 80% power (Fritz & MacKinnon, 2007).

One important implication of this study for research is the need for a more rigorous and nuanced approach to the study of mindfulness. Mindfulness research needs to examine differential responses to brief mindfulness meditations by taking relevant dispositions into accounts (Farias & Wikholm, 2016). Practitioners teaching mindfulness to naïve meditators, regardless of the setting, should be wary that the two defining aspects of mindfulness, observing and non-reactivity, are skills which have distinct skill acquisition trajectories and that practicing observation of the present-moment without a sufficient level of non-reactivity may be lead to negative outcomes (Baer et al., 2008; Eisenlohr-Moul, Walsh, Charnigo, Lynam, & Baer, 2012; Neale-Lorello & Haaga, 2015). Present-moment observation tends to develop more quickly than non-reactivity (Lilja et al., 2011). Furthermore, people vary in their baseline tendency to employ these
skills effectively, as shown in this study, and this can lead to very different, and possibly detrimental, reactions to initial attempts at meditation.

In summary, analysis of the effect of a brief mindfulness meditation on critical thinking (as compared to a sham meditation) revealed no direct or indirect effects (i.e. through executive function). However, conditional direct effects were found which suggested that the brief mindfulness meditation did improve critical thinking in those with a lower tendency towards applying effort to thinking and those with a lower tendency towards thinking in a flexible, open manner. The effect of the mindfulness meditation also appeared to depend on dispositional levels of mindfulness, although this effect was small and should be interpreted with caution. Specifically, engaging in the mindfulness mediation appeared to diminish executive function and critical thinking performance for those with a tendency to process information in a reactive manner. These results show the need for a more rigorous and nuanced approach to the study of mindfulness in order to avoid overlooking subtle effects and support a more contextual view of mindfulness.
Chapter 5

Study 3: Effects of a 6-week Online Guided Mindfulness Meditation Intervention on Mindfulness, Executive functioning and Critical Thinking

5.1 Introduction

Study 1 demonstrated the hypothesised positive indirect effect of dispositional mindfulness on critical thinking through executive functioning, and specifically inhibition. However, an experimental investigation of the relationship between state mindfulness and critical thinking in Study 2 showed a more complex relationship. Though on average a single brief mindfulness meditation did not appear to improve critical thinking to a greater extent than a sham meditation, it did appear to improve the critical thinking performance of those with a lower tendency towards cognitive effort and open-mindedness. This study was a rigorous test of the effects of a single mindfulness meditation, but since there is a dynamic trajectory to the acquisition of mindfulness skills, and most practitioners of mindfulness engage in at least semi-regular practice, a more ecologically valid test of the effects of mindfulness on critical thinking and executive functioning requires a comparison of the effects of regular guided mindfulness practice over an extended period and a closely matched control condition. Study 3 consisted of a rigorously designed randomised controlled trial (RCT) of the effects on executive functioning, key thinking dispositions and critical thinking of a guided mindfulness meditation intervention which was delivered through an online application. These effects were compared to those of an active control condition which consisted of guided sham meditations which were delivered through the same means as the mindfulness meditation condition.

Advances in technology are allowing the design of randomised controlled trials of mindfulness interventions with more experimental control than previously possible (Howells, Ivtzan, & Eiroa-Orosa, 2014). The development of smartphone and web applications focused on the delivery of guided meditations in particular has made it easier to implement.
rigorous designs by facilitating the inclusion of active control conditions and objective measures of time spent meditating and by reducing the resources needed for running an intervention as well as the demands placed on the participants. Previous studies involving smartphone delivery of mindfulness interventions focused on workplace stress (Bostock & Steptoe, 2013), wellbeing (Howells et al., 2014), depression (Ly et al., 2014) and compassion (Lim, Condon, & Desteno, 2015). A recent meta-analysis showed that online mindfulness interventions tend to yield comparable results to traditional interventions focused on similar outcome variables such as stress, depression, anxiety and wellbeing, with effect sizes ranging from $g = .22$ to $g = .51$ (Spijkerman, Pots, & Bohlmeijer, 2016). These studies can also be considered more rigorous due to the standardisation of instruction across participants in the experimental group and the use of objective measures of adherence to the intervention (provided through the app) rather than self-report. However, these studies would have been strengthened further by the inclusion of more closely matched active-control materials using the same interface to deliver sham intervention content which participants could reasonably believe is mindfulness training. The current study takes this approach and includes measures of affect and wellbeing in order to allow comparison to previous studies which employed an online mindfulness intervention.

This is a substantial step in terms of rigour as for the majority of mindfulness intervention studies the control groups employed have involved waitlist controls rather than an active-control condition (Quaglia et al., 2016). An active-control group is desirable in order to rule out the potential effects of relaxation, received attention and demand characteristics. Strategies for designing an active-control condition have included using audiobooks (Zeidan, Johnson, Diamond, David, & Goolkasian, 2010), using progressive muscle relaxation training (Schmidt et al., 2011) and using sham meditation training (Zeidan et al., 2015; Zeidan, Johnson, Gordon, et al., 2010). Sham meditations are the most sophisticated approach but also the least used. They involve breathing exercises which are introduced to participants under the label of mindfulness practice. It is important that these
exercises are guided by the same facilitator and for the same amount of time as the guided mindfulness practice which the experimental group engage in. Therefore, the one key difference between the two groups is the nature of the instructions given. Where the active-control group are given variations on the instruction to “continue breathing as we sit in meditation” every few minutes, the experimental group are given clear instructions on how to pay attention to their breathing in order to cultivate a mindful state (Zeidan, Johnson, Gordon, et al., 2010).

This study consisted of an intervention which made use of the Headspace mindfulness meditation app for smartphones, tablets and web browsers in order to test the following research question: does regular mindfulness meditation practice facilitate critical thinking through the enhancement of executive functioning? To answer this, the current study evaluated whether a 6-week online mindfulness meditation intervention increased dispositional mindfulness, executive functioning, critical thinking performance and the endorsement of key critical thinking dispositions to a greater extent than an active-control sham meditation condition. The hypotheses which were tested can be seen in Table 5.1. Another aim was to investigate the role of executive functioning in mediating the predicted positive relationship between mindfulness and critical thinking performance. Finally, the study aimed to explore the participants’ experiences of taking part in an online mindfulness meditation intervention by assessing the real-world outcomes they perceived as well as its impact on their wellbeing.

Many claims have been made regarding the supposed effectiveness of mindfulness training programmes for improving thinking skills (Lilley, Whitehead, Jones, & Pykett, 2014). While there are theoretical and historical reasons supporting this view, it has not been adequately investigated and so this claim is premature. The contribution of this study lies in its rigorous approach to investigating this claim for the first time in the context of an RCT.
Table 5.1. Hypotheses for Study 3.

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<th>Hypothesis</th>
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<td>Critical Thinking</td>
<td>Halpern Critical</td>
<td>Thinking Assessment¹, Heuristic and Biases items²</td>
<td>Scores on critical thinking measures¹,² will increase more for the MM group than for the SM group from baseline to follow-up</td>
<td>Mixed ANOVA</td>
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<tr>
<td>Critical Thinking</td>
<td>Halpern Critical</td>
<td>Thinking Assessment¹, Heuristic and Biases items²</td>
<td>The effect of the intervention on critical thinking scores¹,² will be moderated by baseline endorsement of thinking dispositions¹,²</td>
<td>ANCOVA</td>
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<tr>
<td>Critical Thinking</td>
<td>Actively Open-minded</td>
<td>Thinking¹, Need for Cognition²</td>
<td>Endorsement of critical thinking dispositions¹,² will increase more for the MM group than for the SM group from baseline to follow-up</td>
<td>Mixed ANOVA</td>
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<td>Executive Control</td>
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<td>Memory Task</td>
<td>Executive control will increase more for the MM group than for the SM group from baseline to follow-up</td>
<td>Mixed ANOVA</td>
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<td>Executive Control</td>
<td>Sternberg</td>
<td>Working Memory Task, Halpern Critical Thinking Assessment¹, Heuristic and Biases items²</td>
<td>Changes in executive control will mediate the relationship between group assignment and critical thinking performance following the intervention¹,²</td>
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<td>Secondary Wellbeing</td>
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<td>Positive Affect and Negative Affect Schedule</td>
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<td>Real-world Outcomes Inventory</td>
<td>Real-world Outcomes Inventory</td>
<td>Negative real-world outcomes will decrease more for the MM group than for SM group from baseline to follow-up</td>
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</table>

¹,² Analyses conducted separately.
5.2 Methods

Ethics approval and consent to participate

This study received full approval from the NUI Galway Research Ethics Committee. Written informed consent was sought from all participants for both their participation and the publication of the results of the research. Participants were reminded of their freedom to withdraw at any time and that their data would be stored securely and anonymously. We had ethical approval to blind participants to their allocated condition and to inform participants that the trial involved comparison of two different forms of meditation rather than fully inform them regarding the comparison of mindfulness meditation and a sham meditation at the outset. Full debriefing was carried out following the end of the follow-up data collection. There are no reported risks associated with mindfulness training and similar online mindfulness interventions. The questionnaires, information and activities may highlight a small amount of emotional distress for some people. However, previous intervention studies on mindfulness suggest that only a small number of participants drop out for these reasons (Zautra et al., 2008). It was clearly communicated that completing the questionnaires and the intervention is voluntary and that if it does bring up difficulties relevant professionals should be contacted. An experienced clinician agreed to provide advice on the management of any participant in whom a high level of emotional distress is identified. This situation did not arise. Since adverse consequences of using Headspace have not been reported in previous studies, we did not have objective criteria for discontinuing the intervention for individuals apart from their own decision to withdraw. The study was registered in the International Standard Randomised Controlled Trial Number registry (RCT ID: ISRCTN16588423).

Design

The CONSORT guidelines for evaluation of randomised controlled trials (Schulz et al. 2010), the CONSORT extension for non-pharmacological treatment interventions (Boutron et al. 2008), the SPIRIT checklist of protocol items and the TIDIER checklist for intervention
description and replication (Hoffmann et al., 2014) were adhered to in the design of this study.

This pre-registered study involved a two-arm randomised-controlled superiority trial with one intervention condition, guided mindfulness meditation, and one active-control condition, sham meditation. The design employed was a 2 (condition) x 2 (time) parallel-group design which is explanatory in nature. Measurement took place immediately before randomisation (T1) and 6 weeks after the beginning of the intervention (T4). The content of both the intervention condition and the active-control condition was delivered via a smartphone/online application between T1 and T4. Manipulation checks were carried out to assess intervention acceptability, technology acceptance and meditation quality two weeks after baseline (T2) and 4 weeks after baseline (T3). The protocol for this study was published in advance of its completion (Noone & Hogan, 2016). No changes were made to the trial following this.

Sample size (Incl. flow chart)

An *a priori* sample size calculation carried out using G*Power* (Faul, Erdfelder, Lang, & Buchner, 2007) revealed that with 2 groups, 4 measurements, an assumed correlation among repeated measures of 0.3 (typically low in such research; Rossi, 2012) as well as a medium effect size (again typical in research on the cognitive effects of mindfulness; Chiesa et al., 2011) and a power of 0.8, the recommended sample size for mixed (repeated-measures and between factors) ANOVA was 56. An attrition rate of 20% from baseline to follow-up was expected based on reported attrition rates of between 20% and 40% (Howells et al., 2014; Lim et al., 2015) for research using the Headspace app and the incentives available in the form of course credit, lunches provided at data collection and free subscription to Headspace for six months following the intervention. With this in mind, we sought to recruit at least 80 participants. Following screening, our baseline sample included 91 participants and attrition led to a follow-up sample of 71 participants. Figure 5.1 depicts the flow of participants through the study.
Table 5.2 presents the characteristics of our sample. Our inclusion criteria specified that university students at NUI Galway who are over 18 years of age, below 65 years of age and have either English as first language or university level English (i.e. equivalent to 80 on TOEFL or 6.5 on IELTS) were eligible for this study.

Those who were already experienced in meditation, alcohol or drug dependent, currently on any form of sedating medication, have suffered from any medical conditions associated with a head injury, spinal injury, epilepsy, or stroke (because these can interfere with cognitive performance) or do not possess normal or corrected-to-normal vision and hearing (required for computerised tasks) were excluded. Furthermore those
exhibiting high levels of depression, anxiety or psychotic symptoms (as assessed with the Modified Mini Screen; OASAS, 2005) were excluded. Debriefing phone calls were made to those excluded and they were offered access to the intervention materials. The opportunity to talk with an experienced clinician (who agreed to provide advice on the management of any participant in whom a high level of emotional distress was identified), was offered to those who exceeded the cut-off score on the Modified Mini Screen.

**Table 5.2. Sample Characteristics.**

<table>
<thead>
<tr>
<th></th>
<th>Sham Meditation</th>
<th>Mindfulness Meditation</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline</td>
<td>Follow-up</td>
<td>Baseline</td>
</tr>
<tr>
<td>N</td>
<td>48</td>
<td>35</td>
<td>43</td>
</tr>
<tr>
<td>Females/Males$^1$</td>
<td>35/13</td>
<td>27/8</td>
<td>34/7</td>
</tr>
<tr>
<td>Age - M</td>
<td>21.06</td>
<td>20.74</td>
<td>20.77</td>
</tr>
<tr>
<td>Age - SD</td>
<td>4.67</td>
<td>3.43</td>
<td>4.11</td>
</tr>
<tr>
<td>Years in higher education - M</td>
<td>1.93</td>
<td>1.87</td>
<td>1.37</td>
</tr>
<tr>
<td>Years in higher education - SD</td>
<td>2.01</td>
<td>2.02</td>
<td>.93</td>
</tr>
</tbody>
</table>

$^1$ Two participants chose not to report their gender

**Randomisation**

Students in NUI Galway were invited to participate by email and through advertisements on social media and on acceptance of this invitation they filled out a screening questionnaire online. The screening questionnaire included demographic questions, questions pertaining to our inclusion and exclusion criteria and the Modified Mini Screen. Those that satisfied the inclusion criteria were invited to take part in the intervention and given instructions on how to attend baseline data collection sessions. Following baseline data collection, participants were randomised to either the mindfulness meditation group or the sham meditation group with a 1:1 ratio. Block randomisation was employed using a fixed block of 6 (Sealed Envelope Ltd., 2015). Unique Headspace access codes corresponding to the
two conditions were provided to the researcher. These were labelled Condition A and Condition B and only after analysis was the nature of these conditions revealed to the researchers by Headspace. Therefore, both participants and researchers were blinded. It is important to note that blinding could have been readily undone on a participant-by-participant basis if the need had arisen.

Intervention

Intervention materials were delivered via Headspace, a commercially available application which runs on all major smartphones, tablets and web browsers. In order to participate, individuals were required to have access to a smartphone or desktop computer with Internet access. Participants can practice at any time of day and wherever they prefer. Headspace offers straightforward, guided, bite-sized mindfulness training that is non-religious in nature. The Headspace meditation scripts are designed by an individual with Buddhist monastic training who guides users through mindfulness meditations and key concepts related to mindfulness meditation using both audio and visual materials.

Guarantees were signed with Headspace ensuring that participant data collected through Headspace will never be sold, distributed, or publicised (except anonymously and in aggregated form in scientific publications) with Headspace having no involvement in the conduct, analysis, or reporting of the research in any way.

Following randomisation, participants were sent an email introducing Headspace and describing the sign-up process. To get started, participants were required to register on headspace.com using their name and email address. Each participant was given a unique code providing free access to Headspace for the duration of the study. After registering, participants could begin meditating straight away, if they so wished.

The intervention was 6-weeks in length. All participants were encouraged to practice meditation (or sham-meditation if assigned to the control group) daily for the course of the 6-weeks by listening to each of the 30 ten minute guided sessions which they accessed through the Headspace
app. The only difference in the user experience across the groups was the nature of the guided sessions, as described next.

**Experimental Condition**

Participants in the experimental condition had access to 30 sessions of guided mindfulness practice. These sessions introduce the concept and practice of mindfulness training and each session gradually builds on the previous one. The sessions are guided by Andy Puddicombe, a trained Buddhist monk who is also a registered meditation consultant with the UK Health Commission. Each session begins with the participant instructed to sit, close their eyes and take deep breaths. Following this, participants are guided through mental body scan exercises intended to cultivate a mindful state which involve practicing focusing attention on present-moment sensations in the body without emotionally elaborating on these sensations. Gradually participants learn to re-direct their attention when the mind wanders and to broaden their present-moment awareness to all current internal and external stimuli. Towards the end of the course of sessions, participants are encouraged to apply this type of awareness to everyday activities.

**Active-control Condition**

Participants in the active-control condition had access to 30 sessions of guided sham meditation practice. These sessions discuss meditation and introduce breathing exercises under the guise of mindfulness practice. However, specific instructions for how to pay attention to the breath or other stimuli are not given. Instead, participants are encouraged to sit quietly, with their eyes closed and every few minutes they are reminded to take deep breaths as they sit in meditation. These sessions are also guided by Andy Puddicombe and accessed in exactly the same way as content in the experimental condition. This approach was taken as it controls for both physiological relaxation and expectations regarding meditation. Other approaches used in previous have only controlled for one of these. For example, progressive muscle relaxation only controls for physiological
relaxation, while mind wandering inductions only control for expectations regarding meditation. These approaches did improve on previous attention-only and audiobook controls and all of these are a significantly better approach than waitlist controls when possible (Davidson & Kaszniak, 2015; Davidson, 2010).

Data Collection

Primary and secondary measures were taken at baseline and following the end of the intervention. Manipulation checks were administered by email during the second and fourth weeks of the intervention. All of the measures were presented using SurveyGizmo. An exception was the Sternberg Working Memory which was presented using Inquisit (Draine, 2014). Baseline data collection took place during the week preceding the start of the intervention in the PC Suite of the School of Psychology at NUI Galway. Three sessions were scheduled in order to facilitate attendance at different times, each of which was able to accommodate up to 30 participants comfortably. A break with food and refreshments was given halfway through the procedure. This data collection approach was repeated during the week following the end of the intervention. No changes were made to the outcome measures used following initial design and registration.

Primary outcome measures

Halpern Critical Thinking Assessment (HCTA; Halpern, 2010)

The HCTA involves 25 real-world involving medical research, social policy analysis and other types of problems encountered in everyday life. Each situation is accompanied by both open and closed questions. A standardised guide answers is used to score forced-choice questions. This guide includes specific scoring prompts for open-ended questions. The total possible score across all situations is 194 (Halpern, 2010). The internal reliability of the HTCA is usually adequate (Butler et al., 2012; Dwyer, Hogan, & Stewart, 2012) and was found to be so at both time points in this study (Baseline: Cronbach’s $\alpha = .72$, $\omega = .74$, Greatest Lower Bound = .79; Follow-up: Cronbach’s $\alpha = .81$, $\omega = .86$, Greatest Lower Bound = .79).
Chapter 5 – Study 3

Heuristics and Biases items (West, Toplak, & Stanovich, 2008)

These 16 items were taken from the literature on judgment and decision-making. It has been suggested that they assess aspects of critical thinking not captured by traditional measures (West et al., 2008). Each of these items was scored as either correct or incorrect so total score of 16 was possible. These items included problems dealing with causal base rates, noncausal base rates, the law of large numbers, regression to the mean, the Gambler’s fallacy, Bayesian reasoning, disjunctive reasoning and framing. Though these items do not represent a unifactorial construct, we followed West and colleagues (West et al., 2008) in aggregating the scores on these items and as a result found poor reliability (Baseline: Cronbach’s $\alpha = .44$, $\omega = .41$, Greatest Lower Bound = .67; Follow-up: Cronbach’s $\alpha = .34$, $\omega = .46$, Greatest Lower Bound = .66) which suggests that multiple processes underlie the rational thinking required by these items. Common to these items, however, is the need to inhibit an automatic heuristic response and this is the process of interest in this study.

Five Factor Mindfulness Questionnaire (FFMQ; Baer, Smith, Hopkins, Krietemeyer, & Toney, 2006)

The FFMQ includes 39 items across 5 sub-scales tapping separate facets of dispositional mindfulness: describing (Baseline: Cronbach’s $\alpha = .89$, $\omega = .92$, Greatest Lower Bound = .93; Follow-up: Cronbach’s $\alpha = .90$, $\omega = .94$, Greatest Lower Bound = .94), observing (Baseline: Cronbach’s $\alpha = .75$, $\omega = .85$, Greatest Lower Bound = .87; Follow-up: Cronbach’s $\alpha = .82$, $\omega = .86$, Greatest Lower Bound = .90), non-reactivity (Baseline: Cronbach’s $\alpha = .82$, $\omega = .89$, Greatest Lower Bound = .91; Follow-up: Cronbach’s $\alpha = .77$, $\omega = .84$, Greatest Lower Bound = .84), non-judgment (Baseline: Cronbach’s $\alpha = .88$, $\omega = .91$, Greatest Lower Bound = .90; Follow-up: Cronbach’s $\alpha = .92$, $\omega = .94$, Greatest Lower Bound = .96) and acting with awareness (Baseline: Cronbach’s $\alpha = .86$, $\omega = .92$, Greatest Lower Bound = .93; Follow-up: Cronbach’s $\alpha = .87$, $\omega = .93$, Greatest Lower Bound = .95). Responses are captured on a 5-point Likert scale (e.g. 1 = never or very
rarely true; 5 = very often or always true). It has been shown to have adequate internal consistency and construct validity (Baer et al., 2006).

Secondary outcome measures

Sternberg working memory task (Sternberg, 1975)

This task is a measure of executive control of working memory. Participants were required to memorise a series of letters. They then indicated, as quickly and accurately as possible, whether a probe was in this series. There were 54 trials and the number of accurate responses was employed as the dependent variable.

Positive Affect and Negative Affect Schedule (PANAS; Watson & Clark, 1994)

This scale was used to assess general levels of positive and negative affect by asking participants to indicate to what extent they felt each of 20 positive and 10 negative emotions over the past week using a 5-point Likert scale (e.g. 1 = very slightly or not at all; 5 = extremely). This scale tends to demonstrate good reliability (Simmons & Lehmann, 2012) and this was replicated in the current study for the positive (Baseline: Cronbach’s $\alpha = .87$, $\omega = .90$, Greatest Lower Bound = .94; Follow-up: Cronbach’s $\alpha = .90$, $\omega = .92$, Greatest Lower Bound = .95) and negative affect subscales (Baseline: Cronbach’s $\alpha = .86$, $\omega = .91$, Greatest Lower Bound = .92; Follow-up: Cronbach’s $\alpha = .86$, $\omega = .91$, Greatest Lower Bound = .92).

Warwick-Edinburgh Mental Wellbeing Scale (Tennant et al., 2007)

This 14 item scale assesses subjective well-being and psychological functioning. The scale is scored by summing responses to each item answered on a 5 point Likert scale. The total possible score is therefore 70 and a high score reflects a high level of positive mental health (Stewart-Brown & Janmohamed, 2008). This scale showed excellent reliability in this study (Baseline: Cronbach’s $\alpha = .85$, $\omega = .89$, Greatest Lower Bound = .94; Follow-up: Cronbach’s $\alpha = .89$, $\omega = .92$, Greatest Lower Bound = .95).
Real World Outcomes Inventory (Butler, 2012)

This is a behavioural checklist focused on negative life outcomes from many domains. Greater performance on the HCTA has been found to be related to fewer negative life outcomes using this inventory (Butler, 2012; Butler et al., 2012). It was slightly adapted to ensure cultural relevance by omitting items which do not fit the Irish student context (e.g. got blisters from sunburn). The checklist presented participants with 32 possible outcomes and they were asked to indicate whether they had experienced each outcome in the previous 2 weeks.

Potential moderators

Need for Cognition scale (Cacioppo & Petty, 1982)

This unidimensional scale assesses individuals’ tendency to engage in effortful cognitive activity (Cacioppo & Petty, 1982). The scale includes 18 items which are rated on a 5-point Likert scale (e.g. 1 = extremely uncharacteristic of me; 5 = extremely characteristic of me) and has a total possible score of 90. It has been extensively validated and has been found to have adequate reliability (Tolentino, Curry, & Leak, 1990). It had excellent reliability in this study (Baseline: Cronbach’s $\alpha = .89$, $\omega = .91$, Greatest Lower Bound = .95; Follow-up: Cronbach’s $\alpha = .90$, $\omega = .92$, Greatest Lower Bound = .92).

Actively Open-Minded thinking scale (Stanovich & West, 1997)

This scale assesses the extent to which individuals tend to approach information in an open and flexible manner. It includes 41 items which are rated on a 6-point Likert scale (e.g. 1 = strongly agree; 6 = strongly disagree). The total possible score is 246. It has been validated as unidimensional and is found to be reliable (Stanovich & West, 2007). It demonstrated adequate reliability in this study (Baseline: Cronbach’s $\alpha = .87$, $\omega = .88$, Greatest Lower Bound = .86; Follow-up: Cronbach’s $\alpha = .89$, $\omega = .91$, Greatest Lower Bound = .89).
Manipulation checks

Participants were asked to complete these manipulation checks online directly following a guided meditation session. A survey containing the following measures was sent to participants by email at two weeks and four weeks following the start of the intervention.

Adherence

Objective adherence data was collected through the Headspace accounts of the participants. The number of completed sessions was recorded.

Practice Quality- Mindfulness questionnaire (Del Re, Flückiger, Goldberg, & Hoyt, 2012)

This 6 item questionnaire consists of two factors assessing perseverance (i.e. persistent returning of focus to object of meditation) and receptivity (i.e. a willingness to embrace the experience) during meditation. Participants indicated the percentage of time during their meditation session that day during which their experience reflected each of the item statements. This scale has been shown to fit a 2-factor structure and practice quality predicts improvements in psychological symptoms (Del Re et al., 2012). Both the perseverance (Week 2: Cronbach’s α = .77, ω = .98, Greatest Lower Bound = .86; Week 4: Cronbach’s α = .67, ω = .79, Greatest Lower Bound = .73) and receptivity (Week 2: Cronbach’s α = .81, ω = .91, Greatest Lower Bound = .82; Week 4: Cronbach’s α = .74, ω = .99, Greatest Lower Bound = .85) subscales showed adequate reliability.

Technology Acceptance Model questionnaire (TAM; Davis, 1993)

The TAM was employed to assess participants’ perceptions regarding their use of the Headspace app. The scale consists of factors assessing barriers to use (3 items; Week 2: Cronbach’s α = .88, ω = .93, Greatest Lower Bound = .92; Week 4: Cronbach’s α = .67, ω = .79, Greatest Lower Bound = .73), perceived ease of use (3 items; Week 2: Cronbach’s α = .89, ω = .94, Greatest Lower Bound = .91; Week 4: Cronbach’s α = .74, ω = .83, Greatest Lower Bound = .79), enjoyment (2 items; Week 2:}
Cronbach’s α = .92; Week 4: Cronbach’s α = .87) and intention to use (2 items; Week 2: Cronbach’s α = .93; Week 4: Cronbach’s α = .90). Items are measured on a 5-point Likert scale (e.g. 1= strongly disagree; 5 = strongly agree).

**Intervention Acceptability (Kirkpatrick, Manoukian, Dear, Johnston, & Titov, 2013)**

Two items assessed satisfaction with the programme and satisfaction with the content of the guided sessions in particular. Another two items asked whether participants would recommend the programme and whether they felt it was worth their time. Questions like these have been used in previous research examining the acceptability of low-intensity online treatments and across a range of different age groups and health conditions (Kirkpatrick et al., 2013).

**Statistical analysis**

Data was primarily analysed through a series of 2 (time – baseline, follow-up) x 2 (group – mindfulness meditation, sham meditation) mixed ANOVAs for each primary and secondary outcome measure. The time x group interaction effects were of primary interest as these can demonstrate the presence of differences between the experimental group and the control group in the amount of change on the dependent variables. Correlations between manipulation check measures were also examined as were their correlations with mindfulness, executive functioning and critical thinking change scores. Whether mediation quality and quantity differed across groups was tested using 2 (time – week 2, week 4) x 2 (group – mindfulness meditation, sham meditation) mixed ANOVAs. Logistic regressions were employed to assess whether manipulation check variables predicted whether participants dropped out of the study. These analyses were completed using SPSS 20 (IBM Corp., 2013). Simple mediation analysis was conducted using Structural Equation Modelling (SEM) to test whether executive functioning was a significant mediator of any potential relationship between mindfulness and critical thinking. This analysis was conducted using AMOS (Arbuckle, 2014). As noted above, these tests were adequately powered –
including SEM analyses (see Iacobucci, Saldanha, & Deng, 2007, for evidence of adequate power for simple mediation using SEM in samples as small as n = 30). Our analyses took an intention-to-treat approach and missing data was treated with a baseline-observation-carried-forward (BOCF) approach as this is the most conservative approach to the treatment of missing data. In addition, since there were just two data collection time-points, other methods of imputation such as worst-observation-carried-forward or last-observation-carried-forward were equivalent to BOCF in this case (Shao, Jordan, & Pritchett, 2009).

5.3 Results

Descriptive Statistics and Data Inspection

Means and standard deviations for each dependent variable are displayed in Table 5.3. The data were inspected to ensure assumptions for the planned analyses were met. Q-Q plots, histograms and skewness and kurtosis values were examined for each continuous variable to assess normality. This revealed that the distributions of responses at both time points for both real world outcomes and negative affect were positively skewed while scores on the executive functioning task were negatively skewed. Log transformations were carried out on these variables. Box plots and z-scores were examined in order to identify potential outliers. One extremely low score was identified in the baseline scores on the executive functioning task. This score was winsorised so that it was brought up to the same value as the next highest score to ensure a normal distribution.

Manipulation Checks

These analyses were carried out to investigate whether any other characteristics of the intervention besides the content may have affected its outcomes and participant adherence and whether the differences in intervention content led to differences in meditation quality. They are limited by a poor response rate which resulted in a lack of adequate power. Tables 5.4 and 5.5 display correlations between manipulation check measures and change scores for executive functioning and critical thinking measures.
Table 5.3. Means with 95% Confidence Intervals and Standard Deviations for Primary and Secondary Measures.

<table>
<thead>
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<th></th>
<th>Sham Meditation</th>
<th>Mindfulness Meditation</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Baseline</td>
<td>Follow-up</td>
</tr>
<tr>
<td></td>
<td>M</td>
<td>95% CI</td>
</tr>
<tr>
<td>Heuristics and Biases</td>
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<td>[6.85, 8.31]</td>
</tr>
<tr>
<td>Wellbeing</td>
<td>49.98</td>
<td>[48.27, 51.71]</td>
</tr>
<tr>
<td>Positive Affect</td>
<td>34.08</td>
<td>[32.13, 35.92]</td>
</tr>
<tr>
<td>Real World Outcomes</td>
<td>3.71</td>
<td>[2.96, 4.54]</td>
</tr>
</tbody>
</table>
Table 5.4. Bivariate correlations between the primary and secondary measures at Time 1

<table>
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<tr>
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<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Observing</td>
<td>—</td>
<td>.14</td>
<td>.09</td>
<td>-08</td>
<td>.18</td>
<td>-04</td>
<td>.03</td>
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<td>.12</td>
<td>.25</td>
<td>.08</td>
<td>-.06</td>
</tr>
<tr>
<td>2. Non-reactivity</td>
<td>—</td>
<td>.32</td>
<td>.31</td>
<td>.10</td>
<td>.16</td>
<td>.29</td>
<td>.25</td>
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<td>.51</td>
<td>.43</td>
<td>.31</td>
<td>-.17</td>
<td></td>
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<tr>
<td>3. Acting with Awareness</td>
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<td>.54</td>
<td>.44</td>
<td>.14</td>
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<td>.03</td>
<td>.31</td>
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<td>.34</td>
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<tr>
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<td>.09</td>
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<td>-.39</td>
<td>-.16</td>
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<td>5. Describing</td>
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<td>.08</td>
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<td>.32</td>
<td>-.18</td>
<td>.29</td>
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<td>6. HCTA</td>
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<td>.56</td>
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<tr>
<td>8. Actively Open-Minded Thinking</td>
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<td>.47</td>
<td>.33</td>
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<td>9. Need for Cognition</td>
<td>—</td>
<td>.03</td>
<td>.31</td>
<td>.29</td>
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<tr>
<td>10. Executive Function</td>
<td>—</td>
<td>-.10</td>
<td>-.10</td>
<td>-.17</td>
<td>-.12</td>
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<td>11. Wellbeing</td>
<td>—</td>
<td>.70</td>
<td>.50</td>
<td>.13</td>
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<td>12. Positive Affect</td>
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<td>-.02</td>
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<td>13. Negative Affect</td>
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<td>14. Real World Outcomes</td>
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* p < .05, ** p < .01, *** p < .001
Table 5.5. Bivariate correlations between the primary and secondary measures at Time 2

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<tbody>
<tr>
<td>1. Observing</td>
<td>—</td>
<td>.36 **</td>
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<td>-.15</td>
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<td>2. Non-reactivity</td>
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<td>3. Acting with Awareness</td>
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<td>.53 ***</td>
<td>.40 ***</td>
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<td>.32 **</td>
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<td>.28 *</td>
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<td>.59 ***</td>
<td>.17</td>
<td>.49 ***</td>
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<td>-.19</td>
<td>-.20</td>
<td>-.12</td>
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<td>8. Actively Open-Minded Thinking</td>
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<td>.35 **</td>
<td>.29 *</td>
<td>.08</td>
<td>.08</td>
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<td>9. Need for Cognition</td>
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<td>.38 ***</td>
<td>.43 ***</td>
<td>-.12</td>
<td>-.24 *</td>
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<td>-.14</td>
<td>-.29 *</td>
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<tr>
<td>11. Wellbeing</td>
<td>—</td>
<td>.73 ***</td>
<td>-.47 ***</td>
<td>-.20</td>
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<td>12. Positive Affect</td>
<td>—</td>
<td>-.15</td>
<td>-.25 *</td>
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<td>13. Negative Affect</td>
<td>—</td>
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<td>14. Real World Outcomes</td>
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</tbody>
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* p < .05, ** p < .01, *** p < .001
Table 5.6. Means and Standard Deviations for Manipulation Check Variables and their Correlations with Change Scores.

<table>
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<tr>
<th>Variable</th>
<th>Sham Meditation</th>
<th>Mindfulness Meditation</th>
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<tr>
<td></td>
<td>N</td>
<td>M</td>
</tr>
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<td>48</td>
<td>14.85</td>
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<tr>
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<td>Week 2 TAM Barriers</td>
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</tr>
<tr>
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<td>5.69</td>
</tr>
<tr>
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<td>14.46</td>
</tr>
<tr>
<td>Week 4 TAM Ease</td>
<td>35</td>
<td>14.00</td>
</tr>
<tr>
<td>Week 2 TAM Enjoyment</td>
<td>13</td>
<td>9.23</td>
</tr>
<tr>
<td>Week 4 TAM Enjoyment</td>
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<td>9.57</td>
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<tr>
<td>Satisfaction</td>
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<td>3.73</td>
</tr>
<tr>
<td>Week 4 Satisfaction</td>
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<td>3.50</td>
</tr>
<tr>
<td>PMQ Perseverance</td>
<td>12</td>
<td>53.69</td>
</tr>
<tr>
<td>Week 4 PMQ Perseverance</td>
<td>35</td>
<td>55.43</td>
</tr>
<tr>
<td>PMQ Receptivity</td>
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<td>54.86</td>
</tr>
<tr>
<td>Week 4 PMQ Receptivity</td>
<td>35</td>
<td>72.73</td>
</tr>
</tbody>
</table>

Note: Δ = Change score; TAM = Technology Acceptance Model; PMQ = Practice Quality – Mindfulness; HCTA = Halpern Critical Thinking Assessment; SWM = Sternberg Working Memory Task; OBS = Observing Subscale of Five Facet Mindfulness Questionnaire; NR = Non-reactivity of Five Facet Mindfulness Questionnaire.
## Table 5.7. Correlations of Manipulation Check Variables for Sham Meditation and Mindfulness Meditation Groups.

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
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<th>8</th>
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<td>-.01</td>
<td>.01</td>
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<td>.16</td>
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<tr>
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<td>.56</td>
<td>.19</td>
<td>.31</td>
<td>.23</td>
<td>.38</td>
<td>.66**</td>
<td>.39</td>
<td>-.13</td>
<td>.52</td>
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<td>3. Week 4 TAM Ease</td>
<td>.59**</td>
<td>.59</td>
<td>1</td>
<td>-.35</td>
<td>.20</td>
<td>-.36</td>
<td>-.03</td>
<td>.16</td>
<td>.24</td>
<td>.21</td>
<td>.08</td>
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<td>.38</td>
<td>.32</td>
<td>-.06</td>
<td>.33</td>
<td>.45</td>
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<td>.50</td>
<td>.58*</td>
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<td>6. Week 2 Satisfaction</td>
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<td>.09</td>
<td>.76**</td>
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<td>.28</td>
<td>.47</td>
<td>.38*</td>
<td>.66*</td>
<td>1</td>
<td>.69*</td>
<td>.18</td>
<td>.46</td>
<td>.23</td>
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<tr>
<td>8. Week 2 PMQ Perseverance</td>
<td>.04</td>
<td>.21</td>
<td>-.25</td>
<td>.24</td>
<td>-.09</td>
<td>.36</td>
<td>.25</td>
<td>1</td>
<td>.71*</td>
<td>.02</td>
<td>.29</td>
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<td>9. Week 4 PMQ Perseverance</td>
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<td>.26</td>
<td>-.24</td>
<td>.27</td>
<td>-.42</td>
<td>.34*</td>
<td>.90**</td>
<td>1</td>
<td>.35</td>
<td>-.07</td>
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<td>10. Week 2 PMQ Receptivity</td>
<td>.25</td>
<td>.33</td>
<td>.03</td>
<td>.01</td>
<td>-.12</td>
<td>.44</td>
<td>-.08</td>
<td>.20</td>
<td>-.01</td>
<td>1</td>
<td>.73**</td>
</tr>
<tr>
<td>11. Week 4 PMQ Receptivity</td>
<td>-.13</td>
<td>.70*</td>
<td>-.07</td>
<td>-.59</td>
<td>-.21</td>
<td>-.13</td>
<td>-.19</td>
<td>-.24</td>
<td>-.45**</td>
<td>.73*</td>
<td>1</td>
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</tbody>
</table>

Note: Bottom Left quadrant = Correlations for Sham Meditation Group. Top Right quadrant = Correlations for Mindfulness Meditation Group. TAM = Technology Acceptance Model; PMQ = Practice Quality – Mindfulness.
There are several correlational relationships of note here. Changes in performance from baseline to follow-up on measures of critical thinking and executive functioning were not related to any manipulation check measures. There were, however, significant positive correlations observed between meditation quantity and increases in HCTA scores and observing in both groups. Meditation quantity was also positively related to task ease and enjoyment for the sham meditation group. In terms of meditation quality, while receptivity was not significantly related to any manipulation check measures, perseverance was positively related to satisfaction with the intervention for both groups and also to task ease within the mindfulness meditation group.

Differences across 2 (time – week 2, week 4) x 2 (group – mindfulness meditation, sham meditation) were analysed using a series of mixed ANOVAs. Different patterns of effects were found for both aspects of meditation quality, perseverance and receptivity. No significant effects were found for time ($F(1, 20) = .04, p = .84, \eta^2_p = .002 [.00, .07]$), group ($F(1, 20) = 1.59, p = .22, \eta^2_p = .07 [.00, .28]$) or their interaction for perseverance ($F(1, 20) = .03, p = .86, \eta^2_p = .002 [.00, .06]$). The main effect of time ($F(1, 20) = .01, p = .93, \eta^2_p = .001 [.00, .02]$) was not significant for receptivity but there was an overall difference between the groups ($F(1, 20) = 5.47, p = .03, \eta^2_p = .22 [.01, .43]$) and an interaction effect was found ($F(1, 20) = 9.04, p = .007, \eta^2_p = .31$). While there was a significant difference between the groups towards the beginning of the intervention ($t(10.23) = -3.91, p = .005$) such that receptivity was higher in the mindfulness meditation group ($M = 83.50$) than the sham meditation group ($M = 58.17$), this difference was not present later in the intervention ($t(20) = -.72, p = .48$) as receptivity increased for those in the sham meditation group ($M = 68.13; t(9) = -2.04, p = .07$) and decreased for those in the mindfulness meditation group ($M = 74.11; t(11) = 2.21, p = .05$), though neither change was significant.

There was no difference between the groups in meditation quantity and, on average, participants completed half of the 30 sessions they were asked to complete ($t(89) = -.32, p = .75$). Table 5.6 breaks down this average
to show that a third of the sample did not complete any meditation sessions, half of the sample completed at least half of the sessions and a quarter of the sample completed all 30 sessions. Both groups appeared to enjoy using Headspace equally, as demonstrated by the non-significant effects of time \((F(1, 21) = 1.03, p = .32, \eta_p^2 = .05 [.00, .24])\), group \((F(1, 21) = 2.16, p = .16, \eta_p^2 = .09 [.00, .30])\) and their interaction \((F(1, 21) = .01, p = .95, \eta_p^2 = .00 [.00, .02])\) on enjoyment measures. Though the main effects of time \((F(1, 21) = .11, p = .74, \eta_p^2 = .01 [.00, .13])\) and group \((F(1, 21) = 1.87, p = .19, \eta_p^2 = .08 [.00, .29])\) were not significant, an interaction effect was found for task difficulty \((F(1, 21) = 6.17, p = .02, \eta_p^2 = .23 [.02, .44])\) which showed that the sham meditation group \((M = 14.73)\) initially found Headspace slightly easier to use than the mindfulness meditation group did \((M = 13.25; t(18) = 2.83, p = .01)\). There was a difference in overall acceptance of the intervention, with those in the mindfulness meditation group \((M = 4.25)\) reporting greater satisfaction on average than those in the sham meditation group \((M = 3.82; F(1, 21) = 5.60, p = .03, \eta_p^2 = .21 [.01, .42])\). Time \((F(1, 21) = 4.35, p = .05, \eta_p^2 = .17 [.00, .38])\) and its interaction with group \((F(1, 21) = .25, p = .62, \eta_p^2 = .01 [.00, .16])\) had no effect on satisfaction.

Table 5.6. Percentage of sessions completed by the overall sample and each group separately.

<table>
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<tr>
<th></th>
<th>None</th>
<th>At least 1</th>
<th>At least 10</th>
<th>At least 15</th>
<th>At least 20</th>
<th>Complete</th>
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<tbody>
<tr>
<td>Overall</td>
<td>31.87</td>
<td>68.13</td>
<td>58.24</td>
<td>50.55</td>
<td>37.36</td>
<td>24.18</td>
</tr>
<tr>
<td>Sham Meditation</td>
<td>35.42</td>
<td>64.58</td>
<td>60.42</td>
<td>54.17</td>
<td>37.50</td>
<td>18.75</td>
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<td>Mindfulness</td>
<td>27.91</td>
<td>72.09</td>
<td>55.81</td>
<td>46.51</td>
<td>37.21</td>
<td>30.23</td>
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</table>

Finally, logistic regressions were carried out to examine what factors (at each measurement point), including meditation quality and quantity, and task enjoyment and difficulty, predicted participant attrition. The model including these factors as measured during week 2 of the intervention was statistically significant and correctly classified 96% of cases \((\chi^2(5) = 16.39, p = .006)\) but none of the factors individually predicted attrition.
Later in the intervention, at week 4, participants who reported greater enjoyment using Headspace and those who completed more meditation sessions were more likely to attend follow-up data collection. This model, which included the same variables as measured during week 2 of the intervention classified 95% of cases correctly ($\chi^2(5) = 38.28, p < .001$). See Table 5.7 for a summary of these models.

Table 5.7. Logistic regressions predicting participant attrition.

<table>
<thead>
<tr>
<th>Week 2</th>
<th>$\beta$</th>
<th>SE</th>
<th>Wald</th>
<th>df</th>
<th>$p$</th>
<th>Odds Ratio</th>
<th>95% CI for Odds Ratio</th>
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</thead>
<tbody>
<tr>
<td>Meditation Quantity</td>
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<td>255.19</td>
<td>0.00</td>
<td>1</td>
<td>.99</td>
<td>.10</td>
<td>.00 1.69 x 10^{216}</td>
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<tr>
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<td>0.05</td>
<td>0.08</td>
<td>1</td>
<td>.78</td>
<td>.99</td>
<td>.90 1.08</td>
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<tr>
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<td>0.08</td>
<td>0.07</td>
<td>1</td>
<td>.79</td>
<td>1.02</td>
<td>.88 1.19</td>
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<tr>
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<td>1.57</td>
<td>1</td>
<td>.21</td>
<td>6.86</td>
<td>.34 139.47</td>
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<tr>
<td>TAM Enjoyment</td>
<td>-1.64</td>
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<td>1.07</td>
<td>1</td>
<td>.30</td>
<td>.19</td>
<td>.01 4.34</td>
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<table>
<thead>
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<th>Wald</th>
<th>df</th>
<th>$p$</th>
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<th>95% CI for Odds Ratio</th>
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<td>.38 .93</td>
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<td>.08</td>
<td>1.11</td>
<td>.99 1.24</td>
</tr>
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<td>1.99</td>
<td>1</td>
<td>.16</td>
<td>4.06</td>
<td>.58 28.47</td>
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<tr>
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<td>3.95</td>
<td>1</td>
<td>.047</td>
<td>.24</td>
<td>.06 .98</td>
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</tbody>
</table>

Primary Analyses

Hypothesis 1 stated that mindfulness would increase more for the mindfulness meditation group than for the sham meditation group from baseline to follow-up. Mixed 2 X 2 ANOVAs were carried out to test this hypothesis for each facet of mindfulness. As explained above, the main focuses of this analysis were the observing and non-reactivity facets and this
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hypothesis would only have been considered as supported if significant interaction effects were demonstrated for at least these two facets. As can be seen in Table 5.8, all aspects of mindfulness increased for both groups from baseline to follow-up, except for acting with awareness. However, no significant interaction effects were found. Therefore, this hypothesis is not supported.

Table 5.8. Mixed ANOVAs testing the effects of group allocation, time and their interaction on dispositional mindfulness.

<table>
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<th>90% CI for η²² Upper</th>
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<td>.001</td>
<td>.00</td>
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Hypothesis 2a\textsuperscript{1} stated that critical thinking as measured by the HCTA would increase more for the mindfulness meditation group than for the sham meditation group from baseline to follow-up. Mixed 2 X 2 ANOVAs were carried out to test this hypothesis for both scores on the HCTA and the heuristics and biases items. While HCTA scores increased from baseline ($M = 107.87$) to follow-up for both groups ($M = 113.65$; $F(1, 89) = 33.65, p < .001, \eta_p^2 = .27 [.15, .39]$), there were no group differences ($F(1, 89) = .001, p = .97, \eta_p^2 < .001 [.00, .0005]$) and no significant interaction effect ($F(1, 89) = .05, p = .83, \eta_p^2 = .001 [.00, .02]$). Therefore, this hypothesis is not supported. Hypothesis 2a\textsuperscript{2} stated that critical thinking as measured by items from the heuristics and biases literature would increase more for the mindfulness meditation group than for the sham meditation group from baseline to follow-up. Neither time ($F(1, 89) = 1.15, p = .29, \eta_p^2 = .01 [.00, .08]$) nor group allocation ($F(1, 89) = 2.16, p = .16, \eta_p^2 = .09 [.00, .10]$) significantly affected scores on these items and their interaction did not significantly affect scores either ($F(1, 89) = 1.37, p = .25, \eta_p^2 = .02 [.00, .08]$). Hypothesis 2b\textsuperscript{1} stated that the effect of the intervention on HCTA scores would be moderated by levels of need for cognition and actively open-minded thinking, respectively. The time by group interaction effects for scores the HCTA did not depend on either need for cognition ($F(2, 85) = .57, p = .57, \eta_p^2 = .01 [.00, .08]$) or actively open-minded thinking ($F(2, 85) = .92, p = .40, \eta_p^2 = .02 [.00, .11]$). Hypothesis 2b\textsuperscript{1} stated that the effect of the intervention on scores on the heuristics and biases items would be moderated by levels of need for cognition and actively open-minded thinking, respectively. The time by group interaction effects for scores the heuristics and biases items did not depend on either need for cognition ($F(2, 85) = 1.98, p = .14, \eta_p^2 = .05 [.00, .12]$) or actively open-minded thinking ($F(2, 85) = 1.63, p = .20, \eta_p^2 = .04 [.00, .11]$).

Hypothesis 3 stated that actively open-minded thinking and need for cognition would increase more for the mindfulness meditation group than for the sham meditation group from baseline to follow-up. There were no overall differences between the conditions in actively open-minded thinking ($F(1, 89) = 1.68, p = .20, \eta_p^2 = .02 [.00, .09]$) but need for cognition was
slightly higher on average in the sham meditation group ($M = 63.67$) than in the mindfulness meditation group ($M = 58.42; F(1, 89) = 4.81, p = .16, \eta_p^2 = .09 [.00, .14]$). While actively open-minded thinking increased for both groups across from baseline ($M = 178.40$) to follow-up ($M = 181.15; F(1, 89) = 7.35, p = .008, \eta_p^2 = .08 [.01, .17]$), need for cognition remained the same ($F(1, 89) = .20, p = .65, \eta_p^2 = .002 [.00, .04]$). There were no interaction effects found for either actively open-minded thinking ($F(1, 89) = 1.73, p = .19, \eta_p^2 = .02 [.00, .09]$) or need for cognition ($F(1, 89) = .83, p = .37, \eta_p^2 = .009 [.00, .07]$).

Hypothesis 4a stated that executive functioning would increase more for the mindfulness meditation group than for the sham meditation group from baseline to follow-up. Hypothesis 4b stated that there would be an indirect effect of group allocation on critical thinking through executive functioning. No differences in performance on the executive functioning task were found between conditions ($F(1, 89) = .10, p = .75, \eta_p^2 = .001 [.00, .04]$) or across time ($F(1, 89) = .49, p = .69, \eta_p^2 = .01 [.00, .06]$). The time by group interaction for performance on the executive functioning task was not significant ($F(1, 89) = .003, p = .96, \eta_p^2 < .001 [.00, .001]$). Furthermore, when simple mediation models were run in AMOS, the bootstrapped 95% confidence intervals for the indirect effects of group allocation on performance on the HCTA ($b = -.41, 95\% CI [-3.17, 2.32]$) and the heuristics and biases items ($b = -.03, 95\% CI [-.29, .14]$) through executive functioning included 0. Therefore, neither of these hypotheses were supported.

Secondary Analyses

Hypothesis 5 stated that wellbeing would increase more across time for the mindfulness meditation group in comparison to the control group. A mixed ANOVA found no evidence to support this hypothesis as the interaction between group allocation and time did not have a significant effect ($F(1, 89) = 2.65, p = .11, \eta_p^2 = .03 [.00, .11]$). There were no overall differences in wellbeing between the groups ($F(1, 89) = .92, p = .34, \eta_p^2 =$
.01 [.0, .07]) but wellbeing did increase for both groups to the same extent from baseline to follow-up ($F(1, 89) = 13.14, p = .0005, \eta_p^2 = .13 [.04, 24])$.

Hypothesis 6a stated that positive affect would increase more across time for the mindfulness meditation group while hypothesis 6b stated that negative affect would decrease more for this group in comparison to the control group. Neither of the two separate mixed ANOVAs demonstrated interaction effects for either positive ($F(1, 89) = .01, p = .91, \eta_p^2 = .0001 [.00, .005]$) or negative affect ($F(1, 89) = .25, p = .62, \eta_p^2 = .003 [.00, .05]$) to support this hypothesis. Negative affect decreased slightly over time ($F(1, 89) = 4.12, p = .045, \eta_p^2 = .04 [.00, .13]$) but there was no overall difference between groups ($F(1, 89) = 1.18, p = .28, \eta_p^2 = .01 [.00, .08]$). There were no differences in positive affect across time ($F(1, 89) = 3.41, p = .07, \eta_p^2 = .04 [.00, .12]$) or condition ($F(1, 89) = .06, p = .81, \eta_p^2 = .001 [.00, .03]$).

Hypothesis 7 stated that the number of recent negative life events would reduce to a greater extent for the mindfulness meditation group. However, a mixed ANOVA showed that there were no significant differences in responses to the Real World Outcomes checklist due to group allocation ($F(1, 89) = .10, p = .75, \eta_p^2 = .001 [.00, .04]$), time ($F(1, 89) = .18, p = .67, \eta_p^2 = .002 [.00, .04]$) or their interaction ($F(1, 89) = 1.76, p = .19, \eta_p^2 = .02 [.00, .09]$).

**Additional Exploratory Analyses**

In order to examine whether the extent to which participants engaged in the intervention was a factor in the results reported above, further exploration of the data was carried out in two ways – a per protocol analysis of the hypotheses tested above and analyses with meditation quantity as a moderator. The per protocol analysis includes only those participants that attended both baseline and follow-up. 75% of this sub-sample of participants completed at least half of the 30 meditation sessions. These analyses followed exactly the same pattern as those reported above and due to this and their exploratory nature, it was deemed unnecessary to report these findings individually. The moderation analyses were carried out using the PROCESS macro for SPSS (Hayes, 2013). These models included group
allocation as the independent variable and the various outcomes measured at
the end of the intervention as the dependent variable. Individual baseline
differences were controlled for by including the outcomes as measured at
baseline as a covariate in each model. The interaction between group
allocation and meditation quantity was included to test for moderation. This
interaction effect was not significant for any of the primary or secondary
outcomes indicating that there were no changes in any outcome due to
increased engagement with meditation sessions.

5.4 Discussion

This study was designed to investigate the claim that mindfulness
practice improves critical thinking. This claim was tested by randomly
allocating carefully screened volunteers to either a mindfulness meditation
program or a closely matched active-control condition for six weeks.
Differences in performance, across time and both groups, on an established
critical thinking measure, items from the literature on heuristics and biases,
key thinking dispositions and executive functioning were examined. The
study also tested whether executive functioning mediates the relationship
between mindfulness and critical thinking in line with default interventionist
theory and previous cross-sectional and experimental studies which
examined this relationship. Secondary analyses examined the effects of
mindfulness practice on wellbeing, affect and life outcomes.

Our results show that, for most outcomes, there were significant
changes from baseline to follow-up but none which can be specifically
attributed to the practice of mindfulness. Looking at dispositional
mindfulness, one can see that participants from both conditions endorsed
each facet (except acting with awareness) to a greater extent at the end of the
intervention. This could be due to insensitivity of the measure employed or
simply that low intensity guided practice of mindfulness meditation is no
more effective in training the skills of mindfulness than the sham meditation
condition we employed. Indeed, critics might argue that we should not
expect people to learn how to practice mindfulness just by using a
smartphone application and without facilitator involvement (Crane et al.,
2012; Fish, Brimson, & Lynch, 2016). However, it must be acknowledged that the delivery of mindfulness training using smartphone applications is currently one of the most common training methods and it appears to be effective, at least for reducing anxiety, depression and stress (Spijkerman et al., 2016). There are many studies using guided meditations similar to those in our mindfulness meditation condition, delivered through smartphone applications (Bostock & Steptoe, 2013; Chittaro & Vianello, 2016; Garrison et al., 2015; Howells et al., 2014; Lim et al., 2015), websites (Aikens et al., 2014; Cavanagh et al., 2013; Glück & Maercker, 2011; Levin, Pistorello, Seeley, & Hayes, 2014; Morledge et al., 2013; Wolever et al., 2012) and CDs (Altschuler, Rosenbaum, Gordon, Canales, & Avins, 2012; Warnecke, Quinn, Ogden, Towle, & Nelson, 2011), which show effects on outcomes reliably associated with increases in mindfulness such as depression, anxiety, stress, wellbeing and compassion. There are two things to note about these studies – they tend not to include a measure of dispositional mindfulness (e.g. only 4% of all mindfulness intervention studies reviewed in a recent meta-analysis included such measures at baseline and follow-up; Quaglia et al., 2016) and they usually employ a weak form of control group such as a no-treatment control or waitlist control (Quaglia et al., 2016). A recent test of the discriminant validity of the FFMQ in the context of a rigorous RCT demonstrated that the FFMQ failed to show any difference between the effects of Mindfulness-Based Stress Reduction and those of a matched active-control condition, the Health Enhancement Programme, though both of these conditions resulted in significantly greater change on the FFMQ than a waitlist control condition did (Goldberg et al., 2015). Therefore, even when change in mindfulness is assessed in mindfulness meditation intervention studies, it is usually overestimated as a result of being compared with a waitlist control condition and this must be borne in mind when comparing the results of this study with those of previous studies. This combined with generally only moderate correlations with behavioural outcomes (Quaglia et al., 2016) suggests that when mindfulness interventions are effective, dispositional measures do not fully capture what has changed. This suggests that the effects of the current intervention on dispositional mindfulness are not conclusive due, in part, to the poor
sensitivity of the dispositional mindfulness measure. This poor sensitivity may undermine the use of sham meditations as an active control as the wording of the dispositional mindfulness items could be in line with the expectations of participants who think they are engaging in meditation, particularly given the current ubiquity of information about meditation and mindfulness.

While some evidence for a distinction between the effects of the experimental and control conditions can be seen in the difference in receptivity during initial meditation sessions, it is clear that more studies evaluating the Headspace intervention materials are required in order to ensure its efficacy for increasing mindfulness. These results align with those of a recent study using mobile devices to deliver a mindfulness meditation intervention or a sham meditation intervention which also included much more fine-grained data by including multiple momentary assessments during each day of the intervention (Ruscio, Muench, Brede, MacIntyre, & Waters, 2016). While this study also found no changes in trait mindfulness which could be attribute to the mindfulness intervention, analysis of the momentary data using linear mixed models showed that state mindfulness increased to a greater extent over time for the mindfulness meditation group. Future research evaluating the Headspace intervention materials should take this innovative approach to data collection and analysis, evaluating both state and trait mindfulness changes, and the relationship between state and trait mindfulness changes over the course of the intervention assessment period.

Even if the mindfulness meditation intervention did indeed succeed in increasing dispositional mindfulness somewhat, this did not result in a greater increase in critical thinking than the sham meditation condition did. While performance on the Halpern Critical Thinking Assessment improved from baseline to follow-up for both groups, no such improvement was found for performance on the heuristics and biases items. Furthermore, performance on the executive functioning measure was stable across both groups and time and there was no evidence of conditional effects dependent on thinking dispositions or an indirect effect on critical thinking through
executive functioning. Similarly, there were no significant group related changes in actively open-minded thinking or need for cognition and baseline levels of these thinking dispositions did not moderate the effect of the intervention. The only previous mindfulness intervention study to focus on an outcome related to critical thinking found a positive effect of regular mindfulness practice on cognitive rigidity (Greenberg, Reiner, & Meiran, 2012). This study suggested the inhibition of automatic intuitive responses as the likely mechanism underlying observed effects but did not test for this.

As described in Chapter 2, this is a possible mechanism by which mindfulness might facilitate critical thinking. The results Study 1 supported this hypothesis as the relationship between critical thinking and dispositional mindfulness was positive and mediated by inhibition (for both observing and non-reactivity). However, this effect was also complicated by the existence of a negative direct effect of non-reactivity on critical thinking (Noone, Bunting, & Hogan, 2016). In the current study, engaging in a 6-week long mindfulness meditation intervention did not improve critical thinking or executive functioning to a greater extent than a closely matched active control condition. Due to participant attrition and possible problems with the sensitivity of the FFMQ, it is unclear whether this null finding is due to a failure to manipulate dispositional mindfulness or due to the existence of a weak relationship between dispositional mindfulness and critical thinking. While further research is warranted to examine whether more intensive mindfulness meditation interventions can enhance critical thinking, it appears that one of the most common methods for learning mindfulness meditation (i.e., the 6-week online mindfulness intervention) does not do so.

This method for learning mindfulness meditation also failed to significantly affect emotional experience or wellbeing when compared to the sham meditation condition. These effects were examined in order to provide a comparison with previous studies which employed the Headspace app. Two previous studies employing Headspace where participants engaged in less meditation sessions did report positive effects on wellbeing and positive affect (Bostock & Steptoe, 2013; Howells et al., 2014). However, these
effects were relatively small and resulted from comparisons with a waitlist control group and a poorly matched active control group, respectively. Therefore, conclusions in these studies regarding the efficacy of Headspace appear to be premature. Though participants in the current study engaged in more meditation sessions, we did not observe significantly better outcomes for wellbeing, positive affect or negative affect for those in the mindfulness meditation group and this was likely due to how well matched the sham meditation active control condition was. Only one other study comparing a mindfulness meditation condition to a sham meditation condition has examined changes in negative affect over time. This study showed that negative affect decreased to a greater extent for those in the mindfulness meditation group (Zeidan, Johnson, Gordon, et al., 2010). However, this intervention lasted only three days and so is not comparable to that of the current study. Finally, there was an increase in wellbeing and a decrease in negative affect for both groups which could have been due to expectation effects and/or genuine positive effects of the relaxed breathing common across both intervention conditions (Szabo & Kocsis, 2016). Again, whether a more intensive or long-term application of an online mindfulness intervention would prove effective in improving emotional experience and wellbeing is an open empirical question.

This study had many strengths. It was pre-registered and the protocol has been published (Noone & Hogan, 2016). The use of an active-control which is identical in expectations (as measured) and presentation (i.e. through the Headspace application and by Andy Puddicombe, a trained Buddhist monk) represents an advance from the usual attention or waitlist controls employed in previous mindfulness meditation interventions (Chiesa et al., 2011). Another advance is the use of objective measures of intervention adherence. Where most previous studies have relied on self-report measures of adherence (when included), the application used to deliver the intervention materials in this study allowed the objective and accurate measurement of the amount of guided meditations participants engaged in. Adherence to the guided meditation programmes was equivalent across both conditions and higher than in previous studies. Finally,
participants were allocated to their respective groups without knowing which the experimental condition was and this information was also kept from the primary researcher until after data analysis was completed in order to ensure a double-blind RCT design.

There are however some weaknesses associated with this study also. While it was intended that the only difference between the experimental and the active-control conditions would be the provision of specific instructions to do with building specific mindfulness skills in the guided mindfulness meditations, this was not possible in practice as Headspace only provided one guided sham meditation recording. Therefore, another key difference between the conditions was the variability in the content participants were exposed to, as the guided sham meditation was repeated in an identical format for each session completed by those in the active-control group. This was in contrast to the progressive nature of the guided mindfulness meditations. The fact that we failed to observe increases specific to the mindfulness meditation group in dispositional mindfulness or measures of wellbeing and emotional experience usually associated with mindfulness practice raises the possibility that this intervention was not effective and that similar previous studies did not really raise levels of mindfulness (i.e. significant effects may be an artefact due to high sample sizes and poorly matched control groups). If this is the case, we cannot reasonably conclude anything about the relationship between mindfulness and critical thinking except that this approach to learning mindfulness does not enhance critical thinking. It must also be borne in mind that while the amount of sessions engaged in by participants was higher than in previous studies, only a quarter of participants completed all 30 meditation sessions and close to a third did not complete any meditation sessions (the majority of whom did not attend follow-up but were included in intention-to-treat analyses). This is a significant limitation and future research will have to carefully consider how to encourage adherence in online mindfulness interventions. It is possible that there is something specific about those who do adhere closely to online mindfulness interventions which limits the generalisability of these studies. In terms of measurement of executive functioning, though the task
employed had been shown previously to be related to dispositional mindfulness (Ostafin, Kassman, & Wessel, 2013), a task more specifically focused on inhibition may have been more sensitive to the effects of mindfulness. A recent systematic review of the effects of mindfulness meditation practice on executive functioning suggested inhibition specifically as the aspect of executive functioning most strongly related to mindfulness (Gallant, 2016). Finally, participants were drawn from the student population only and so any conclusions made based on this study may not be generalizable to the wider population. However, critical thinking is a skill which is of particular importance as an outcome of university education and therefore this study may have practical implications regarding the implementation of mindfulness programmes in universities.

Several recommendations for future research arise out of the current study. A priority for the field of mindfulness research should be the development of better measures. Few studies, the current one included, show significant increases in dispositional mindfulness following intervention which suggests that the measures available are not sensitive enough (Quaglia et al., 2016). It is possible that with a longer or more intensive mindfulness intervention, and/or the involvement of a mindfulness instructor, that changes in dispositional mindfulness and critical thinking may have been observed. More research of this sort is needed before the findings of the current study can be confirmed. As the relationships between dispositional mindfulness, state mindfulness and cognition is complex (Watier & Dubois, 2016), future studies should plan to recruit adequate sample sizes to allow mediation and moderation analyses and SEM to disentangle these relationships. It also would have been useful to have manipulated state mindfulness at follow-up to examine whether being in a state of mindfulness at the time of measurement is necessary to observe the effects of a mindfulness intervention and future studies should consider this approach.
To summarise, this study was designed in order to rigorously test the effects of regular mindfulness practice on critical thinking performance in a sample of university students who had never practiced mindfulness meditation before. No evidence was found to suggest that engaging in guided mindfulness practice for 6 weeks improves critical thinking performance. While further research is warranted, claims regarding the benefits of mindfulness practice for critical thinking should be tempered in the meantime.
Chapter 6

General Discussion

6.1 Thesis Overview

The aim of this thesis was to present a critical analysis of the historical, theoretical and empirical support for claims regarding the supposed benefits of mindfulness practice for everyday thinking skills and to describe a series of studies designed to test such claims. The Three-stage model of Analytic Engagement (Pennycook, Fugelsang, & Koehler, 2015), a default interventionist dual process theory of higher-order cognition, was connected to a model of mindfulness and executive functioning (Teper, Segal, & Inzlicht, 2013) and this combined model was employed as a theoretical framework which informed a number of specific hypotheses that were evaluated across three empirical studies presented in this thesis (see figure 2.4 in Chapter 2).

The Three-stage model of Analytic Engagement proposes that human cognition can be achieved through two different processes – Type-1 processes and Type-2 processes. The defining feature of Type-1 processes is that they are autonomous, in the sense that they require no voluntary control (Pennycook et al., 2015). They generate intuitive responses as a result of rapid, automatic searches of associative memory, which occur by default in response to triggering stimuli (Ostafin, 2015; Strack & Deutsch, 2004). In contrast, the defining feature of Type-2 processes is that they depend on working memory resources in order to maintain, switch between and update hypothetical representations of the world – a process referred to as cognitive decoupling (Evans & Stanovich, 2013).

Notably, it has been argued that critical thinking is a Type-2 process (Bonnefon, 2016; Facione, 2013; Halpern, 2013). The Three-stage model of Analytic Engagement suggests that for Type-2 processes to be engaged, conflict must be detected between intuitive responses. The detection of this conflict triggers the self-regulation of working memory resources to ensure that the initial Type-1 intuitive responses are inhibited, and that an alternate response can be generated through cognitive decoupling (Pennycook et al.,
2015). The basic processes underlying the self-regulation of working memory resources are known as the *executive functions* and include the updating of working memory representations, shifting between working memory representations and the inhibition of pre-potent thoughts or responses (Hofmann, Schmeichel, & Baddeley, 2012). A cognitive model of mindfulness proposed by Teper and colleagues (2013) suggests that both components of mindfulness – present-moment attention and non-reactivity – facilitate the early detection of conflict and the subsequent engagement of the executive functions. Furthermore, mindfulness has been found to be positively related to Type-2 processes akin to critical thinking, including insight problem-solving (Ostafin & Kassman, 2012), creative thinking (Lebuda, Zabelina, & Karwowski, 2016), unbiased thinking (Hafenbrack, Kinias, & Barsade, 2013; Hopthrow, Hooper, Mahmood, Meier, & Weger, 2016), and cognitive rigidity (Greenberg, Reiner, & Meiran, 2012). Based on these theoretical and empirical considerations, the overarching hypothesis of the research presented in this thesis was that mindfulness facilitates everyday thinking skills, as indicated by performance on critical thinking tasks, and that a key mechanism underlying this relationship is executive functioning. This hypothesis was tested across three empirical studies.

Study 1 examined the structural relations between facets of *dispositional mindfulness* – specifically, the self-reported tendency to pay attention to the present-moment and the tendency to have a non-reactive orientation to experience – and measures of both the executive functions and critical thinking ability. Study 2 investigated the effects of an experimental manipulation of *state mindfulness* on executive functioning and critical thinking and the extent to which these effects depended on dispositional mindfulness, need for cognition, and actively open-minded thinking. Study 3 consisted of a randomised controlled trial (RCT) of an online *mindfulness intervention* which examined the effects of regular mindfulness meditation practice on executive functioning and critical thinking. Overall, the work presented in this thesis has made a number of theoretical, conceptual and methodological contributions and there are important implications for future
Chapter 6 – General Discussion

empirical research arising out of this work. These contributions and implications will be discussed following a brief summary of each study conducted in preparing the current thesis.

Study 1 – Structural relations between dispositional mindfulness, executive functioning and critical thinking

This study took an individual differences approach to examining the relationships between dispositional mindfulness, executive functioning and critical thinking. A sample of 178 undergraduate students completed a self-report measure assessing the present-moment observation and non-reactivity facets of dispositional mindfulness and a range of behavioural tasks assessing executive functioning processes (i.e. updating, inhibition and shifting), and critical thinking. This design allowed the use of structural equation modelling (SEM) to examine the relations between these constructs. The use of SEM allowed for the reduction of measurement error by employing multiple indicators of the factors composing mindfulness and executive function. This analysis revealed a number of interesting results. As expected, performance on the executive function tasks was positively related to critical thinking performance. It was hypothesised that present-moment attention would be positively related to updating, inhibition and shifting and that non-reactivity would be positively related to inhibition and shifting. Due to problems with model fit, the shifting factor was dropped. In the resulting structural model, present-moment observation was positively related to inhibitory control but was not related to working memory updating. Non-reactivity was not found to be significantly related to inhibition. Turning to the relationship between dispositional mindfulness and critical thinking, positive indirect effects through inhibitory control were found for both present-moment observation and non-reactivity. The results suggest that the positive relationship between present-moment observation and critical thinking is fully mediated by inhibitory control. However, the effects of non-reactivity are more complex, as along with a positive indirect effect of non-reactivity on critical thinking mediated by inhibition, a negative direct effect of non-reactivity on critical thinking was also observed. This type of result is referred to as competitive mediation by
some authors (Zhao et al., 2011) and suggests that there are additional mediators not accounted for which have a deleterious effect on critical thinking.

**Study 2 – Short-term effects of a brief mindfulness meditation on executive functioning and critical thinking**

In order to test the relationships observed in Study 1 experimentally, Study 2 employed a mixed factorial design to examine whether 65 participants randomly assigned to complete a brief mindfulness meditation would show a greater improvement in performance on executive functioning and critical thinking tasks, from before the meditation to immediately afterwards, when compared with participants randomly assigned to completing a sham meditation. This experimental design was combined with an individual differences approach. Differential responses to the experimental manipulation were examined using moderation and conditional process analyses involving dispositional mindfulness and the thinking dispositions of actively open-minded thinking and need for cognition. On average, neither executive functioning nor critical thinking improved to a greater extent for the mindfulness meditation group in comparison to the control group. However, several interesting effects were found in analyses of differential responses to the mindfulness manipulation. Though engaging in the mindfulness meditation was of no benefit to the critical thinking performance of those higher in need for cognition and actively open-minded thinking, it did facilitate improved performance from baseline for those who reported lower endorsements of these thinking dispositions. Furthermore, the lower an individual’s score on these thinking dispositions, the more beneficial the mindfulness meditation was to their critical thinking performance. In addition, a more tentative finding was the negative conditional indirect effect found which suggested that for those participants who reported low levels of non-reactivity, engaging in the mindfulness meditation led to decreased critical thinking performance, which was mediated by slower reaction times on the executive functioning task.
Study 3 - Long-term effects of a regular mindfulness meditation practice on executive functioning and critical thinking

While experiments involving brief mindfulness meditations are useful for attaining good internal validity, their external validity is questionable as most people participate in a longer-term learning process when engaging with mindfulness practice and their responses to guided mindfulness meditations may change as they learn. For example, regular mindfulness meditation practice has been shown to increase dispositional mindfulness through progressive gains in the ability to cultivate a state of mindfulness (Kiken, Garland, Bluth, Palsson, & Gaylord, 2014). To overcome the limited external validity of Study 2, a randomised controlled trial of a 6-week online mindfulness meditation intervention was conducted to assess its effects on the primary measures of executive functioning, critical thinking and the key thinking dispositions of need for cognition and actively open-minded thinking. Secondary measures assessed wellbeing, positive and negative affect, and real-world behavioural outcomes, in order to allow comparison with outcomes reported in previous studies which employed online mindfulness interventions. This intervention was delivered through an online application called Headspace which delivers mindfulness training content through smartphones, tablets and web browsers. A total of 91 participants were randomly allocated to a series of either guided mindfulness meditations or guided sham meditations which were all accessed through the Headspace application and both participants and researchers were blinded to group allocation. No significant interactions between time of measurement and group allocation were observed for either primary or secondary measures. Furthermore, mediation analyses testing the indirect effect of group allocation on critical thinking through executive functioning performance did not reveal a significant result. Finally, moderation analyses showed that the effect of the intervention did not depend on baseline levels of the key thinking dispositions, actively open-minded thinking and need for cognition.
6.2 Theoretical Issues

The primary motivation for the research described in this thesis was the accumulation of relatively unquestioned claims regarding the benefits of mindfulness practice for everyday thinking skills. As discussed in Chapter 1, these claims have been made by researchers, practitioners, commercial and non-profit organisations and governments (Mindfulness All-Party Parliamentary Group, 2015; Good, Lyddy, Glomb, & Bono, 2016; Insead Knowledge, 2014; Penman, 2015; Pykett, Lilley, Whitehead, Howell, & Jones, 2016; Search Inside Yourself, 2016). The fact that these claims were made with little reference to empirical evidence demonstrates the need for rigorous research examining the relationship between mindfulness and critical thinking. The research presented in this thesis is a first step in examining this specific relationship and will provide a basis for a cumulative research effort focused on determining the extent to which mindfulness and critical thinking are causally related to each other. The results of this research suggest specific insights regarding the effects of dispositional mindfulness, state mindfulness, and mindfulness interventions on executive functioning and critical thinking.

Mindfulness and the Three-stage model of Analytic Engagement

In reviewing research on the cognitive processes involved in mindfulness and critical thinking, it was found that self-regulation, supported by effective executive functioning, is thought to be a key outcome of mindfulness and a necessary precursor to critical thinking. An initial contribution of this thesis is the introduction of default interventionist theory to the literature on the cognitive effects of mindfulness, specifically the Three-stage model of Analytic Engagement (Pennycook et al., 2015). While reference is made post hoc to self-regulation and the interruption of automatic processing in most previous studies on mindfulness and higher-order cognition, few of these studies attempt to form a testable theory to account for the effects found and predict what may be causing them. Even when dual processing accounts are invoked to describe the effects of mindfulness, this is often done without reference to the finer details of how
mindfulness practice might make Type-2 processing more likely (Hart, Ivtzan, & Hart, 2013). The Three-stage model of Analytic Engagement specifies how conflict between intuitive responses serves as a trigger for the engagement of executive functioning which facilitates the operation of Type-2 processes such as critical thinking (Pennycook et al., 2015). A key contribution of this thesis is linking the Three-stage model of Analytic Engagement to a proposed model of the relationship between mindfulness and executive functioning which also focuses on conflict as a mechanism which triggers executive functioning.

Specifically, the Three-stage model of Analytic Engagement aligns with Teper and colleagues’ (2013) model of mindfulness and executive functioning, which suggests that the enhanced present-moment attention associated with a mindful state increases awareness of conflict-related negative affect which in turn triggers the engagement of executive control. An important aspect of this model, reflected in this thesis, is the focus on two distinct cognitive processes involved in mindfulness – present-moment attention and non-reactivity – rather than a single mindfulness factor (Teper et al., 2013). This focus is important because, as discussed in Chapter 2, present-moment attention and non-reactivity appear to have distinct effects on executive functioning and, according to the results presented in this thesis, critical thinking. Connecting this model of mindfulness and executive functioning to the Three-stage model of Analytic Engagement suggests the central hypothesis of this thesis – that mindfulness might facilitate critical thinking through the enhancement of executive functioning.

The results presented in this thesis do not fully support this hypothesis. Though Study 1 demonstrated evidence for both components of dispositional mindfulness facilitating critical thinking through the enhancement of executive functioning, an experimental manipulation of state mindfulness in Study 2 and an experimental intervention designed to enhance dispositional mindfulness in Study 3 did not find evidence for this relationship. Thus, although the empirical effects observed in Study 1 provide some support for the underlying theoretical model presented in this thesis, a relationship between mindfulness, executive functioning, and
critical thinking may be difficult to demonstrate and leverage for a variety of reasons. For example, focusing on executive functioning and critical thinking, it is reasonable to assume that although executive functioning is necessary for effective critical thinking, it is not sufficient. In other words, the intervention of executive functioning to inhibit the Type-1 response – the mechanism underlying the engagement of Type-2 processes – can only benefit critical thinking if the individual has the capacity to generate a more adequate alternative response. This suggests a need to broaden the scope of the Three-stage model of Analytic Engagement to better describe critical thinking because it is now acknowledged that in addition to being able to (1) inhibit the default Type-1 response, one must also (2) be disposed towards critical thinking, (3) have the requisite level of critical thinking skill and (4) have appropriate domain-specific declarative knowledge relevant to the critical thinking test items to draw on when generating alternative responses to one’s intuitive response (Stanovich, 2016). In other words, while mindfulness might facilitate the inhibition of the default Type-1 response and support the ongoing execution of executive processes, other key processes and factors may constrain any potential effects of executive functioning on critical thinking outcomes.

Enhancing critical thinking skills is challenging. Attempts to enhance thinking dispositions, thinking skills and relevant domain-specific knowledge in university students in the context of critical thinking intervention studies have produced mixed results. Instructional interventions aimed at increasing critical thinking performance come in many different forms but tend to focus on teaching students critical thinking skills such as how to actively engage with information using tools of logic and argumentation, either separate to or in combination with the teaching of domain-specific knowledge. Broadly, Ennis (1989) describes four types of instruction approaches: (1) general approaches which explicitly teach critical thinking skills separately to other aspects of learning, (2) infusion approaches which explicitly teach critical thinking skills as part of a specific subject (e.g. within a module focused on history, psychology, or English literature), (3) immersion approaches which implicitly teach critical thinking
skills as part of a specific subject and (4) mixed approaches which focus on separate learning goals for critical thinking and knowledge acquisition. Too few studies have been conducted to identify through meta-analysis which approach is most effective but, in general, research on direct critical thinking instruction has shown that even when specific thinking skills are taught, the effect sizes of the differences between these instructional approaches and teaching as usual are small (\(g = .20 \ [0.09, .30]\); Niu, Behar-Horenstein, & Garvan, 2013). While there is considerable heterogeneity in instruction approach and research design which might in part explain this small effect size, it may be that critical thinking in university students is difficult to enhance in the context of short-term interventions (i.e., typically 6 – 12 weeks), and enhanced performance may require much longer and more intense intervention than that provided by current critical thinking intervention studies or the studies applying mindfulness in the present thesis.

Halpern (2001) points to the slow and cumulative nature of cognitive development as a reason for the modest effects of critical thinking interventions. However, critical thinking interventions focus on directly training the skills of thinking, often alongside teaching of domain-specific knowledge, and do not target self-regulation or executive functioning per se. It is possible that in combination with critical thinking instruction, mindfulness may provide a facilitative context that supports better critical thinking performance due to its positive effects on self-regulation. For example, future research could examine whether dispositional mindfulness moderates the effects of critical thinking interventions, for example, across the four types of critical thinking intervention approaches described by Ennis (1989). Since both components of dispositional mindfulness may facilitate critical thinking through the enhancement of inhibition, as observed in Study 1, it is possible that individuals higher in dispositional mindfulness would benefit most from critical thinking instruction as they may be better able to inhibit their intuitive responses and apply the thinking skills they are learning. This may accelerate their rate of learning and skill acquisition in the context of a critical thinking training programme.
Future studies could also examine whether regular mindfulness practice in the context of critical thinking training is more effective than critical thinking training alone at improving critical thinking performance. Perhaps the enhanced attention to the present moment brought about by regular mindfulness practice would enable individuals to notice opportunities to apply their newly learned thinking skills. This would align with the perspective of Fisher’s skill theory (2008) which suggests that, even in familiar domains, the application of cognitive skills such as critical thinking varies in effectiveness according to contextual support. The limited support found for the effects of mindfulness on executive functioning and critical thinking in the studies presented in this thesis may be due to the fact that in both Study 1 and Study 3, a state of mindfulness was not cultivated in the context of the testing situation. It is notable that in Study 2, where a state of mindfulness was cultivated immediately prior to testing, those who required contextual support the most, the individuals low in need for cognition and actively open-minded thinking, did indeed improve their critical thinking performance as a result of cultivating a state of mindfulness.

Mindfulness and Executive Functioning

Another discrepancy between the theoretical framework employed and the results obtained was that experimental manipulations designed to influence both state and dispositional mindfulness did not affect performance on executive functioning tasks. There are a number of theoretical considerations which may explain why mindfulness might not be as strongly related to executive functioning as expected. It is important to reflect on the malleability of executive functioning in university students, the relationship between stress and executive functioning, and the possible relationship between mindfulness and habituation when considering the results presented in this thesis and the inconsistency in findings on the relationship between mindfulness and executive functioning to date, which
have produced effect sizes varying in size from small to moderate (Chiesa, Calati, & Serretti, 2011; Gallant, 2016).

One possible reason for failure to change executive functioning through experimental manipulations of mindfulness in both Study 2 and Study 3 is that many of the participants involved in these studies are likely at, or close to, the peak of their developmental trajectory for executive functioning. Executive function tends to develop slowly through childhood, with rapid gains made during frontal lobe growth spurts between the ages of 7 and 9 and later between 16 and 19 approximately, before a peak level of executive functioning is reached between the ages of 20 and 29 (Jurado & Rosselli, 2007; Luca et al., 2010). Though the developmental trajectories of separate executive functions vary, with some maturing faster or slower and some declining earlier or later, young adulthood appears to be a time of optimal functioning for all aspects of executive functioning (Best & Miller, 2010). Therefore, the malleability of executive functioning at this age may be limited. For example, following difficulty in improving executive function in healthy adults using cognitive training methods (Melby-Lervåg & Hulme, 2013), researchers focused on the computerised cognitive training approach for intervening in executive function are now concentrating their efforts on groups who tend to exhibit executive dysfunction, including children with attention deficit hyperactivity disorder, children who grew up in low socioeconomic status homes, and the elderly (Hsu, Novick, & Jaeggi, 2014; Karbach & Verhaeghen, 2014).

Another possible explanation for the inconsistent findings for the effects of mindfulness on executive functioning could be the moderating role of stress, as recently suggested by Gallant (2016). Since high levels of stress are known to negatively affect performance on executive functioning tasks (Lupien, Maheu, Tu, Fiocco, & Schramek, 2007; Schoofs, Wolf, & Smeets, 2009), Gallant speculated that the stress reduction effects of mindfulness may lead to enhanced executive functioning performance in the context of stress, and that these benefits might not be seen outside of stressful contexts. There is some support for this idea. A study by Jha and colleagues (2010) only demonstrated positive effects of mindfulness on
working memory updating in a stressed pre-deployment military group, while no such effect was found for military and civilian control groups. A study with older adults showed that perceived stress mediated the positive relationship between mindfulness and executive shifting ability (Fiocco & Mallya, 2015). Another study directly compared the effects of mindfulness meditation to an active-control condition before and after the presentation of a stressful writing task. There was no difference between the conditions before the stressor but following the stressor, those in the control condition performed significantly worse than those in the mindfulness meditation group (Banks, Welhaf, & Srour, 2015). These results align with those of an RCT of another form of stress reduction, hatha yoga, which demonstrated beneficial effects on shifting and working memory updating that were accounted for by reductions in both self-reported stress and cortisol (Gothe, Keswani, & McAuley, 2016). Together, these findings suggest that future research on mindfulness and executive functioning should give consideration to the role of stress. The fact that stress was not measured in any of the studies in this thesis could be considered a limitation.

Another intriguing idea, which may explain a weaker link between mindfulness and executive functioning than expected, is that the non-reactivity facet of mindfulness may develop because sustained engagement of present-moment attention to experience leads to habituation, rather than an enhanced ability to inhibit elaborative processing. It has been suggested that the self-regulation of attention towards the present moment results in engagement with all experiences, including those that individuals would usually tend to avoid (e.g. through behavioural avoidance or thought suppression; Bishop et al., 2004). Furthermore, there is a growing literature suggesting that repeated engagements with negative experiences leads to habituation to stress and decreased reactivity (Hughes, Howard, James, & Higgins, 2011). In particular, those high on the personality trait of openness to experience appear to demonstrate habituation to stress following initially higher reactivity to the stress exposure (Ó Suilleabháin, 2016). This pattern of reactivity is similar to the findings of a study by Uusberg and colleagues which were presented in Chapter 1. This study focused on the effects of a
brief mindfulness mediation on emotional reactivity to aversive images and showed that, in comparison to those in distraction and control conditions, individuals in the open-monitoring meditation condition showed increased initial reactivity to negative stimuli and greater decreases in reactivity across subsequent repetitions of the negative stimuli (Uusberg, Uusberg, Talpsep, & Paaver, 2016). Crucially, both openness to experience and the present-moment attention cultivated through mindfulness meditation involve engagement with experience which, over repeated exposures to negative experience, may result in habituation. Interestingly, another study showed that the relationship between mindfulness experience and habituation to a startling acoustic probes may be non-linear. While experienced meditators with moderate levels of practice showed greater habituation to a series of startle probes than non-meditators, experienced meditators with more intense levels of practice (across a similar number of years) showed similar levels of habituation to the startle probes as non-meditators (Antonova, Chadwick, & Kumari, 2015). The authors suggest that at intensive levels of practice, experienced mindfulness meditators might maintain attention to the present moment in a way that leads to experiencing stimuli as novel regardless of its familiarity. This claim is tenuous however, as Antonova and colleagues focused on perceptual stressors only and their study was cross-sectional so its generalisability is limited. In general, few studies have focused on the relationship between mindfulness, habituation and reactivity so further rigorous research with different types of stressors is required to clarify both the relationship between mindfulness and habituation and the connection between non-reactivity and the inhibition of elaborative processing.

In summary, it is important to consider that the relationship between mindfulness and executive functioning might not be as strong as expected. While most of the studies presented in Chapter 2 demonstrated positive effects, many of these effects are in the small to moderate range and there are still too few studies on mindfulness and executive functioning to draw a strong conclusion about their relationship. Furthermore, a recent systematic review of research on the effects of mindfulness on executive functioning
concluded that the only consistent finding is the positive relationship between mindfulness and inhibition specifically (Gallant, 2016). The results of Study 1 are consistent with the conclusions of that review, specifically, highlighting a direct effect of present-moment attention on inhibition and indirect effects of both present-moment attention and non-reactivity on critical thinking through inhibition. Study 2 and Study 3 employed broader measures of executive functioning and did not demonstrate any effect of mindfulness on these measures. This pattern of effects suggests a weaker relationship between mindfulness and executive functioning than anticipated.

Further research is needed to clarify the relationships between specific components of mindfulness and executive functioning. Taking a similar measurement approach to Study 1, research on the effects of the components of dispositional mindfulness on updating, inhibition and shifting could be carried in a longitudinal design in order for stronger causal claims to be made through the modelling of time-lag effects. Combining this approach with mindfulness training interventions would allow for the developmental trajectories of present-moment attention and non-reactivity and possible changes in their relationships with updating, inhibition and shifting to be estimated.

*Dispositional Mindfulness and Critical Thinking*

Another way in which the results presented in this thesis and the theoretical model employed diverged was in the finding of a competitive mediation effect of non-reactivity on critical thinking in Study 1. Those who report higher levels of non-reactivity appear to be able to perform better on a critical thinking task due to their skill in inhibitory control. However, higher levels of non-reactivity were also directly negatively related to critical thinking performance. Therefore, it is possible that higher scores on non-reactivity also, to some extent, reflect a general tendency to be accepting towards experience which could in turn impede critical thinking. However, whether the type of acceptance non-reactivity is associated with in practice extends to all information, or just to emotional responses, is unclear. Critical
thinking performance may require some regulation of ongoing emotional responses, but critical thinking problems, on current tests of critical thinking ability, involve the processing of specific types of information, specifically, the logical relationships between propositions. Understanding the impact of mindfulness-based acceptance and non-reactivity on different types of information processing outcomes would go a long way towards explaining why mindfulness practice generally facilitates self-regulation, but does not appear to significantly improve critical thinking.

Though the indirect effect of observing on critical thinking in Study 1 was in the expected direction and the mediating role of inhibition was consistent with the theoretical framework employed, this effect was also small in size. The negative direct effect of non-reactivity on critical thinking was larger but also relatively small. A stronger test of these relationships would be a longitudinal experimental manipulation of dispositional mindfulness comparing mindfulness training to a closely matched active control condition. While such a test was attempted in Study 3, the pattern of results did not provide any evidence that levels of dispositional mindfulness increased in the intervention group to a greater extent than was seen in the control group. Longer and more intense interventions (and within-study variations of duration and intensity) are needed in future studies in order to accurately estimate the direct relationship between dispositional mindfulness components and critical thinking outcomes. Currently, the impact of dispositional mindfulness on critical thinking appears to be minimal – at least in the absence of a mindfulness state.

State Mindfulness and Critical Thinking

When a mindfulness state is induced through a brief meditation, as in Study 2, the relationship between a disposition towards present-moment attention and non-reactivity and critical thinking performance appears to be complex. For those with moderate to high levels of both present-moment attention and non-reactivity, engaging in a brief meditation appears to have little effect on critical thinking performance. However, engaging in a brief mindfulness meditation actually impaired critical thinking performance.
immediately afterwards for those low in non-reactivity. Individuals with low levels of non-reactivity also declined significantly in their performance on an executive functioning task and this decline accounted for their poorer critical thinking performance. This suggests that those with higher levels of non-reactivity may have been better able to maintain their level of executive control following the brief mindfulness meditation. This finding is consistent with studies demonstrating self-regulation lapses in individuals with a tendency towards paying attention to the present moment in a reactive manner. As discussed in Chapter 1, in individuals low in non-reactivity, present-moment attention has been found to be positively associated with alcohol intake (Leigh, Bowen, & Marlatt, 2005) and substance abuse (Eisenlohr-Moul et al., 2012). While the conditional effect of non-reactivity on executive functioning and critical thinking is an interesting finding, it must be borne in mind that there is a high chance of it being a false positive as the conditional process analysis was not sufficiently powered. Furthermore, this effect was relatively weak and applied to less than 20% of the sample. Therefore, replication in a large enough sample to ensure adequate power is required before this finding can be considered substantive.

A pair of moderation effects found in Study 2 involving need for cognition and actively open-minded thinking could be considered as consistent with the idea that mindfulness facilitates the engagement of Type-2 processing to the benefit of critical thinking performance. These thinking dispositions both reflect particular habits regarding how individuals tend to engage with and process information. Notably, thinking dispositions in general are considered to be indicators of the likelihood that individuals will engage in Type-2 processing (Stanovich & Stanovich, 2010). Higher levels of need for cognition represent a greater tendency to put effort into cognitive activities such as critical thinking (Cacioppo, Petty, Feinstein, & Jarvis, 1996). Higher levels of actively open-minded thinking represent a greater tendency to be flexible in how one considers information by actively seeking and fairly weighing up evidence which disconfirms one’s beliefs (Stanovich & West, 1997). In Study 2, people who highly endorsed these
thinking dispositions did not benefit from the brief mindfulness meditation. Perhaps those who tend to put a lot of effort into cognitive activity performed at the upper limit of their critical thinking ability at baseline and this could not be improved upon following the meditation. Engaging in a brief mindfulness meditation only improved critical thinking performance for those individuals who reported moderate to low levels of need for cognition and those who reported moderate to low levels of actively open-minded thinking. These individuals could be considered to have habitual approaches to thinking which correspond with generally lower levels of critical thinking performance (Facione, Facione, & Giancarlo, 2000). It appears that engaging in a brief mindfulness meditation may have allowed them to overcome their usual thinking habits in response to critical thinking problems. As described in Chapter 2, habitual responding is considered to be a type of default Type-1 response and engaging in mindfulness meditation may facilitate the inhibition of such responses (e.g. lack of cognitive effort, inflexible approach to thinking) when they are in conflict with the goal of thinking critically (Ostafin, 2015; Verplanken & Fisher, 2013).

These complex conditional effects of state mindfulness on critical thinking are interesting and highlight the importance of taking individual differences in relevant traits into account. Doing so provides us with information regarding who does and who does not benefit from mindfulness practice. However, finding these conditional effects should not lead us to ignore the fact that, on average, a brief mindfulness meditation did not appear to improve either executive functioning or critical thinking to a greater extent than a sham mindfulness meditation did. In fact, on average, neither condition improved critical thinking from baseline performance. Whether this was due to the particular configuration of the brief mindfulness meditation used to manipulate state mindfulness in Study 2, or just a generally weak effect of state mindfulness on critical thinking, is unclear.

In summary, this thesis demonstrates that the claims which have been made regarding the benefits of mindfulness for critical thinking are not supported by conclusive evidence. While these claims are reasonable in theory, some have pointed out that the close link between mindfulness and
acceptance may undermine the relationship between mindfulness and critical thinking (Brendel, 2015). Non-reactivity, the facet of mindfulness most closely linked to acceptance, had both positive and negative effects on critical thinking in Studies 1 and 2, and yet it appears to be vital to many of the benefits of mindfulness in other areas of behaviour (Desrosiers, Vine, Curtiss, & Klemanski, 2014; Eisenlohr-Moul, Walsh, Charnigo, Lynam, & Baer, 2012). More research is needed on facet-level effects of mindfulness and the mechanisms underlying the effects of specific facets of mindfulness on critical thinking. This type of research is needed in order to establish consistent findings regarding the relationship between mindfulness and critical thinking. In order for future research to do this successfully, there are a number of methodological issues which need to be considered.

6.3. Methodological Issues

Each of the studies presented in this thesis involved advances in methodological rigour over previous studies focused on mindfulness and higher-order cognition. For example, where previous studies focused on mindfulness as a unitary construct, Study 1 took a fine grained approach to examining the relationship between dispositional mindfulness, executive functioning and critical thinking by measuring specific facets of mindfulness and executive functioning and relating them to critical thinking in a structural equation model. Scholars have called for mindfulness research to examine the specific effects of both the present-moment attention and non-reactivity components of mindfulness and this study was the first to do this while focusing on higher-order cognitive outcomes (Baer et al., 2008; Desrosiers et al., 2014). A further benefit of the application of SEM was the use of latent variables to overcome the task impurity problem in executive functioning assessment. Since there are many non-executive processes required to successfully complete executive functioning tasks, examining the effects of an experimental manipulation on a single task does not allow any inferences about specific executive functions to be made. Using a latent variable approach, several tasks which are different in form but assess a single common executive function are administered and a factor composed of the shared variance between these tasks is used to represent that specific
executive function (Miyake et al., 2000). Previous studies focusing on the relationship between mindfulness and executive functioning have failed to take in to account (1) the differential effects of separate components of mindfulness on aspects of executive functioning and (2) the task impurity problem associated with the measurement of aspects of executive functioning. Taking these methodological issues into account enabled a more detailed and accurate estimation of the relationships between the two components of mindfulness, the executive functions of updating, inhibition and shifting, and critical thinking performance.

Study 2 integrated this fine grained individual differences approach into an experimental examination of the effects of a mindfulness state on executive functioning and critical thinking. This was an important contribution as mindfulness research has been criticised for neglecting the possibility that individuals are likely to react differently to mindfulness meditation (Farias & Wikholm, 2016). Few studies focusing on experimental manipulations of mindfulness have taken the moderating effect of mindfulness dispositions into account and no studies focusing on mindfulness and higher-order cognitive outcomes had previously done this. Other relevant dispositional traits which may moderate the effect of experimental manipulations of mindfulness are also rarely given consideration. Studies of the effects of mindfulness states on higher-order cognition should consider the moderating role of thinking dispositions in particular. Study 2 employed an extensively used brief mindfulness meditation in order to experimentally manipulate state mindfulness. This experimental manipulation was applied in as rigorous a manner as possible by blinding participants to the exact nature of the experimental manipulation and including an active-control condition. Furthermore, where most studies have employed a purely between-groups design, this study took baseline measures of performance on each task and focused on the change in performance directly attributable to the mindfulness manipulation.

Study 3 primarily examined the effects of regular mindfulness practice on executive function and critical thinking. A key methodological innovation in this study was the use of an online mindfulness training
programme as part of an RCT comparing a mindfulness meditation training condition and a sham meditation condition. The use of an online platform for delivering the intervention content also avoided a number of common methodological problems in mindfulness intervention studies as it allowed the standardisation of instruction across all participants within each condition, blinding of both participants and researchers and the objective collection of adherence data.

Despite these methodological strengths, a number of methodological challenges which are pervasive in mindfulness research also applied to the studies presented in this thesis. These challenges pertain to the measurement and manipulation of mindfulness.

*Measuring Mindfulness*

Mindfulness research is overwhelmingly reliant on self-report measures of both state mindfulness and dispositional mindfulness. However, as discussed in Chapter 1, despite a number of mindfulness questionnaires being available, it has been acknowledged by researchers that there are a number of problems with assessing mindfulness by self-report and with the factor structure of the most widely used and recommended questionnaire, the Five Facet Mindfulness Questionnaire.

There are concerns about the usefulness of self-report measures for assessing mindfulness, whether dispositional or state, because it is thought that individuals who are new to the concept of mindfulness might overestimate their tendency to engage in a mindful state. One reason for this is that people tend to be poor at reporting accurately on the quality of their attention as shown in research by Smallwood and colleagues (2007). Another reason is that since mindfulness inherently involves cultivating a greater awareness of one’s own attention, those who are more experienced in mindfulness may be more aware of their own attentional lapses (Grossman, 2011). These problems have led to some researchers suggesting that mindfulness questionnaires may in fact be measuring *perceived* mindfulness rather than actual mindfulness (Quickel, Johnson, & David, 2014). These concerns regarding the assessment of mindfulness by self-
report may limit the findings presented in this thesis related to the effects of dispositional mindfulness and may explain the lack of a significant difference in state mindfulness between the experimental and control groups in Study 2.

As shown in Chapter 1, the Five Facet Mindfulness Questionnaire (FFMQ), which was used in each study presented in this thesis, is considered the most appropriate measure of mindfulness for use in healthy populations. However, there have been inconsistent findings regarding the factor structure of the FFMQ. Several different factor structures have been proposed for the FFMQ. For example, there have been ongoing doubts about whether a five factor solution or a four factor solution without the observing subscale provides a better fit to data collected from novice meditators (Baer et al., 2008). A recent study showed that in data from trials of Mindfulness-based Cognitive Therapy, the four factor structure fit the baseline data better and the five factor structure fit the follow-up data better (Gu et al., 2016). It has also been suggested that a bifactor model, where all items load on a general mindfulness factor as well as loading on their respective factor (out of the usual five) is a more adequate structure (Aguado et al., 2015). Aguado and colleagues also found that, when this revised factor structure was confirmed in both non-meditating and meditating groups, the observing subscale items only loaded on the general mindfulness factor in the meditating group. Closer to the conceptualisation of mindfulness employed in this thesis is the factor structure proposed by Tran and colleagues (2013) which consists of two higher-order factors, self-regulation of attention and orientation to experience. However, this factor structure was only a good fit in a 15 item German version of the FFMQ. It is clear that the FFMQ requires more development work in order to identify a consistent factor structure which represents mindfulness with good construct validity.

In the research presented in this thesis, a two-component model of mindfulness, consisting of present-moment attention and non-reactivity, was applied. To measure these components of mindfulness, the observing subscale of the FFMQ was used to represent present-moment attention and the non-reactivity to experience subscale was used to represent non-
reactivity. This approach was taken following the work of Anicha and colleagues (2011) which showed that these facets have dissociable cognitive correlates that are consistent with mindfulness theory, with present-moment attention positively correlating with perceptual skill in visual working memory and temporal order tasks, and non-reactivity positively correlating with successful inhibition in a Stroop task. It also follows findings by Eisenlohr-Moul and colleagues (2012) and Desrosiers and colleagues (2014) which suggested high levels of observing in the presence of high levels of non-reactivity are related to adaptive outcomes including reduced depression, anxiety and substance use. This approach would be questioned by those who recommend that the observing subscale not be used among non-meditators because it did not load on a general mindfulness factor in a non-meditating sample (Aguado et al., 2015). Furthermore, it has been suggested that, because of its consistent positive correlation with non-reactivity and the attentional focus of its constituent items, the acting with awareness subscale of the FFMQ may be the best indicator of present-moment attention (Rau & Williams, 2016). However, the items that form the acting with awareness scale are drawn from the Mindful Awareness and Attention Scale (MAAS) which defines present-moment attention in terms of a lack of attentional lapses. This approach has been widely criticised and it has been suggested the MAAS is measuring a construct focused broadly on attention regulation and distinct from the operationalisation of mindfulness employed in this thesis (Bergomi et al., 2012b; Grossman, 2011; Siegling & Petrides, 2014; van Dam et al., 2010). The observing subscale, while problematic, is closer to the construct of present-moment attention in its formulation. For example, a representative item is “I pay attention to sensations, such as the wind in my hair or sun on my face”.

Future research must focus on the development of more valid and objective measures of mindfulness. Davidson and Kasznia (2015) suggest two possible approaches – momentary measures and behavioural task measures. Momentary measures such as experience sampling, where participants are prompted to report on their current attentional state at pseudo-random times during their everyday lives, help overcome the
limitations associated with retrospectively reporting about one’s tendency to pay attention. Behavioural tasks focused on aspects of cognition related to mindfulness would have the benefit of being more objective than questionnaires. However, it is still unclear which cognitive tasks best reflect the presence of mindfulness. As mentioned in Chapter 1, some newly developed measures of state mindfulness are behavioural tasks which focus on measuring attention to the breath. These include the Mindfulness Breath Awareness Score task (Frewen, Hargraves, DePierro, D’Andrea, & Flodrowski, 2016; Frewen, Lundberg, MacKinley, & Wrath, 2011) and the Breath Counting task (Levinson, Stoll, Kindy, Merry, & Davidson, 2014). The Mindfulness Breath Awareness Score task is a self-report measure of attention during a brief mindfulness meditation. A bell is rung at 3 minute intervals during the meditation and at these times participants are required to report whether their attention was focused on their breath or not by placing a tick in the appropriate space on a piece of paper on front of them (Frewen et al., 2016, 2011). The Breath Counting task requires participants to pay attention to their breath and to click a button for every breath they take, with a different button press required for every ninth breath. Counting accuracy is then calculated by comparing this behavioural data to physiological data from a respiration belt (Levinson et al., 2014). These tasks are still being validated but are showing promise. The Mindfulness Breath Awareness Score task appears to be reliable in assessing individual differences over time while also being sensitive to regular meditation practice (Frewen et al., 2016, 2011), while the Breath Counting task is related to self-reported mindfulness, can differentiate between long-term meditators and age-matched controls and is positively associated with positive mood, meta-awareness and non-attachment and negatively associated with mind-wandering (Levinson et al., 2014). For mindfulness research to progress, it is vital that better measures are available which give a valid, reliable and as objective an indication as possible of both mindfulness dispositions and states.
Manipulating Mindfulness

Experimental manipulations of mindfulness can focus on the state level or the dispositional level. Most experimental manipulations of state mindfulness involve getting participants to complete a brief mindfulness meditation and comparing the effects of this to those of a control condition. Longer-term mindfulness interventions are assumed to manipulate dispositional mindfulness and there is evidence to suggest that regular mindfulness meditation practice results in increased dispositional mindfulness and that individual trajectories in the ability to cultivate a mindfulness state predict the extent to which dispositional mindfulness increases (Kiken et al., 2014; Quaglia, Braun, Freeman, McDaniel, & Brown, 2016). A major limitation of mindfulness research is that little is known about the specific characteristics (e.g. type of meditation, dosage, method of training) of each of these approaches which contribute to an effective manipulation of mindfulness. As a result, there is great heterogeneity in the methods used in experimental mindfulness research which leads to difficulty in synthesising the evidence provided by this research. There is a need to establish best practice when it comes to experimentally manipulating mindfulness, both at the state level and the dispositional level.

The use of brief mindfulness meditations is a popular method for experimentally studying mindfulness – over 50 studies on the effects of brief mindfulness meditations have been published in the past 10 years. Unfortunately, there has been a dearth of work critically examining this method. As mentioned above, methodological heterogeneity is a problem as studies tend to use different types of meditations, different durations and different control groups. A recent systematic review of mindfulness studies employing brief meditations highlighted several implicit features of how these meditations are guided which could affect subsequent behaviour including the amount of silence used, the level of agency given to the participants, whether eyes are open or closed, whether inner speech is suggested and whether there is a focus on a problem to be solved (e.g. dealing with negative mood) or not (Fisher, Thompson, & Malinowski,
The infrequent use of mindfulness state measures as manipulation checks and the variability in outcome measures means that this literature is not suitable for the use of meta-analysis to identify the methodological characteristics which lead to the most effective manipulation of mindfulness. Consequently, though the brief mindfulness meditation used in Study 2 is the one which has been most regularly employed, there is no empirical reason to suggest that it is the best method of manipulating state mindfulness, or even at least better than other meditations which have been used. There is a need for research explicitly focused on evaluating the use of brief mindfulness meditations as a method of manipulating state mindfulness because as it stands, it is unclear whether null results (when published) are due to a failure to manipulate mindfulness or a lack of a relationship between state mindfulness and the outcome variable.

When it comes to longer-term manipulations of mindfulness which focus on evaluating the effects of regular mindfulness meditation practice, there is considerable tension between the need for experimental rigour and external validity. Study 3 is a good example of this because just as the use of an online mindfulness training program overcame a number of methodological limitations of previous mindfulness intervention studies, it was also a very different and certainly a less intense and guided way of learning mindfulness than traditional class-based and instructor-led mindfulness interventions. However, mindfulness interventions guided in person by an instructor do not allow double-blinding to occur, make standardisation of intervention delivery difficult and mostly rely on self-report measures to track adherence to the intervention (Davidson, 2010). A recent meta-analysis of the effects of mindfulness interventions on dispositional mindfulness demonstrates some empirical evidence for this tension between rigorous design and external validity. It showed that studies with waitlist control groups, the least rigorous type of control group design, had significantly higher effect sizes than studies with active control groups, for the present-moment attention component of mindfulness (Quaglia et al., 2016). It also showed that intervention length had a significant effect on the development of non-reactivity, with studies including 7 or more intervention
sessions having significantly higher effect sizes than those with less than 7 sessions (Quaglia et al., 2016). Still, more detailed research is needed on the specific intervention content and dosage which most effectively increases dispositional mindfulness in participants. An important barrier to this research has been the lack of transparency and detail in the reporting of mindfulness intervention designs. A reason for this could be that there has been no way of systematically describing the characteristics of mindfulness interventions and the meditative practices involved in them.

One possible way of overcoming these barriers would be for mindfulness researchers to move towards the development and use of a systematic taxonomy for describing methods of manipulating mindfulness. An example of an attempt to do this is the phenomenological matrix of mindfulness-related practices proposed by Lutz and colleagues (2015). This matrix depicts ways of cultivating mindfulness in an integrated multidimensional framework and allows different mindfulness meditation practices (and other cognitive behaviours) to be mapped according to where they fall along 7 continua describing aspects of cognitive behaviour and experience (Lutz, Jha, Dunne, & Saron, 2015). These include 3 primary dimensions which are behavioural features of mindfulness meditation practices and 4 secondary dimensions which are features of experience affected by meditation practice. The primary dimensions are object orientation, which refers to the extent to which attention is focused on a specific object (e.g. one’s breath); dereification, which refers to the extent to which thoughts, emotions and perceptions are considered to be transient mental processes as opposed to an accurate reflection of reality; and meta-awareness, which refers to the extent to which an individual is aware of the contents of their consciousness. The 4 secondary dimensions are aperture, which refers to the breadth of attention; clarity, which refers to the vividness of the experience; stability, which refers to the degree to which a specific task-set is maintained; and effort, which refers to the difficulty individuals have in sustaining the intended mental state (Lutz et al., 2015). More work is needed to confirm and clarify aspects of this matrix and to map the full range of meditative practices used in mindfulness research according to the
dimensions of this matrix. Combining this work with systematic practices of methodological reporting would reduce the problem of heterogeneity in mindfulness research by providing more clarity around which studies are similar enough to be compared with one another and what the effects of specific aspects of mindfulness meditation practices are.

Each of the methodological issues discussed above suggests ways in which mindfulness research in general can be improved. As demonstrated in this thesis, research on the effects of mindfulness on higher-order cognition and critical thinking in particular is lacking. With a greater focus on doing rigorous research to examine the effects of mindfulness on critical thinking and other aspects of higher-order cognition, claims regarding these relationships can be questioned and more valid claims can be developed.

6.4. Conclusion

The aim of this thesis was to examine recent claims regarding the supposed beneficial effects of mindfulness on everyday critical thinking skills which have been made by researchers, practitioners, commercial and non-profit organisations and governments. It was shown that while there is some historical, theoretical and empirical support for a positive relationship between mindfulness and critical thinking, there are also reasons to doubt whether this relationship exists. However, there has been a lack of research focused on resolving the question of whether mindfulness facilitates critical thinking. By drawing on research on the relationship between mindfulness and self-regulation and models of rational thinking which highlight the role of self-regulation in critical thinking, this thesis attempted to address this gap in the literature. It was hypothesised that the two components of mindfulness – present-moment attention and non-reactivity – would enhance the executive functions which underlie self-regulation – updating, inhibition and shifting – in specific ways and that this would mediate a positive relationship between mindfulness and critical thinking. While some support was found for this relationship, the effects of mindfulness on critical thinking were mostly small and, in the experimental studies run, indistinguishable from the effects of a control condition. Being the first
studies to directly focus on mindfulness and critical thinking, these findings are far from conclusive. However, these studies and the literature discussed in the introduction to this thesis do suggest that there is currently not enough evidence in favour of the claims that mindfulness has beneficial effects on critical thinking. Consequently, when such claims are encountered, they should be strongly questioned.
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PARTICIPANT INFORMATION SHEET

An analysis of the effects of mindfulness on executive function and critical thinking.

• Invitation
You are invited to take part in this research study. Before you decide, it is important that you understand why the research is being done and what it will involve. This Participant Information Sheet tells you about the aims, risks and benefits of this research. If you agree to take part, we will ask you to sign a Consent Form. If there is anything that you are not clear about, we will be happy to explain it to you. Please take as much time as you need to read this information. You should only consent to participate in this research study when you feel you fully understand what is being asked of you, and you have had enough time to think about your decision. Thank you for reading this.

• Purpose of the Study
Chris Noone, a Ph.D. candidate at the School of Psychology, supervised by Dr. Michael Hogan, NUI Galway, is carrying out a study that is concerned with understanding the cognitive and emotional processes which contribute to effective critical thinking and the role mindfulness may play in this. You will be asked to fill out questionnaires focusing on how you pay attention and how you think in certain situations. You will also be asked to rate your mood and to complete some computerised cognitive tasks.

• What does the study require me to do?
The study involves filling out 4 questionnaires and completing a test of critical thinking online and then arranging a lab visit where you will be asked to complete 6 short computerised tasks. The online tasks should take Just over 1 hour in total (5 mins each for two of the questionnaires, 10 mins each for the other two and approx. 30 mins for the critical thinking test). It is not necessary to complete all this in one sitting, you can log in again at a later time. When the online tasks are completed, we will arrange a lab visit. The lab visit will last about 1 hour and you will be asked to complete 6 short computerised tasks which are similar to basic computer games.
•  **What happens to my data?**  
All data are, in accordance with the Data Protection Act, strictly confidential. Your information will be provided with a number and are stored as numbered files and forms, without your name or other personal information. The personal and experimental data is therefore stored anonymously. Only the researchers involved have access to this data. Only one researcher has access to the details of the subjects. It is anticipated that the findings of this study will be written up for publication in a peer-reviewed journal and presented at international conferences. All results will be anonymous no data will be traced to you. Your information will never be given to third parties.

•  **Do I have to take part?**  
It is up to you to decide if you want to take part. If you decide to take part you will be asked to sign a Consent Form. If you change your mind after signing the consent form, you are still free to withdraw at any time and without giving a reason. A decision to withdraw at any time, or a decision not to take part, will not affect your rights in any way.

•  **What happens if I change my mind during the study?**  
You are entitled to change your mind about participating in this at any time without disadvantage or penalty.

•  **What are the possible benefits in taking part?**  
Benefits include the opportunity to contribute to the understanding of the role of mindfulness and other cognitive and emotional process in critical thinking. Participants will also receive the book “Mindfulness in Plain English” as a gift. Participants will be informed of the results of the study when they are ready.

•  **Who do I contact for more information or if I have further concerns?**  
Chris Noone may be contacted at any time regarding questions about this study at noonec@gmail.com or by telephone at 086 063 0498. If you have any concerns about this study and wish to contact someone in confidence, you may contact the Chairperson of the NUI Galway Research Ethics Committee c/o Office of the Vice President for Research, NUI Galway, ethics@nuigalway.ie
Participant Identification No. : ________________________

Title: *An analysis of the effects of mindfulness on executive function and critical thinking.*

Name of Researcher:  Chris Noone

Please initial box

1. I confirm that I have read the information sheet for the above study and that I □ understand the information given.
2. I am happy that I have had enough time to think about the information □ and have had the chance to ask the researcher questions.
3. I understand that participation is voluntary and that it is □ possible to withdraw at any time, without giving any reason, without any legal rights being affected.
4. I, the participant, agree to take part in the study □

*Remember, even though you agree to participate you may choose to withdraw at any time*

Please sign below

_____________________________   _______________________________   _________________
Name of Participant          Signature          Date

_____________________________   _______________________________   _________________
Name of Researcher           Signature          Date
PARTICIPANT INFORMATION SHEET

An analysis of the effects of relaxation on sustained attention and critical thinking

• Invitation
You are invited to take part in a research study on the cognitive effects of relaxation. Before you decide, it is important that you understand why the research is being done and what it will involve. This Participant Information Sheet tells you about the aims, risks and benefits of this research. If you agree to take part, we will ask you to sign a Consent Form. If there is anything that you are not clear about, we will be happy to explain it to you. Please take as much time as you need to read this information. You should only consent to participate in this research study when you feel you fully understand what is being asked of you, and you have had enough time to think about your decision. Thank you for reading this.

• Purpose of the Study
Chris Noone, a Ph.D. candidate at the School of Psychology, supervised by Dr. Michael Hogan, NUIG, is carrying out a study that is concerned with understanding the cognitive and emotional processes which contribute to effective critical thinking and the role relaxation may play in this. You will be asked to fill out questionnaires focusing on how you pay attention and how you think in certain situations. You will also be asked to complete some computerised cognitive tasks.

• Who can take part?
We are recruiting students from NUI, Galway who are over 18 years of age, and have English as a first language or university level English (i.e. equivalent to 80 on TOEFL or 6.5 on IELTS). Due to the nature of the study the following students are not eligible to participate:
• those currently taking any type of sedating medication
• those who do not possess normal or corrected-to-normal vision and hearing
• those who are drug/alcohol dependent.
• those who are not right handed
What does the study require me to do?
The study involves visiting our lab and completing 2 questionnaires and 2 short computerized tasks. The questionnaires you will be asked to fill out focus on how you pay attention and how you think in certain situations. You will also be asked to complete some computerised cognitive tasks. These tasks assess your ability to pay attention and keep count of numbers presented on a computer screen. These are all standard tests of mental function that are used regularly in psychological research.

The experimental procedure will take about 1 hour to complete. First you will complete a demographics sheet and a questionnaire about how you generally pay attention. Then you will complete the computerised tasks assessing your ability to pay attention and keep count of numbers presented on a computer screen and a critical thinking assessment. After that you will listen to a guided relaxation audio clip. Then you will complete the computerised tasks and critical thinking assessment again.

What happens to my data?
All data are, in accordance with the Data Protection Act, strictly confidential. Your information will be provided with a number and are stored as numbered files and forms, without your name or other personal information. The personal and experimental data is therefore stored anonymously. Only the researchers involved have access to this data. Only one researcher has access to the details of the subjects. It is anticipated that the findings of this study will be written up for publication in a peer-reviewed journal and presented at international conferences. All results will be anonymous no data will be traced to you. Your information will never be given to third parties.

Do I have to take part?
It is up to you to decide if you want to take part. If you decide to take part you will be asked to sign a Consent Form. If you change your mind after signing the consent form, you are still free to withdraw at any time and without giving a reason. A decision to withdraw at any time, or a decision not to take part, will not affect your rights in any way.

What happens if I change my mind during the study?
You are entitled to change your mind about participating in this at any time without disadvantage or penalty.
• **What are the possible benefits in taking part?**
Benefits include the opportunity to contribute to the understanding of the role of relaxation and other cognitive and emotional process in critical thinking. Participants will also receive an ebook as a gift. Participants enrolled in 1st year or 2nd year psychology can receive 5 research participation credits for taking part in this study and those enrolled in Introduction to Positive Psychology can earn 5% course credit for taking part.

• **What are the possible disadvantages in taking part?**
There are no risks to taking part. You may get tired – in which case we will give you a break – but the tasks are short so this is unlikely. Refreshments will be provided also.

• **Who do I contact for more information or if I have further concerns?**
Chris Noone may be contacted at any time regarding questions about this study at [noonec@gmail.com](mailto:noonec@gmail.com) or by telephone at [086 063 0498](tel:0860630498). If you have any concerns about this study and wish to contact someone in confidence, you may contact the Chairperson of the NUI Galway Research Ethics Committee c/o Office of the Vice President for Research, NUI Galway, [ethics@nuigalway.ie](mailto:ethics@nuigalway.ie)
PARTICIPANT INFORMED CONSENT FORM

Participant Student ID No. : _______________________

Title: An analysis of the effects of relaxation on sustained attention and critical thinking

Name of Researcher: Chris Noone

Please initial box

1. I confirm that I have read the information sheet for the above study and that I understand the information given. ☐

2. I am happy that I have had enough time to think about the information and have had the chance to ask the researcher questions. ☐

3. I understand that participation is voluntary and that it is possible to withdraw at any time, without giving any reason, without any legal rights being affected. ☐

4. I, the participant, agree to take part in the study ☐

Remember, even though you agree to participate you may choose to withdraw at any time

Please sign below

Name of Participant ___________________________ Signature ___________________________ Date ___________________________

Name of Researcher ___________________________ Signature ___________________________ Date ___________________________
PARTICIPANT DEBRIEFING SHEET

• Purpose of the Study
You have taken part in a research study that is concerned with understanding the cognitive and emotional processes which contribute to effective critical thinking and the role mindfulness may play in this. Specifically, this study investigates the effects of mindfulness on executive functioning and critical thinking.

This study involves two groups – an experimental group receiving a mindfulness induction and a control group receiving a mindlessness induction. We expect the mindfulness group to perform better than the mindlessness group on executive functioning and critical thinking tasks.

In order for the study to be as tightly controlled as possible, we decided to avoid revealing that mindfulness was the key variable being manipulated in this experiment. We did this with the permission of the NUI Galway Research Ethics Committee. If you have any concerns about this study and wish to contact someone in confidence, you may contact the Chairperson of the NUI Galway Research Ethics Committee c/o Office of the Vice President for Research, NUI Galway, ethics@nuigalway.ie

This study follows up on previous research by Chris Noone and Dr. Michael Hogan demonstrating a link between mindfulness and critical thinking mediated by working memory updating performance. For more details, see the attached poster.

We would appreciate if you kept the purpose of this study from other you know that are participating in this study in the future.

Having read this debriefing sheet, are you happy for your data to be used in this study? Yes No

Thank you very much for participating!
Appendix D - Mindfulness Meditation Script

Mindfulness Induction Study Recording Script kindly provided by Joanna J. Arch

Mindfulness Meditation Script

1. Now we’re going to do an exercise for 10 minutes.

2. First, settle into a comfortable sitting position, sitting with your back straight against the back of the chair, your legs uncrossed, your feet flat on the floor and your hands in your lap. Now gently close your eyes. Ask yourself, “What is my experience right now? What am I thinking about? What am I feeling emotionally? What sensations are present in my body?” Just observe your experience, whatever it is.

3. Bringing your awareness to your body, focus your attention on the sensations of touch or pressure where your body makes contact with the chair. Spend a moment or two exploring these sensations.

4. Now bring your attention to the changing physical sensations in your lower abdomen as the breath moves in and out of your body. To help you pay attention to your breathing, place your hand on your lower abdomen, and become aware of the changing sensations where your hand makes contact with your abdomen. When you’ve "tuned in" to the physical sensations in this area, you can remove your hand if you like, and continue to focus on the sensations in your abdomen.

5. Focus your awareness on the sensations of slight stretching as the abdomen rises with each inbreath, and of gentle deflation as it falls with each outbreath. Pay attention as best you can to the changing physical sensations in the lower abdomen all the way through as the breath enters your body on the inbreath, and all the way through as the breath leaves your body on the outbreath perhaps also noticing the slight pause at the end of the inbreath, and the slight pause between the end of one outbreath and the beginning of the next inbreath.

6. Focusing on the actual sensations of breath entering and breath leaving the body There is no need to think about the breath – just experience the sensations of it. And there is no need to try to control the breathing in any way - simply let the breath be natural. As best you can, also bring this sense of allowing to the rest of your experience. There is nothing to be fixed, no particular state to be achieved. As best you can, simply allow your experience to be your experience, without needing to change it in any way.

7. Sooner or later your mind will wander away from the focus on the breath in the lower abdomen to thoughts, feelings, daydreams, drifting along - whatever. This is perfectly OK - it's simply what minds do. When you notice that your awareness is no longer on the breath, acknowledge gently and briefly where the mind has been. Then, gently bring your awareness back to the changing physical sensations in the lower abdomen,
renewing your intention to pay attention to the breath coming in and breath going out.

8. Whenever you notice that the mind has wandered (and this may happen over and over again), congratulate yourself each time on reconnecting with your experience in the moment, gently escorting the attention back to the breath, and simply continue in noticing the physical sensations that come with each inbreath and outbreath.

9. Now simply continue with this, perhaps reminding yourself from time to time that the intention is simply to be aware of your experience in each moment, as best you can, using the breath as an anchor to gently reconnect with the here and now each time you notice that your mind has wandered and is no longer down in the abdomen, following the breath. I’ll let you know when it’s time to move on to something else.

10. Now allow your attention to expand to your whole body, to your posture, your facial expression, and other parts of your body. Continue with this.

11. Now when you are ready, slowly and gently open your eyes.
Appendix E - Sham Meditation Script

Mindfulness Induction Study Recording Script kindly provided by Joanna J. Arch

Sham Meditation Script (Mindlessness Induction)

1. Now we’re going to do an exercise for 10 minutes.

2. First, settle into a comfortable sitting position. Now simply think about whatever comes to mind. Let your mind wander freely without trying to focus on anything in particular. Just let your mind roam as it normally would <pause pause>

3. Now simply continue with letting your mind wander and think about whatever you want. I’ll let you know when it’s time to move on to something else. <pause 5 minutes>

4. Continue letting your mind wander, letting your thoughts go wherever they take you. <pause 3 minutes> (repeat variants of this instruction, then wait another 4 min)

4. Remember to just continue letting your mind wander, and follow wherever it takes you. Just think about whatever comes to your mind. I’ll let you know when it’s time to move on to something else

4. Now we will move on to the next part of the study.
PARTICIPANT INFORMATION SHEET

• Invitation
You are invited to take part in a research study which involves evaluating the effects of a 6-week mindfulness meditation intervention on cognitive ability. Participants will spend 6-weeks learning about the concept and practice of mindfulness using Headspace, an app which runs on all major smartphones, tablets and web browsers. You will be provided with a free subscription to Headspace which will last for another 6 months after the study finishes if you complete all data collection. This is usually worth around €60.

Before you decide, it is important that you understand why the research is being done and what it will involve. This Participant Information Sheet tells you about the aims, risks and benefits of this research. If you agree to take part, we will ask you to sign a Consent Form before data collection begins. If there is anything that you are not clear about, we will be happy to explain it to you. Please take as much time as you need to read this information. You should only consent to participate in this research study when you feel you fully understand what is being asked of you, and you have had enough time to think about your decision. Thank you for reading this.

• Purpose of the Study
Chris Noone, a Ph.D. candidate at the School of Psychology, supervised by Dr. Michael Hogan, NUIG, is carrying out a study that is concerned with determining effects on cognitive ability of using Headspace for a 6 week mindfulness intervention. You will be asked to try out the Headspace Foundations programme, to answer some questionnaires, complete some cognitive tasks and you may be asked to give your thoughts on your experience of the programme in a focus group.

• What does the study require me to do?
First, if you understand and are happy with the information in this document, then we will ask you to sign a consent form. This signature just acts as way of telling us you feel you understand what this study involves and does not result in any obligations on your part – you will be free to withdraw at any time if you so wish without penalty.

Second, you will be asked to complete a screening form online. This entails some demographic information, some questions about medical history and some questions regarding your mental health. You can rest assured that this information will not be seen by anyone except the researchers and will be anonymised following analysis. We cannot anonymise before this because ethically we must provide support to any participants exhibiting signs of emotional distress. Unfortunately we cannot include everyone in our data collection beyond this point. Those with previous experiences of meditation and possible confounding pre-existing conditions such as learning difficulties, clinical mental health conditions or use of certain medications/drugs (i.e. those that affect self-regulation and cognition including anti-depressants, anxiolytics and recreational drugs) will be ineligible to participate in data collection for the intervention. However, as a mark of courtesy for their interest, these individuals will be offered access to the mindfulness meditation intervention materials through Headspace.
Third, you will be asked to complete baseline measures assessing critical thinking, working memory, thinking dispositions such as how much effort you tend to put into thinking and how open-minded you tend to be, mindfulness and wellbeing. These will be completed in a 3 hour lab session which will include a 30 minute break for lunch which will be provided to you.

Fourth, you will be introduced to Headspace and the sign-up process. To get started, you are required to register on headspace.com using your name and email address. Each participant will be given a unique code providing free access to Headspace for the duration of the study. After registering, you can begin meditating straight away or whenever suits you. This will take just 10 minutes per day and you can do it anywhere at any time using internet using either smartphone, tablet or personal computer. There are two different types of meditation being investigated and to ensure control and rigour, neither the participants nor the researchers will be aware of which condition any individual participant is in until after the data has been analysed. At this point all participants will be debriefed.

The intervention is 6-weeks in length. You will be encouraged to practice meditation daily for the course of the 6-weeks using materials from the Foundation Pack which includes 30 x 10 minute sessions introducing the concept and practice of mindfulness training. Guided throughout, each session gradually builds on the previous one. Reminders will be sent by text message a couple of times per week.

Fifth, in week 2 and week 4 we will ask you to complete short questionnaires assessing mindfulness meditation quality and task expectations, enjoyment and difficulty. These will be completed online, allowing you to complete them at your convenience.

Sixth, you will be asked to complete outcome measures at the end of the 6 weeks assessing critical thinking, working memory, thinking dispositions such as how much effort you tend to put into thinking and how open-minded you tend to be, mindfulness and wellbeing. These will be completed in a 3 hour lab session which will include a 30 minute break for lunch which will be provided to you.

Finally, you will be debriefed regarding the purposes of the studies, the results and the condition you were in.

• What happens to my data?
All data are, in accordance with the Data Protection Act, strictly confidential. Your information will be provided with a number and are stored as numbered files and forms, without your name or other personal information. The personal and experimental data is therefore stored anonymously. Only the researchers involved have access to this data. Only one researcher has access to the details of the subjects. All results will be anonymous no data will be traced to you. Your information will never be given to third parties.

• Do I have to take part?
It is up to you to decide if you want to take part. If you decide to take part you will be asked to sign a Consent Form. If you change your mind after signing the consent form, you are still free to withdraw at any time and without giving a reason. A decision to withdraw at any time, or a decision not to take part, will not affect your rights in any way.

• What happens if I change my mind during the study?
You are entitled to change your mind about participating in this at any time without disadvantage or penalty.

• What are the possible benefits in taking part?
Taking part in the Headspace Foundations programme has been demonstrated to have beneficial effects on wellbeing which you might experience. Students recruited from the cohort of
first and second year psychology students will receive course credit for participating in the study (i.e. 10% of a 5 ECTS module). Those that complete all measures at all time-points will receive a complimentary 6-month subscription to Headspace (worth approx. €60). In addition, you will have the opportunity to contribute to the understanding of the role of mindfulness in higher-order cognition. Participants will be informed of the results of the study when they are available.

• What are the possible disadvantages in taking part?
The questionnaires may highlight a small amount of emotional distress for some people. However, previous intervention studies on mindfulness suggest that only a small number of participants experience this. Completing the questionnaires and the intervention is voluntary and if it does bring up difficulties we can recommend relevant professionals who can be contacted.

• Who do I contact for more information or if I have further concerns?
Chris Noone may be contacted at any time regarding questions about this study at noonec@gmail.com or by telephone at 086 063 0498. If you have any concerns about this study and wish to contact someone in confidence, you may contact the Head of the School of Psychology at annmarie.groarke@nuigalway.ie

If you are happy to proceed, please sign the consent form provided below.

PARTICIPANT INFORMED CONSENT FORM

Name of Researcher: Chris Noone

Please initial box

1. I confirm that I have read the information sheet for the above study and that I understand the information given.

2. I am happy that I have had enough time to think about the information and have had the chance to ask the researcher questions.

3. I understand that participation is voluntary and that it is possible to withdraw at any time, without giving any reason, without any legal rights being affected.

4. I, the participant, agree to take part in the study

Remember, even though you agree to participate you may choose to withdraw at any time

Please sign below

________________________________________ ________________ ____________
Name of Participant Signature Date

________________________________________ ________________ ____________
Name of Researcher Signature Date
Appendix G - Headspace Memorandum of Understanding

Memorandum of Understanding between Headspace and a recipient of subscription donations for research purposes

This Agreement is made on 9th of June 2015

Parties

(1) Headspace Inc., whose registered office is at 612 Hampton Drive, Venice CA 90291 (Headspace); and

(2) Chris Noone, PhD Candidate, School of Psychology, National University of Ireland, Galway

Headspace is donating subscriptions at no charge to your organisation as part of our research initiative to further our mission of improving the health and happiness of the world. By receiving these subscriptions you agree to all conditions of Headspace’s Terms and Conditions (available at www.headspace.com), in addition to the following provisions:

- You will make all reasonable efforts to ensure any donated subscriptions are only used for their intended purpose, namely research.
- The subscriptions will not be used for any financial gain for your organisation i.e. sold or auctioned.
- You will not use any of Headspace’s intellectual property without prior consent e.g. any of Headspace’s content, assets, logos.
- Headspace has the right to use your name, trademarks and logo on our website and to generally publicize the relationship in order to further our mission.
- Headspace has the right to see all research findings, including those unpublished, and, in the event that any finding is not intended to be published, Headspace has the right to publicize the findings, accurately represented as ‘unpublished’.
- You agree that Headspace may revoke any donated subscriptions at any time, without notice, if we believe that the subscriptions aren’t being used for their intended purposes, or if there are any violations of the terms laid out in this MOU.
- You agree to indemnify Headspace and its officers, employees, and agents against any claims, damages, losses or expenses arising out of your (or a third party’s) use of the subscriptions.

For the avoidance of doubt, your organization will also be subject to the general Terms and Conditions of the Headspace product, which can be found at www.headspace.com. These Terms and Conditions include details on other important aspects of this agreement, including but not limited to our privacy policy, medical disclaimers, data privacy, liability, copyright, warranties and limitations & indemnification.

Data Privacy:

We believe the details of Headspace journeys should be personal and confidential. Details about individuals’ use of the Headspace tools will never be seen or shared by/with anyone outside the Science team at the company.

Individual usage and demographic information will only be used by Headspace Inc. in accordance with the standard Headspace user terms & conditions.

No data will be shared with any other organisations, unless with prior agreement, and all data is kept confidential.
Read and agreed

By: [signature]

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Date: 16/06/15
Headspace Session 1

The first session begins with advice on the practicalities of meditating including how to build a routine regarding where to meditate, what time to meditate and the attitude to bring to meditation. The guided meditation follows the following steps:

1. The guided meditation begins with instructions on getting into a comfortable seated position and taking deep breaths with the eyes open. (Approx. 30 seconds)
2. The participant is then invited to notice the weight of their body against the chair and other physical sensations. (Approx. 30 seconds)
3. The participant is guided through a scan of their body from head to toe and back up to the chest where the focus of the participant is guided towards the breath. (Approx. 1 minute)
4. The participant is then instructed to anchor their attention to the breath by counting each breath, starting at 1 and ending at 10 before repeating the cycle. During this time, the participant is encouraged to monitor for mind-wandering and to gently return attention to the breath when mind-wandering is detected. (Approx. 7 minutes)
5. The participant is then allowed to let their mind wander before bringing their attention back to their body and their surroundings to end the meditation. (Approx. 1 minute)

Headspace Session 2

This session and each of the subsequent sessions follow the same sequence as the guided meditation in the first session but with subtle differences which will be noted below. For example, this session gives more time to the breath counting exercise.
Headspace Session 3

This session begins with an animation explaining how to monitor thoughts and feelings in the present moment by using a metaphor of watching passing cars from the side of a road.

Headspace Session 4

This session begins with an introduction which encourages the participant to bear in mind the metaphor presented in the previous session and then continues with the guided meditation.

Headspace Session 5

An animation is presented at the beginning of this session which discusses the role of effort in mindfulness meditation, where it is suggested that exerting too much effort is detrimental to the practice. This point is made using the metaphor of taming a wild horse.

Headspace Session 6

In this session, the guided meditation is presented in a similar way to previous sessions but with extra emphasis put on the body scan exercise. Participants are encouraged to try their best to not resist unpleasant feelings during this exercise.

Headspace Session 7

This session starts with an animation which discusses detachment from unpleasant thoughts and feelings. This is elaborated upon by comparing a calm state of mind to a clear sky and a stressed state to a stormy sky. Detachment is compared to the ability to fly high enough away from the clouds so that the sky is again clear. The guided mediation then proceeds per the same sequence as previous sessions, though more periods of silence (and less instructions) are included.
Headspace Session 8

This session begins with the instruction to pay attention specifically to one’s mood state during the guided meditation.

Headspace Session 9

At the start of this session, an animation is presented which compares the mind to a still pool of water which can be disturbed, but always has the potential to return to being still. This metaphor is explored further in order to explain the importance of allowing thoughts and feelings to come and go, rather than resisting them.

Headspace Session 10

At the start of this session, the participant is encouraged to reflect on what differences they have noticed since they began the series of meditation sessions.

Headspace Session 11

This session begins with a video in which the instructor, Andy Puddicombe, reminds participants of the tips presented in the first session regarding how to approach the guided meditations. It then proceeds with the same steps as previous guided meditations but in this and the following sessions, there is gradually longer periods of silence and less instruction during the breath counting exercise.

Headspace Session 12

This session begins with the participant to reflect on how their motivation to meditate relates to how their meditation practice affects others around them.

Headspace Session 13

At the beginning of this session, participants are reassured about the difficulty they may be experiencing in motivating themselves to meditate and encouraged to be non-judgmental towards themselves.
Headspace Session 14

A similar reminder to be non-judgmental regarding one’s motivation to meditate is presented at the beginning of this session.

Headspace Session 15

This session begins with a video which includes tips on integrating mindful attention into daily activities. It then discusses the barrier of restlessness during meditation and encourages participants to not react to this feeling.

Headspace Session 16

This session begins with a discussion of the barrier to practice of sleepiness during meditation with the instruction to notice any resistance to sleepiness during the guided meditation.

Headspace Session 17

This session begins with a discussion of the barrier to practice of boredom during meditation with the instruction to approach the guided meditation with a curious attitude.

Headspace Session 18

This session begins with a discussion of the barrier to practice of pain or discomfort during meditation with the instruction to give up resistance to these feelings.

Headspace Session 19

This session begins with a discussion how daydreaming, even if pleasant, can be a barrier to meditation. Participants are encouraged to monitor for any instances of daydreaming and to gently direct their attention back to the present moment when daydreaming is noticed.
Headspace Session 20

This session starts with a video in which Andy Puddicombe congratulates the participant for completing 20 sessions. He then advises participants to think about their relationships with others when considering their motivation to practice mindfulness before the guided meditation begins.

Headspace Session 21

At the beginning of this session a video is presented featuring Andy Puddicombe discussing the barriers to meditation considered in previous sessions. He also discusses the integration of mindful attention into daily activities and explains that common to both issues is the need to engage with difficult feelings as they arise rather than resist them.

Headspace Session 22

At the end of this session and subsequent sessions, participants are encouraged to monitor their breath without counting it. Participants are instructed to monitor for any instances of mind-wandering during this time.

Headspace Session 23

This session starts with tips on how to remember to pay mindful attention during the day by placing post-it notes or other physical cues in places where they will be noticed.

Headspace Session 24

At the start of this session, participants are encouraged to plan specific times during the day at which they will engage in a short body scan exercise, recalling the instructions from the guided meditations.

Headspace Session 25

This session begins with a video in which Andy Puddicombe gives advice on how to apply the body scan exercise at different times during the day by using physical cues other than the breath such as steps when walking or the feeling of heat upon one’s skin.
Headspace Session 26

The beginning of this session focuses on encouraging the participant to reflect on how they have been applying mindful attention in their everyday life.

Headspace Session 27

At the beginning of this session, participants are advised that a useful cue for initiating the engagement of present-moment attention is the transition between sitting and standing.

Headspace Session 28

This session begins with participants being asked to reflect on whether using the transition between sitting and standing as a cue to pay attention to the present moment was useful.

Headspace Session 29

The start of this session reiterates the importance of applying mindfulness during daily activities and suggests that this can help with engagement during the guided meditations.

Headspace Session 30

At the start of this session, a video is presented which features Andy Puddicombe congratulating the participant on reaching the final session.