THE MATTER OF MINDFULNESS

INVESTIGATIONS INTO THE MECHANISMS OF MINDFULNESS

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ABSTRACT

Mindfulness may be described as a state of heightened present-moment awareness that we all experience to a greater or lesser extent. Enhancing this quality of awareness through training has shown to alleviate stress and promote mental and physical well-being and, as a consequence, the clinical application of mindfulness is gaining in popularity. Because of this, there is a growing need to understand *how* mindfulness achieves desirable outcomes. The cognitive and neural mechanisms of mindfulness were investigated in a series of research studies in this thesis, by means of literature analysis, clinical intervention, functional brain imaging and brain-lesion methods. In Study One a total of 10 commonly proposed mechanisms of mindfulness were identified through a qualitative systematic analysis of the literature: self-regulation, exposure, cognitive flexibility, acceptance, disidentification, awareness/insight, reattribution, attention, metacognition, and relaxation. Mediation analyses in Study Two confirmed that acceptance and cognitive flexibility significantly mediated the relationship between mindfulness and reduced symptoms of stress and that acceptance significantly mediated the relationship between mindfulness and mood disturbance. Functional magnetic resonance imaging was employed in Study Three to further test these findings and state mindfulness was shown to mediate midline cortical regions associated with interoception. The findings of Study Three suggest that mindfulness may be

associated with positive outcomes through a process of disidentification; a process described as removing the 'self' in the experience of passing events. Damage to the midline cortical brain regions identified in Study Three, however, showed to have no significant effect on naturally-occurring mindfulness, according the results of a pilot brain-lesion investigation in Study Four. Based on the findings of the studies in this thesis, it is suggested that mindfulness may reduce vulnerability to stress and emotional distress through a meta-mechanism of disidentification and through more direct mechanisms: acceptance and cognitive flexibility. The collected evidence supports the application of mindfulness training as an intervention to advance affective and cognitive well-being. At a broader level, the findings also establish a firmer relationship between mental control and optimal mental functioning.

CHAPTER ONE

INTRODUCTION

The search for meaning in life has inspired all of what we have come to learn and know in the world as human beings. The tireless compulsion to understand our outer and inner natures separates us from other living organisms on earth and is strongly driven by an effort to improve the human condition. The work of this thesis has been inspired by the belief that we *can* live richer and more meaningful lives, and its particular focus is on how present-moment awareness may achieve this.

The nature of the human mind is perhaps the most timeless ambiguity, not least because the related exploration inscrutably relies on the very application of the apparatus under study. Despite this, man's preoccupation with understanding the mind and improving its performance has a long history as any retrospective look at philosophy will attest. Some of the earliest pre-scientific theories of the mind emerged in the 5th and 6th centuries BCE in Greece, China and South Asia. These theories were primarily based in theology and concentrated on the interaction between the mind and the soul, rather than the popular contemporary scientific debate on the relationship between the mind and the brain (Chalmers, 2002). Although some common themes emerged in a surprising number of these early records, particularly the perfectibility of mind and the virtue of emotional equanimity, Eastern philosophical traditions went further to develop a collection of practical techniques to better understand the mind and the nature of self. These

techniques were geared to nurture awareness and insight. While spiritual and scientific debates regarding the mind surged over the centuries that followed, these mental techniques have been consistently and invariantly practiced within Eastern philosophical traditions, with purported benefits of enhanced mental, physical and spiritual well-being. Nearly two millennia later, these same mental training techniques were being applied and studied in Western medicine and empirical science, perhaps the most unexpected of settings (Benson, 1996; Davidson et al., 2003; Kabat-Zinn, 1994). Scientific interest has grown exponentially as the application of these practices has been shown to assist in the treatment of stress related illnesses and also in the promotion of well-being in the healthy (Benson, 1996; Grossman, Niemann, Schmidt, & Walach, 2004).

Against the grander backdrop of improving the human condition, this thesis takes a special interest in optimal mental health, and the mind's potential to enhance such well-being through training (Schwartz & Begley, 2002). Ironically, the topic of optimising well-being has been almost foreign to the academic discipline of psychology, which holds the mind at its epicentre. Despite the uniquely human interest in enhancing functioning, the very discipline that concerns mental life has largely focused on pathology since it took its place in academia in the late 19th century – by 2004, *Psychology Abstracts* had documented over 168 000 published articles on anger, anxiety and depression, and less than 4000 on mental wellness (Myers, 2004). Although an interest in characterising mental health has inspired the development of psychological theories, which have evolved alongside this mainstream occupation of understanding, delineating, categorising and treating mental illness, the former effort has, until recently, been negligible by comparison.

In the late 1800s William James theorised that gaining, keeping and recovering happiness is the secret motivation behind all human action (Myers, 2004) and he subsequently launched a scientific inquest into how to live more fully. James and his followers contemplated life ideals and explored methods to transcend

normal experiences and achieve optimal functioning, inspiring a wave of theoreticians in the 20th century. Models were developed on the role of individuation (Jung, 1981), the fully functioning individual (Rogers, 1963), self-actualisation (Maslow, 1968), the constituents of mental health and the mature individual (Allport, 1961; Jahoda, 1958), adaptation to life (Vaillant, 1977), self-determination (Deci & Ryan, 1985) and psychological well-being (Ryff & Singer, 1996). Programmes have also been developed to enhance positive mental states (Fordyce, 1977, 1983).

In recent years the interest in optimal well-being has picked up pace and a 'positive psychology' paradigm has emerged to contain scholars who seek to understand optimal functioning, what it is and how it may be induced, and to unite disparate theories about advancing happiness (Peterson & Park, 2003). The field of positive psychology has endeavoured to set an agenda to articulate a vision of what they describe as *the good life*, and isolate what actions lead to individual, community and societal well-being (Linley & Joseph, 2004). The journal *American Psychologist* devoted its millennium issue to the emerging science of positive psychology (Seligman & Csikszentmihalyi, 2000) and more recently a classification manual, described as the DSM of subjective well-being, has been published: *Character Strengths and Virtues: A Handbook and Classification* (*CSV*; Peterson & Seligman, 2004). The CSV outlines six virtues and 24 character strengths considered to promote wellness; preliminary research provides some support that these determinants are relevant across cultures (Dahlsgaard, Peterson, & Seligman, 2005) and that the associated clinical interventions are effective (Seligman, Park, & Peterson, 2005). It must be said, however, the former study relied on a literature review of the virtues underscoring major ancient philosophical traditions and is arguably limited by the fact that the identified virtues where contextually isolated from the grander philosophical tenets. The primary limitation of the latter randomized control study was its reliance on a convenience sample made up of well-educated, white,

financially stable participants who were, on average, mildly depressed and motivated to improve their mental state; a more heterogeneous sample group would be required to truly validate these interventions.

The positive psychology discipline, and its promotion of virtuous life ideals, is not without controversy. Although the study of resilience and human strengths is largely applauded, criticism has been levelled against dividing the discipline of psychology into positive and negative approaches to studying the human mind – the two are argued to be mutually beneficial and to hold the same inherent ideals (Held, 2004). Held (2004) noted the potential minefield that lies in defining virtuous attributes and the good life, and also, the fine line that separates *describing* what is good and *prescribing* it. Prescribing a 'one size fits all' model of a good life negates cultural and individual idiosyncrasies. Then there is the unintended consequence of classifying certain mental qualities and dispositions as 'good' or 'bad', which may foster self-judgment and even self-criticism; non-judgment has been cited as a key mechanism in improving psychological health (Hayes, Strosahl, & Wilson, 1999). Furthermore, negative affective states have been shown to have salutary qualities themselves (Held, 2004) and forcing optimism is associated with its own perils (Norem & Chang, 2002).

While the broader interest of this thesis (optimal mental health) may fall within the ambit of positive psychology ideals, it is not based on the assumption that mental states endorsing happiness should be isolated and ubiquitously prescribed across geographies and cultures. Furthermore, this thesis does not share the ambition of advancing happiness per se, because happiness is not considered an ultimate affective state that should endure – the precedence of happiness over other affective states is not considered an indicator of optimal mental health. Here optimal well-being is considered a product of the effective identification, interpretation and regulation of the full spectrum of affective states, which each have evolutionary significance and manifest cyclically and inevitably.

NURTURING OPTIMAL WELL-BEING

The question of whether the mind, and more specifically the mature brain, is able to accommodate lasting functional change challenges all psychotherapeutic interventions, regardless of whether their application is geared toward alleviating suffering or improving well-being. Numerous critics over the years have argued that behavioural styles are genetically determined, that mood states may fluctuate but are fixed at specific set-points and that the brain is hard wired, unable to accommodate lasting functional change (Eysenck, 1967; Solomon, 1980; Unger, 1970). These arguments also challenge this thesis, which is based on the assumption that optimising mental health is achievable. Fortunately neuroscientific research has provided convincing support for this assumption. While it was initially proposed that frontal brain asymmetry predicts qualities of dispositional mood and other emotion-relevant biological indices, and that related measures of hemispheric asymmetry are present within the first year of life and remain stable over time (Davidson, 1992), these asymmetries have subsequently been shown to shift in response to meditation training (Davidson et al., 2003). In addition brain circuitry has proven capable of being rewired in the process of neuroplasticity (Restak, 2004; Schwartz & Begley, 2002). Neuroplasticity refers to alterations in the organisation of the brain resulting from experience and learning after critical developmental periods have been reached. This reorganisation is made possible by axonal sprouting, the process whereby axons form new nerve endings and connect to alternative neurons (Carmichael & Chesselet, 2002). Previously, as stated, it was believed that the adult brain is immutable to such adaptation. Over and above the obvious clinical implications of neuroplasticity, most importantly the potential for recovery of lost function following brain injury or disease, neuroplasticity provides strong evidence that mental activity indeed moulds the physical brain, a notion that

accommodates the possibility of advancing optimal mental health.

Neuroplasticity is an increasingly popular topic of study in Western science. Investigations into the role of the placebo effect and the role of psychotherapy in inducing changes in emotional well-being and concurrent alterations in brain physiology, have further inspired research in this area (Mayberg, 2002, 2004). Mayberg (2002) first explored the neuroanatomy of the placebo effect as part of an inpatient neuroimaging study of an antidepressant drug. Patients with unipolar depression receiving a placebo showed comparable improvements in psychological symptoms and metabolic increases in the same brain regions to those receiving the antidepressant following a 6-week double-blind trial. In other words, the mere belief that treatment was being administered brought about not only improvements in mental health but also associated neurophysiological alterations. In a later study by Mayberg (2004) cognitive-behavioural therapy (CBT) for depression was shown to produce not only self-reported improvements in affect but also the accompanying modulation of cortical-limbic pathways implicated in major depression. More recently studies of meditation have provided additional support for the influence of willed mental control over mental and physical well-being and also over the material brain (Lazar et al., 2005; Schwartz, 1999).

PRESENTING THIS THESIS

Throughout this introduction, reference has been made to mental control techniques originating in Eastern philosophical traditions that are being applied today to assist in the treatment of mental illness and the promotion of wellness. The specific mental practice that is studied in this thesis is *mindfulness*. Mindfulness can be described as a state of heightened present-moment awareness that is cultivated through practice and considered a foundation of mental health in Buddhist philosophy (Nyanaponkia, 1949). Mindfulness has received much attention over the

last few decades in Western science, and specifically the fields of clinical and experimental psychology. Acquiring mindfulness skills through training, which focuses on increasing awareness and the skilful responding to mental processes, has been shown to increase positive affect and reduce cognitive vulnerability to stress and emotional distress in clinical and non-clinical populations (Grossman et al., 2004).

The most documented application of mindfulness training in the Western world is to nurture stress coping mechanisms (Kabat-Zinn, 1993). Investigations over the last three decades describe stress as a common factor underpinning mental and physical illness, with as many as 60 to 90% of doctor visits resulting from stress-related illness (Benson, 1996), which offers convincing support for the need of stress-reduction techniques. Aside from stress management, mindfulness training has also been applied to cultivate tolerance, acceptance, compassion and non-judgement, as a secondary effect of reduced stress. In this context mindfulness is said to emancipate one not only from habitual views of the self, but also of others and the world, allowing alternative responses to be flexibly considered (Kabat-Zinn, 1993). The possibility of engendering such qualities has been cited as a major contribution to societies around the world in alleviating discrimination, prejudice and destructive emotions in general (Goleman, 2004). Mindfulness interventions have also been employed in a variety of environments (including hospitals, educational institutions and correctional services systems) to engender these positive mental qualities; there employment in such settings is based on studies showing the positive effect of mindfulness in the treatment of addiction (Witkiewitz, Marlatt, & Walker, 2005), impulse control disorders (Lakey, Campbell, Brown, & Goodie, 2007), and hostility and violence (Horton-Deutsch, 2003; Singh, Wahler, Adkins, & Myers, 2003). There is also a growing interest in introducing mindfulness training to the broader community, to promote mental health (Goleman, 2004).

While mindfulness training has been incorporated into numerous psychotherapies based on positive research findings that support its ability to mitigate stress and emotional distress, few empirical investigations have sought out the *mechanisms* through which it achieves such positive outcomes. The growing application of mindfulness and other meditation techniques used to alleviate and even treat stress-related conditions in the clinical healthcare setting, creates an imperative for empirical evidence to support their efficacy and also to offer a clear appreciation of the mechanisms through which they achieve positive health outcomes. In an endeavour to add to the current body of knowledge on mindfulness, the research studies in this thesis explore the *cognitive* and *neural* mechanisms of mindfulness to offer a richer scientific understanding of the mental state and potentially offer enhanced insight into optimal well-being.

LITERATURE REVIEW

Mindfulness may simply be described as a mental state of present moment awareness that results from paying attention in a particular way. Yet behind this modest description lies a rich and complex phenomenon with far-reaching outcomes. The essential qualities of mindfulness continue to be a topic of debate in Western science in appreciation of this complexity, and unconventionally, most of these explorations begin by conferring with Eastern philosophies. This literature review, which aims to capture what is currently understood about the mental state, will be no different, starting with a portrayal of the role of mindfulness in contemplative traditions.

Mindfulness has its origin in Buddhism, where the central aim is to eliminate suffering and advance spirituality (Lutz, Dunne, & Davidson, 2007). To this end, Buddhist traditional practices involve inducing mental states that bring about desirable changes in behavioural and psychological traits, not dissimilar to the ambitions of Western psychology (Gethin, 1998). These practices refer in particular to contemplative, or meditation practices, which work to improve concentration and insight as central mechanisms through which undesirable emotions and traits are recognized and dissipated. These practices hold mindfulness at their core.

Early Buddhist theoreticians (ca. 500 BCE) developed a detailed scholastic doctrine known as *Abhidharma* in Sanskrit, to describe and specify the meditation techniques that should be practiced to eliminate suffering and advance spirituality[1].

[1] Historical accounts of Buddhist traditions are most commonly recorded in one of two classical South Asian languages, Sanskrit or Pali. Pali is a scholarly language of Theraveda Buddhism and Sanskrit is that of Tibetan, Korean, Chinese and Japanese Buddhism. Sanskrit terminology will be used throughout this thesis.

In these teachings mindfulness is described as a continued and clear comprehension of an object that steadies and holds clarity in the mind to facilitate insight, which is in turn described as the clear perception of an object as it is in reality (Nyanaponika, 1949). In this description mindfulness is neither the beginning aim nor the end product of meditation but instead a mental state that emerges as a result of applied concentration, and that in turn facilitates insight. Importantly, mindfulness is cultivated through meditation but not constrained to it, meditation merely nurtures the mental state, which is ultimately intended to 'spill over' into daily life. Nevertheless, mindfulness in this context may be best understood by returning once again, and taking a more meticulous look at the practice of meditation.

Meditation is a collective description for a number of discrete mental control strategies aimed at calming and focusing the mind. Meditation, or *bhavana*, literally means *causing to become* (Lutz et al., 2007). Mostly all meditation practices pivot around two central skills, which are initially enhanced through their own respective meditation styles; *concentration (samatha)*, pointed attention to a single percept; and *insight (vipasyana)*, full and open awareness of the present moment (Goleman & Epstein, 1983). Although concentration and insight meditations are considered, and initially practiced as two distinct meditations, Tibetan theorists maintain the highest forms of meditation integrate the qualities (Lutz et al., 2007). Mindfulness has strong associations with both concentration and insight, however its hallmark lies in open awareness, as practiced in insight meditation. A ubiquitous form of the meditation that combines these skills, and one that may help our understanding of mindfulness, is practiced in this way: Concentration is first focused on the breath in order to still and focus the mind. Once concentration is stable, awareness is intentionally opened to bodily sensations, thoughts and mental images – open awareness involves shifting attention freely from one percept to the next with mental and physical events observed in a detached manner, as if from the perspective of an external observer. Should the meditator at any point become lost

in these thoughts, attention is once again brought back to the breath. As this process evolves the practice of concentration and open awareness supposedly afford a clearer insight into the habitual working of the mind (Lutz et al., 2007).

Sustained attention itself, or concentration in *samatha*-oriented practice, is believed to lead to trait changes according to Buddhist teachings, but it is the accompanying practice of open awareness or *vipasyana*-orientated meditation, that fosters insight into habits and assumptions about identity and emotions and subsequently acts to regulate emotion (Gethin, 1998). It should come as no surprise then that mindfulness is considered a primary health factor in Eastern psychologies and when present, is believed to facilitate all other mental health properties (Goleman & Epstein, 1983). Significantly, *smrti* is the term used for mindfulness in Sanskrit, and this term is used interchangeably with awareness.

In light of the Buddhist interpretation of mindfulness, or shall we say what remains in the wake of translation, it would be misleading if not overly-reductionist to refer to mindfulness as a *concept*, it may be better understood as a quality of present-moment awareness that is intentionally nurtured through contemplative practice to bring about improved functioning.

FROM EAST TO WEST

Mindfulness in Western Science

The Western scientific investigation of mindfulness has grown exponentially over the last three decades, with contributions from a variety of academic disciplines including psychology, psychiatry, medicine, philosophy, education and commerce. With specific reference to the field of mental health, mindfulness has received much attention in clinical psychology and, albeit to a lesser extent, in experimental psychology too. Studies of naturally-occurring mindfulness (i.e., that which exists to a greater or lesser extent within and between us all in the absence of formal

training), have been shown to be significantly associated with positive mental health constructs, and studies of learnt mindfulness (i.e., that which is acquired or intentionally cultivated through training), have demonstrated that training can increase positive affect and reduce cognitive vulnerability to stress and emotional distress in both clinical and non-clinical populations.

One of the earliest appearances of mindfulness in Western scientific literature was in the work of Ellen Langer (1975). Although Langer stressed that her use of the term should not be likened to its Eastern counterpart, the two literatures share some fundamental similarities. For instance, Langer described mindfulness as being alert to the present moment, to distinctions, context, multiple perspectives and novelty. In an attempt to enhance such qualities her version of mindfulness practice involved considering information and events from multiple perspectives to increase mental flexibility and creativity (Langer, 1989). To this end Langer promoted mindfulness as a means of ensuring that each task and decision is considered with care and discernment and with a clear and deep appreciation of the present moment.

Consistent with the overriding interest in psychopathology at the time, Langer's approach to studying mindfulness was informed by investigating *mindlessness* and its detrimental effects on human functioning. Langer referred to these counterproductive rituals as *mental automaticisms*, mental operations that become so well-rehearsed they become automatically executed without being mediated by thought; this subsequently leads to acting from a single perspective. Perhaps intuitively, this mindlessness feeds learned helplessness and reduced self-esteem and is cited as an impulse that all too often drives behaviour. Kabat-Zinn (1994, p. 9) noted that

> We get caught up in the torrent and it winds up submerging our lives as it carries us to places we may not wish to go and may not even realize we are headed for.

Despite the obvious parallels with the use of the term in Buddhist teachings, Langer produced what was essentially a cognitive model of mindfulness that fell somewhat short of the Buddhist interpretation. More pointedly, Langer described mindfulness as a favourable cognitive process whereas Buddhist doctrines described it as the quality of awareness that *facilitates* favourable cognitive processes. In addition Langer developed a mindfulness intervention to enhance the mental state by focusing on manipulating aspects of the external world, such as information, which stands in opposition to Buddhist practices, which aim to bring about change by focusing on and gaining insight into the internal landscape.

Mindfulness research that followed Langer's work has generally paid more homage to Eastern contemplative traditions and reference is typically made to this philosophical descent. Having said this, mindfulness practice has been secularised for the purpose of more widespread appeal in academic and clinical settings. In forgoing the role of the mental state in advancing spirituality, most scientific investigations have focused especially on assessing the efficacy of mindfulness training in promoting stress coping mechanisms and maturing emotional well-being.

Conceptual and Operational Definitions of Mindfulness

Conceptual and operational definitions of constructs are the bedrock of scientific investigations. Widespread adoption of such definitions ensures that the constructs under study are routinely measured in the same way in order for research questions to build on one another to advance knowledge. Mindfulness, although a popular subject of study, is poorly defined. Although researchers have made efforts to conceptually and operationally define the phenomenon, discrepancies regarding its exact definition remain. As a consequence, a variety of measuring instruments have been developed and used in the study of mindfulness and understandably,

inconsistent findings often emerge in the literature. Ironically, and as it will become obvious, systematic efforts to operationalise mindfulness have for the most part post-dated empirical research on the efficacy of related training.

Conceptually Defining Mindfulness

A variety of assumptions have emerged from attempts to 'unpack' mindfulness as a construct. Arguably the most notable conundrum is whether mindfulness incorporates elements of attention control (concentration) and insight or whether these skills merely facilitate and stem from mindfulness awareness respectively. Bishop (2002) has pointed out that caution should be taken to tease out what are truly components of mindfulness as opposed to outcomes of mindfulness training. Another particularly important consideration in operationally defining mindfulness is the consequence of binding mindfulness to meditation.

In an early Western literature on the subject, Goleman and Schwartz (1976) broadly defined mindfulness as the intentional self-regulation of attention, a conceptualisation that has since become regularly adopted. Around the same time Hanh (1976) referred to mindfulness as a process of keeping consciousness alive to present reality, seemingly involving consciousness and attention. Since that time most authors have defined the construct as a quality of awareness or consciousness (see, e.g., Bishop, 2002; Brown & Ryan, 2003; Kabat-Zinn, 1982; Kutz, Borysenko, & Benson, 1985). In a slight variation of this theme, Martin (1997) referred to mindfulness as a process of observation, and one that is essentially non-biased, explorative and also task-centered.

As scientific interest in the subject grew, Kabat-Zinn (1994, p. 9) expanded on this definition to arrive at one of the most commonly cited definitions in current research, and one that combines elements of both attention and awareness

> Paying attention in a particular way: on purpose, in the present moment and nonjudgmentally.

In 2003 Brown and Ryan agreed that mindfulness should be understood as quality of consciousness encompassing both attention and awareness, where awareness is considered the background monitor of the internal and external environment and attention focuses such awareness to a limited range of experience. In this definition mindfulness was further defined by Brown and Ryan (2003, p. 822) as

> Enhanced attention to and awareness of current experience and present reality.

To dispel the notion that mindfulness could be considered a cognitive process, the authors proposed that mindfulness operates *on*, rather than *within* thoughts, feelings and other content of consciousness, and therefore, the fact that mindfulness can be brought to bear on thought and emotions means it cannot be reduced to them. The mode of mindfulness is *perceptual* according to these authors. Turning this causal relationship around, Bishop and colleagues (2004) argued that while mindfulness may incorporate aspects of both attention and awareness, its mode of awareness or observation is evoked only when attention is regulated in a particular way. It would be useful here to restate the process of meditation practice aimed to elicit mindfulness, that is to say it begins with concentration on the breath and once concentration is steady, awareness is opened to internal events, a process that in turn facilitates insight. In this process, mindfulness is considered the open awareness, which provides support for Bishop's interpretation of the causal relationship between attention and awareness. Having said this it also seems self-explanatory that attention, or concentration, is a skill that engenders mindfulness but is not inherent to mindfulness per se.

Mindfulness has been referred to as a mental state, a quality of consciousness, and quality of awareness, and a particular way of paying attention in the current body of literature. In this thesis mindfulness is understood as the quality

of awareness that arises when attention is intentionally regulated in a specific way. Mindfulness, then, flavors the experience of momentary events, or contents of consciousness, and facilitates insight. As an aside, this quality of awareness may be likened to Damasio's (1999) portrayal of the state of consciousness, which provides the background tone against which events, or contents of consciousness are experienced – the state of consciousness is a quality of mind that affects how the contents of consciousness are experienced.

Operationally Defining Mindfulness

Relatively few systemic analyses have been conducted to further operationalise mindfulness and to better understand its factor-structure. In measuring mindfulness however, assumptions need to be drawn regarding such a factor-structure. In the development of mindfulness measurements, then, some authors have operationalised the construct as having a single factor while others have considered it to have multiple factors; this divergence has lead to the development, and deployment, of a number of different tools. More recently there has been an effort among researchers to agree on an operational definition in the interest of developing a reliable measuring instrument and a dominating theory to guide further study. With this ambition in mind Bishop (2004), in consult with several mindfulness researchers, proposed a 2-factor model of mindfulness involving (1) self-regulation of attention and (2) the adoption of a particular orientation towards experience. They then developed the Toronto Mindfulness Scale (TMS), which measures state mindfulness[2] with the assessment required directly following formal mindfulness practice. The authors of the TMS proposed that the first component of mindfulness involves sustained attention as well as attentional switching (backward

[2] *State mindfulness* refers to the experience of mindfulness during meditation, in contrast, *trait mindfulness* refers to mindfulness as it is experienced in everyday life, or the residual mindfulness that exists between meditation sessions. While this distinction is drawn between these two forms of mindfulness in the literature, the two vary only in their intensity and not their inherent quality.

and forward between the breath and present moment occurrences) and that the self-regulation of such attention, essentially a metacognitive skill, engages cognitive inhibition to facilitate non-elaborative awareness. The second component in the model is 'open orientation to experience' and akin to the Buddhist concept of open awareness. Open orientation to experience, in this context, refers to a curiosity and acceptance of each momentary event and is believed to be related to be experientially openness, which is opposite to a repressive coping style.

Although this model is insightful in many respects, there is still debate regarding its appropriateness. For instance, Brown and Ryan (2004) argued that according to their own conceptualisation of mindfulness as a mode of perception operating on thought, feelings and other contents of consciousness rather than within them, the mental state cannot be reduced to a cognitive process, or to a metacognitive skill as described by Bishop's 2-factor model. In addition those authors raised the problematic binding of awareness and attention, which they believe to be a single and primary feature of consciousness. On this basis Brown and Ryan (2004) have argued that mindfulness has one single factor – attention to and awareness of the present moment.

In a recent meta-analysis of several popular mindfulness scales, Baer, Smith, Hopkins, Krietemeyer, and Toney (2006) used factor analysis and confirmatory factor analysis to derive a 5-factor model of the construct. The questionnaires included in the study, and their factor-structures, are detailed in Table 1. In addition to validating the internal consistencies of these scales and affirming their correlation to one another, and after pooling all of the items from the individual scales, the authors identified five factors that where internally consistent and only modestly correlated with each another. Initial confirmatory factor analysis supported four of the five factors identified, however, all five were shown to relate significantly to meditation experience in later research (Baer et al., 2008). The findings of the 2003 meta-analysis and the later 2008 study showed mindfulness might legitimately be

considered a multifaceted construct, with the five specific facets being *observe, describe, act with awareness, non-judgment* and *non-reaction*.

Table 1

Description of Mindfulness Questionnaires Analysed by Baer and Colleagues (2006)

Name	**Author/s**	**Assumed Factor-Structure**	**Scale Type**
Mindfulness Attention Awareness Scale (MAAS)	Brown and Ryan (2003)	Single factor: 1) Attention and awareness	15-item on 6-point Likert-type scale
Freiburg Mindfulness Inventory (FMI)	Buchheld, Grossman and Walach (2001)	Two factors: 1) Nonjudgmental present-moment awareness 2) Openness to experience	30-item on 4-point Likert-type scale
Kentucky Inventory of Mindfulness Skills (KIMS)	Baer, Smith and Allen (2004)	Four factors: 1) Observing 2) Describing 3) Act with awareness 4) Accepting without judgment	39-item on 5-point Likert-type scale
Cognitive and Affective Mindfulness Scale (CAMS)	Feldman, Hayes, Kumar and Greeson (2004)	Four factors: 1) Attention 2) Awareness 3) Present-focus 4) Acceptance	12-item on 4-point Likert-type scale
Mindfulness Questionnaire (MQ)	Chadwick, Hember, Mead, Lilley and Dagnan (2005)	Four factors: 1) Mindfulness observation 2) Letting go 3) Nonaversion 4) Nonjudgment	16-item on 7-point Likert-type scale

The 5-factor operational definition of mindfulness proposed by Baer and her colleagues has been adopted in the studies that make up this thesis because, in a field where opinion is still divided, it manages to assimilate commonalities among

the existing definitions and could thus be considered a catch-all type model less likely to overlook any potential characteristics of mindfulness. It should also be clear at this point that, although mindfulness may seem to be a simple construct, its make-up is complex and as such, relevant to the studies in this thesis, its mechanisms of action are likely to be diverse.

Explorations into Naturally-Occurring Mindfulness

Mindfulness, in addition to being a learnt skill, can also be considered a natural attribute of consciousness that fluctuates between and within us all, as already highlighted. In 2003, Brown and Ryan conducted several studies to capture the essence of this naturally-occurring variety of mindfulness and its role in predicting day-to-day self-regulation and well-being. The collection of studies also tested the psychometric properties of the Mindfulness Attention Awareness Scale (MAAS), an instrument designed to measure naturally-occurring mindfulness.

As an introduction to this investigation, the authors predicted mindfulness would be associated with self-regulation, which was proposed to foster positive health outcomes. The authors identified open awareness as a critical feature of psychotherapeutic techniques in the enhancement of self-regulation and well-being; examples cited included free association in psychoanalysis and the calculated use of attention to gather factual information on behaviour and subjective experience in cognitive therapeutic techniques. The initial research findings supported the authors' proposed single-facet structure of naturally-occurring mindfulness – attention to and awareness of the present moment – and reported favourable psychometric properties of the MAAS. Subsequent studies showed naturally-occurring mindfulness, when measured using the MAAS, to be associated with more autonomous activity and lower levels of unpleasant affect, measured both in terms of intensity and frequency. The study also noted a positive relationship between the construct and positive experiences across three outcomes: higher levels

of autonomy, more intense and frequent pleasant affect, and less intense and less frequent unpleasant affect. In addition the authors showed that mindfulness is associated with the *openness to experience* dimension of personality that involves receptivity to new experiences. This was one of the few explorations to have been conducted into naturally-occurring mindfulness, however, the KIMS has also been used to assess dispositional mindfulness (Dekeyser, Raes, Leijssen, Leysen & Dewulf, 2008). The current body of literature shows an overriding bias towards learnt mindfulness with an aim of assessing the efficacy of training interventions.

Explorations into Learnt Mindfulness

Mindfulness ought to be formally practiced, through meditation and other exercises, to become reliable and robust enough to afford therapeutic benefits (Kabat-Zinn, 1994). The corpus of research conducted into the clinical use of learnt mindfulness, applied as a self-help tool, has shown its ability to achieve three essential outcomes; improved psychological well-being, reduced stress and improved stress coping resources. Over the years several varieties of mindfulness training interventions have been developed to enhance the mental state and engender well-being in clinical and non-clinical populations.

Mindfulness Interventions

Mindfulness-Based Stress Reduction (MBSR)

Numerous mindfulness interventions have been developed in the Western scientific context with most incorporating, but not restricted to, meditation practices. One of the most widely used training programmes is Mindfulness Based Stress Reduction (MBSR), developed in 1979 by Jon Kabat-Zinn at the University of Massachusetts Medical Center, under the auspices of mind-body medicine. This programme was designed as an 8-week training intervention comprising formal and informal practices of mindfulness. Shorter versions of the MBSR have also been applied.

Formal practice refers to a collection of activities including body scan, sitting meditation and sequences of hatha yoga: Body scan involves slow and systemic movement of attention through the body, noting sensations and tensions and intentionally and progressively calming each region of the body until full relaxation is achieved. Sitting meditation involves assuming a seated posture and focusing on the breath while observing passing thoughts, sensations and sounds but not reacting to them; this develops an observational style of perception rather than a reactive one (Goleman, 2004). Hatha yoga further complements formal MBSR practice, nurturing musculoskeletal strength, balance and flexibility and so nurturing a greater awareness of the physical body (Kabat-Zinn, 1993).

Within MBSR the *informal practice* of mindfulness involves intermittently and spontaneously reminding oneself to focus on the present moment during the course of everyday life. As one acquires more experience in the formal practice of mindfulness, so the informal practice is thought to increase habitually.

Mindfulness-Based Cognitive Therapy (MBCT)

Informed by their information-processing model of depressive relapse, Teasdale, Segal and Williams (1995) proposed that the attentional control strategy in mindfulness would be helpful in preventing relapse in major depressive episodes. These researchers subsequently adapted the MBSR programme in the development of a Mindfulness-Based Cognitive Therapy (MBCT) intervention. This 8-week group intervention incorporates a variety of mindfulness practices designed to cultivate non-judgmental observation of thoughts, emotions and bodily sensations, highlighting these events as transient in nature and separate from the self. This process embraces the cognitive therapy technique of *decentering*, which may be described as a learnt metacongitive skill in which emotional experiences are considered ephemeral events, separate from the self. This process is believed to prevent the escalation of negative thoughts into rumination (Teasdale et al., 2000).

Interventions Incorporating Mindfulness

Dialectical behavioral therapy (DBT) is a psychosocial treatment for individuals with borderline personality disorder (Dimeff & Linehan, 2001). The therapy is based on behavioural and cognitive theoretical traditions but incorporates mindfulness as a central component. The four primary modules in DBT include interpersonal effectiveness, distress tolerance, emotion regulation and mindfulness. DBT is based on the belief that reality consists of opposing forces; in the case of mental life these are acceptance and change. The mindfulness skill of nonjudgmental observation of emotions, thoughts and behaviors is taught to synthesize these two opposing forces and broken into *what* skills: observe describe and participate, and *how* skills: non-judgmentally, one-mindfully and effectively.

It is worth noting here that *Acceptance and Commitment Therapy (ACT)*, based on contemporary behaviour analysis, works on similar principles: In ACT patients are taught to step back from thoughts, emotions and bodily sensations and watch these as 'external', without judgment or evaluation (Hayes et al., 1999). In other words, and akin to DBT, MBCT and MBSR, ACT encourages accepting the passing procession of internal events without judgment or reaction.

Relapse-Prevention (RP) for substance abuse, developed by Marlett and Gordon in 1985, is another CBT-based protocol incorporating mindfulness skills. The authors maintain that accepting the present-moment in mindfulness is applied in this form of treatment to offset the urge to escape the present moment, a central feature of addiction. In turn patients are encouraged to accept urges as normal responses and taught to cope with these urges in an adaptive manner.

Explorations into the Efficacy of Mindfulness Training

Mindfulness training has been widely administered to nurture stress coping resources and to reduce stress in a variety of population groups, as well as to

alleviate the symptomatology in physical and psychological stress-related disorders.

Mindfulness Training in Stress-Related Disorders and Chronic Pain

One of the first enquiries with regards to mindfulness training was the investigation of its effects on stress and symptoms of stress. Kabat-Zinn (1982) studied the effect of a 10-week stress reduction and relaxation programme on self-reported chronic pain in a group of chronic pain patients. The study reported significant decreases in reported pain and mood disturbance and psychiatric symtomatology in this group. According to Kabat-Zinn there appeared to be an uncoupling of the sensory dimension of pain experience from the affective reactions to such pain through the process of cognitive reappraisal. In a continuation of this study, by expanding the sample and adding a control, similar positive results were reported (Kabat-Zinn, Lipworth, & Burney, 1985) and positive outcomes held in a follow-up evaluation several years later (Kabat-Zinn, Lipworth, Burney, & Sellers, 1987). Over a decade later Randolph, Caldera, Tacone and Greak (1999) investigated the effects of MBSR combined with medical intervention in the multidisciplinary treatment of 78 chronic pain patients; they reported significant reductions in symptoms of stress and chronic pain.

These studies have helped validate stress reduction as an outcome of MBSR practice, and the maintenance of such results over time. Mindfulness is believed to improve stress coping mechanisms by nurturing the ability to step back from thoughts and feelings during stressful times, instead of engaging in worry or negative-thinking patterns that could escalate stress and heighten emotional distress (Bishop, 2002). In this way mindfulness is said to nurture a deeper perspective on reactions to everyday stress through promoting intentional awareness of thoughts, while at the same time, the meditation component of mindfulness practice induces deep states of relaxation, which relieve muscle tension.

Mindfulness Training in Psychological and Psychiatric Disorders

An equally popular topic of interest has been the efficacy of mindfulness training in the treatment of psychological and psychiatric disorders. One of the first investigations in this area evaluated the effects of training on anxiety and mood disorders (Deatherage, 1975). This study showed pre- to post-intervention improvements in mental health outcomes with an effect size of 0.7. Significant reductions in anxiety, panic and depression were also reported in an evaluation of a stress-reduction programme, based on mindfulness meditation, for patients with anxiety disorders (Kabat-Zinn et al., 1992) and in a 3-year follow-up of these patients (Miller, Fletcher, & Kabat-Zinn, 1995). Another randomised control study recruited participants to take part in an 8-week MBSR intervention after which the experimental group showed significant reductions in overall psychological symptomatology and significant improvements on sub-scales of depression, anxiety, obsessive-compulsive behaviour, somatization, interpersonal sensitivity, and psychotic and paranoid ideation (Astin, 1997). The treatment group also showed significant increases in spiritual experience, overall domain-specific sense of control and the degree of self-acceptance and perceptions of self-agency. Positive outcomes of mindfulness training on symptoms of generalised anxiety disorder (GAD) have been further supported in more recent literature (Roemer, Salters-Pedneault, & Orsillo 2006).

Significant improvements in measures of eating and mood were reported in a study of the effects of MBSR in binge-eating on 18 female patients (Kristeller & Hallett, 1999). This evidence was recently supported by a study noting significant improvements in binge eating symptoms as well as increased levels of mindfulness following an MBCT intervention (Baer, Fischer, & Huss, 2005), and these positive outcomes carried through in a 6-month follow-up.

In terms of depression, a study conducted by Teasdale, Segal and Williams (1995) found that when incorporating mindfulness techniques in group

interventions to treat patients with recurrent depression in remission, the combined therapy effectively halved relapse rates in patients with three or more previous episodes of depression. Later research by Teasdale and colleagues (2000) further revealed the positive effect of mindfulness training, when combined with cognitive-behavioural therapy, in abating recurrent episodes of major depression. In an evaluation of a subset of the patient group in this study, Watkins, Teasdale and Williams (2000) tested over-general autobiographical memory, believed to be a characteristic of people with depression, and found patients to be reporting more specific memories in response to cues following MBCT. More recent research has shown MBCT to play a central role in preventing relapse in recurrent depression and anxiety (Ree, 2007).

Significant reductions in symptoms and an increased capacity to evoke mindfulness have also been reported in OCD patients. A case study of one such patient, who completed an 8-week MBSR programme, showed significant reduction in symptoms (Patel, Carmody, & Simpson, 2007). In a more thorough investigation, the neural circuitry involved in OCD was favourably altered following training in a 4-step mindfulness programme (Schwartz & Begley, 2002). Schwartz trained his patients to adapt their responses to anxiety and obsessive behaviour by (1) *relabeling* thoughts and urges to shift away from self-identification, (2) *reattributing* symptoms as false signals to direct attention away from stressful attempts to suppress obsessive urges, (3) *refocusing* attention on the breath to redirect attention away from obsessions, and (4) *revaluing* disturbing thoughts as false and not worth acting on. PET scans before and after the 4-step mindfulness training showed significant changes in the pathological neural circuitry associated with OCD.

The preliminary data have also supported the efficacy of mindfulness training in the treatment of addictive behaviour (Witkiewitz, Marlatt, & Walker, 2005) and more generally, mindfulness training has been associated with improved social functioning, role-emotion and mental health (Reibel, Greeson, Brainard, &

Rosenzweig, 2001) as well as reductions in overall symptoms in general psychological distress (Ostafin et al., 2006).

Mindfulness Training in other Medical Conditions

It is unclear whether mindfulness has the potential to reverse the disease process, as opposed to complement orthodox treatment, but mindfulness practice does appear to relieve the suffering associated with disease and assist in the self-regulation of chronic pain by increasing awareness of bodily sensation and emotional reactions to such sensations.

With regards to specific medical conditions, two studies have explored the effects of mindfulness training on fibromyaligia: Both reported significant symptom reductions (Goldenberg et al., 1994; Kaplan, Goldenberg, & Galvin-Nadeau, 1993). The 8-week MBSR programme has also been shown to accelerate skin-clearing rates in patients with psoriasis (Kabat-Zinn et al., 1998).

It should come as no surprise based on its reported efficacy in these areas that the benefits of mindfulness training have also been explored in the field of oncology. In a randomised control trail to investigate the effects of MBSR in the complementary treatment of cancer, significant improvements in mood and reduced symptoms of stress were noted in patients (Speca, Carlson, Goodey, & Angen, 2000). In the same way, mindfulness training has also been shown to bring about significant improvements in stress-related factors, mental adjustment and locus of control in breast cancer patients (Tacon, Caldera, & Ronaghan, 2004). In a further study of 59 patients with breast cancer and 10 with prostate cancer, MBSR brought about significant improvements in overall quality of life, and in quality of sleep, and decreased symptoms of stress (Carlson, Speca, Patel, & Goodey, 2004). In addition, this study was reported to be the first to show changes in cancer-related cytokine production associated with MBSR participation. More recently a study reported that MBSR may permit an earlier return to psychological and

immunological normalcy in women undergoing diagnosis and treatment for cancer (Janusek, Albuquerque, & Matthews, 2006). An overview of the clinical applicability of mindfulness meditation in oncology concluded that while more randomised controlled studies are necessary, the benefits of mindfulness training have been consistently reported in areas of psychological functioning, reduced symptoms of stress and enhanced coping and well-being (Ott, Norris, & Bauer-Wu, 2006).

Positive research findings have sparked interest in other domains too. While preliminary studies into the efficacy of mindfulness training in the rehabilitation of traumatic brain injury (TBI) have failed to show significant improvements in cognitive functioning or in quality of life in this population group (Bedard et al., 2003; McMillen, Robertson, Brock, & Chorlton, 2002), a study into insomnia found significant improvements in nightmare symptoms, pre-sleep arousal, sleep effort and dysfunctional sleep-related cognitions (Ong, Shapiro, & Manber, 2008). Empirical research has also been encouraged to explore the efficacy of training in stress management for individuals with HIV/AIDS (Logsdon-Conradsen, 2002).

Mindfulness Training in Non-Clinical Groups

One of the first studies to investigate the potential benefits of mindfulness training in non-clinical populations found that MBSR produced significant improvements in psychological symptoms, empathy ratings and spiritual experiences (Astin, 1997). Similar findings were reported in a later study by Shapiro, Schwartz and Bonner (1998), in which spiritual growth was associated with decreased negative psychological symptoms and enhanced physical and psychological well-being. Again, significant improvements in medical and psychological symptoms have been reported as an outcome of MBSR in community volunteers (Williams, Kolar, Reger, & Pearson, 2001) and more recent research has shown MBSR training to increase emotional flexibility (Ortner, 2006), which was suggested to account for improvements in well-being.

Meta-Analyses

In 2003 Baer conducted a conceptual and empirical review of research exploring the benefits of mindfulness training. She reported that while the body of literature was limited by a number of methodological shortcomings, mindfulness-based interventions appear to be helpful in the treatment of a number of physical and psychological disorders. The most noticeable shortcomings in the current body of literature noted by Baer included the widespread lack of control groups, small sample sizes, inconsistent delivery of mindfulness training and the lack of documented clinical significance of research. A more recent meta-analysis of 20 studies on the health benefits of mindfulness training, concluded that increased levels of mindfulness help a broad range of individuals to cope with clinical and non-clinical problems (Grossman et al., 2004, p. 39).

> The consistent and relatively strong level of effect sizes across very different types of samples indicates that mindfulness training might enhance general features of coping with distress and disability in everyday life, as well as under more extraordinary conditions of serious disorders or stress.

It is plausible to conclude from this literature review that learnt mindfulness has the potential to reduce negative affect, increase positive affect, improve coping resources and reduce stress. In addition, no studies to date have shown mindfulness training to elicit negative mental or physical effects.

Proposed Mechanisms of Mindfulness Training

One of the most elementary reasons for the positive outcomes of MBSR training is that it teaches patrons to focus on what is *right* with their functioning and not what is *wrong,* according to Kabat-Zinn (1993*).* This process is said to cultivate inner strength to mobilize behaviour change in positive ways. Brown and Ryan (2003) propose that increased levels of mindfulness contribute to well-being by not only

adding clarity and vividness to every moment, but also by fostering informed and *self-endorsed behavioural regulation* by disengaging automatic thinking, habits and unhealthy behaviours. This self-endorsed behaviour has been associated with improved well-being and is a key aim of mindfulness training. Said differently, Martin (1997) believes mindfulness fosters 'psychological freedom' as present moment attention allows one to disengage a sense of permanence, and as such, emancipates one from stereotypical psychological schemata, or habitual views of the self and the world, allowing for the development of fresh awareness and insight – a process referred to earlier in this dissertation as *deautomization*. Incidentally, this process has been proposed as a critical component of all psychotherapies (Bohart, 1983). Using the term *detachment*, Bohart (1983) describes the process as distancing oneself from problems in an attempt to disengage from automatic maladaptive schema. Whether labelled self-endorsed behavioural regulation, deautomization or detachment, this process has been shown to be a key outcome of mindfulness practice and a suggested mechanism through which it elicits positive outcomes.

The Neuroscience of Mindfulness

In addition to clinical trials and theoretical and conceptual reviews of mindfulness, neuroscientific investigations have been conducted, although scarce, to try and learn more about the mindfulness state itself. Neuroscientific investigations are helpful to validate findings from self-report studies since they offer a less biased account of physical and mental states.

Electroencephalography Studies

EEG methods have been employed to explore mindfulness meditation in advanced practitioners. These studies have shown increased alpha amplitude and alpha activity spreading frontally, as well as decreased alpha frequency (Kasamatsu & Hirai, 1966) and increased theta coherence and temporal gamma coherence (Farber

et al., 2004). Alpha rhythms are associated with a more relaxed, reflective mental state where gamma activity is associated with certain cognitive and motor functions. Studies of novice practitioners have reported increased frontal alpha coherence (Murata et al., 2004) and increased frontal theta and low alpha power (Takahashi et al., 2005). One of the more remarkable EEG investigations into learnt mindfulness was a randomised control study conducted by Davidson and colleagues (2003), which explored EEG and immunological response to influenza vaccination. MBSR brought about significant increases in left-sided prefrontal brain activity – a pattern associated with improved positive affect (Davidson, 1992) – as well as significant increases in antibody titers to the influenza vaccine in the treatment group. These findings demonstrated that a programme in mindfulness training produces effects on brain and immune functioning (Davidson et al., 2003).

Functional Imaging Studies

In one of the first functional imaging studies, five mindfulness practitioners were assessed to uncover the functional changes associated with onset mindfulness compared to a relaxation state. Magnetic signal increases were reported in the dorsolateral prefrontal cortex and the anterior cingulate cortex, and signal decreases were reported in the occipital cortex (Baerentsen, 2001).

A later study using a similar design but focusing on a Zen form of mindfulness meditation, found some contradictory findings. Nonetheless this second study did report the same signal increases in the dorsolateral prefrontal cortex (with a right hemisphere bias) and bilateral basal ganglia but signal decreases in the right anterior superior occipital gyrus and anterior cingulate (Ritske, Ritskes-Hoitinga, Stodkilde-Jorgensen, Baerentsen, & Hartman, 2003).

In a further controlled study, comparing vipasyana meditation with Kundalini yoga, vipasyana meditation produced signal increases in the dorsal cingulate cortex and right temporal lobe compared to a control block in which

random numbers were generated (Lazar et al., 2003). Some consistent findings were noted in a study investigating the neural correlates of dispositional mindfulness during affect-labelling (describing, or naming emotions), which reported widespread prefrontal cortical activation and in addition, reduced bilateral amygdale activity during affect labelling, compared to a gender labelling control task. In addition a strong negative association was found between prefrontal cortex and right amygdale activity in participants with higher levels of mindfulness (Creswell, Baldwin, Eisenberger, & Lieberman, 2007).

More recently, a group of MBSR participants showed marked reductions in activity in the medial prefrontal cortex and increased engagement of the right lateral prefrontal cortex, insula, secondary somatosensory cortex and inferior parietal lobule compared to a novice group during an experiential-focused self-reference task (Farb et al., 2007). The authors suggest that this pattern of activity is indicative of an increased capacity to disengage from narrative generation to support present-centred self-awareness.

Structural Magnetic Resonance Imaging Studies

One structural magnetic resonance imaging (sMRI) study has been conducted to assess potential anatomical differences between the brains of experienced meditators compared to those with no prior exposure to meditation. This study found that meditation experience was associated with increased cortical volume in brain regions involved in attention, interoception and sensory processing, specifically the prefrontal cortex and right anterior insula in the meditation group (Lazar et al., 2005). In addition cortical volume correlated positively with meditation experience.

THE AIMS AND OBJECTIVES OF THIS THESIS

The synopsis of mindfulness and related research in this chapter has provided convincing evidence that acquiring mindfulness skills through training reduces cognitive vulnerability to stress and emotional distress in clinical and non-clinical populations. The focus of such training is on increasing awareness and the skilful responding to mental processes. Although the clinical application of mindfulness has grown in response to these encouraging research findings, few empirical investigations have sought to identify the mechanisms through which mindfulness achieves such positive outcomes. This search for mechanisms is a necessary subject of study, and the next logical step in the investigation of mindfulness (Baer et al., 2006; Davidson et al., 2003; Lazar et al., 2000; Shapiro et al., 2006). The expressed need for clarity regarding mechanisms of action motivated the set of research studies in this thesis, which are designed to explore the *cognitive* and *neural* mechanisms of mindfulness by empirically testing the most commonly proposed cognitive mechanisms and investigating the neural substrates of state mindfulness.

Conceptual and Operational Definitions of Mindfulness in this Thesis

Informed by the literature described in this chapter, mindfulness is conceptualised in this thesis as a quality of awareness, characterized by heightened present-moment awareness of events taking place in the body and noticing these events without judgment or reaction. Succinctly speaking then, mindfulness is considered a state of consciousness that is facilitated by intentionally directing attention to the present moment, allowing the moment to be embraced with receptivity and flexibility.

Operationally, mindfulness is measured as a multiple-factor construct relying on 5-factor model arrived at by Baer and colleagues (2006), and using their Five-Facet Mindfulness Questionnaire (FFMQ). As noted earlier, the five factors in

this model include *observe, describe, act with awareness, non-judgment* and *non-reaction;* all of these have been shown to be internally consistent and only modestly correlated with one another. This 5-factor operational definition of mindfulness is preferred because it assimilates commonalities among the existing factor-structure models and may thus be considered a catch-all type model that is less likely to overlook any previously identified characteristics of mindfulness.

An Outline of the Thesis

Authors of most empirical studies on mindfulness have proposed possible cognitive mechanisms of mindfulness based on the insight they have gained into the mental state through research; others have developed models of these mechanisms. Although a few studies have tested mechanisms through empirical means (see, e.g., Arch & Craske, 2006; Dobkin, 2007; Ortner, 2006), these studies have been limited by small sample groups and methodological weaknesses. Chapter Two of this thesis presents the results of two studies: Study One, a synthesis of proposed cognitive mechanisms through a qualitative systematic analysis of the literature, and Study Two, an empirical investigation of these mechanisms using mediation techniques. Chapter Three presents the result of two additional studies: Study Three, an exploration of the neural substrates of mindfulness using functional Magnetic Resonance Imaging (fMRI) and Study Four, a pilot brain-lesion investigation to test the effects of damage to the regions identified, on mindfulness. Chapter Four presents a final discussion of the collective findings and concludes the thesis.

CHAPTER TWO

THE COGNITIVE MECHANISMS OF MINDFULNESS

STUDY ONE: IDENTIFYING COMMONLY PROPOSED MECHANISMS OF MINDFULNESS

Empirical research on mindfulness has shown that training interventions geared to enhance the mental state are successful in improving measures of well-being, most specifically those related to reduced stress and reduced mood disturbance. Research has also shown that naturally-occurring mindfulness is associated with improved mental health outcomes. As the application of mindfulness training grows in response to these research findings, so does the need for a clear scientific understanding of the mental state, expressly its essential factors and the mechanisms through which it brings about improved health. Although there is still some discrepancy in the scientific community as to the definition and factor-structure of mindfulness, the imperative to scientifically validate mindfulness and related training interventions for therapeutic use in the healthcare setting, continues to drive research relying on the current knowledge base. It is therefore important to make explicit the assumptions regarding the conceptual and operational definitions of mindfulness adopted by this research study, which formed the bedrock of the investigation. As illustrated in the previous chapter, all the studies in this thesis

work on a trio of assumptions: that mindfulness (a) can be defined as a quality of heightened present-moment awareness, (b) is a multiple-factor construct and, (c) incorporates the features, *observe*, *describe*, *act with awareness*, *non-judgment* and *non-reaction*.

Because there is satisfactory evidence of an association between mindfulness and improved health indicators, and because it is clear that mindfulness training has the ability to enhance these indicators, the next logical question is *how* mindfulness achieves this. Accordingly, the subject of mechanisms of action is addressed in this chapter.

The term mechanism refers to the action of variables that mediate a casual relationship between an independent and dependent variable. Identifying mechanisms at work adds depth to the understanding of any established cause and effect relationship. The concept of mediation was first proposed by Woodworth (1928) and presented in the Stimulus-Organism-Response (S-O-R) model of behaviour. This model introduced 'organism' to the traditional behaviourist Stimulus-Response model, and so implied that a stimulus effects a response through a transformation process within the organism (Baron & Kenny, 1986). The S-O-R model has influenced theoretical and empirical psychology, emphasising the importance of the role of mediation in the processes of cause and effect. One classical example of mediation, taken from social psychology, is the role of intention in the relationship between attitudes and behaviour – attitudes influence intention, which in turn, influences behaviour (Fishbein & Ajzen, 1975). In accordance with the S-O-R model, understanding the potential mechanisms through which mindfulness achieves its positive health outcomes will add depth to the understanding of mindfulness itself.

The empirical study of the cognitive mechanisms of mindfulness requires, at its outset, a theoretical model, or at the very least the identification of potential

mechanisms that may be tested (MacKinnon, Fairchild, & Fritz, 2007). Although only one such model has been presented (Shapiro et al., 2006), the majority of published articles on mindfulness suggest possible mechanisms through which mindfulness may be working to improve health. In addition Baer and colleagues (2008) have recently established that mindfulness, and in particular the five factors that are theorised to comprise it, mediate the relationship between meditation practice and psychological well-being. In this study, and Study Two, the cognitive mechanisms that mediate the relationship between mindfulness and reduced stress, and those that mediate the relationship between mood disturbance, were explored. In the present study, the most commonly proposed mechanisms were extracted from the current body of literature by means of qualitative systematic analysis, and in Study Two, these mechanisms were empirically tested using mediation analysis. In this approach, empirical testing served to validate elements of the Shapiro model as well as testing the broader spectrum of mechanisms put forward by other researchers. Understanding the cognitive mechanisms of mindfulness is clearly an important effort in itself, but more generally, it may further our understanding of some critical features of optimal well-being.

METHOD

Study Design

A narrative literature review was conducted to identify the most commonly proposed mechanisms of mindfulness. This review was designed as a qualitative systematic analysis of previously published research articles and mindfulness texts that presented possible cognitive mechanisms through which mindfulness may operate. This design was used as an alternative to a quantitative meta-analysis owing to the lack of empirical investigations into the mechanisms of mindfulness,

and the subsequent lack of data – a meta-analysis relies on statistical data for further analysis and extrapolation of consensual findings.

A qualitative systematic analysis is a variety of the more rudimentary literature review, which is designed to provide a synopsis of a particular knowledge base (Baumeister & Leary, 1997). While the two study designs share the aim of objectively collating and reporting on the current state of knowledge regarding a particular topic through a systematic review of literature, the qualitative systematic analysis employs more rigorous and explicit methods of analysing the literature to answer a focused question (Green, Johnson, & Adams, 2001). In this type of analysis every effort is made to obtain all primary research studies that pertain to the topic of interest by searching multiple databases, performing hand searches and contacting authors where necessary. Publications are then reviewed in a systematic and consistent way and rated according to a scoring system appropriate for the study. Specifically developed criteria are used to determine whether publications should be included or excluded in the final synthesis. Ultimately and evidence table is produced to review the differences in the results of studies.

The current study used methods of qualitative systematic analysis to answer the question of which cognitive mechanisms have been most commonly cited by researchers. It was accepted that the authors of the texts analysed in this study, gained insight into the construct of mindfulness as a result of their investigations into the efficacy of mindfulness training, or through the development of theoretical models pertaining to the mental state's conceptualisation and operationalisation.

Sample of Studies

Relevant research works and texts addressing the potential mechanisms of mindfulness, and published before February 2008, were identified through searches of the PsycINFO, ScienceDirect and PubMed electronic databases. In the case of the PsycINFO database, search terms were *mindfulness* in the title and *mechanisms* in the

abstract. In the ScienceDirect electronic database, search terms were *mindfulness* in the title and *mechanisms* anywhere in the full text. Search terms in the PubMed database specified *mindfulness* in the title and the search results were then limited to those works citing *mechanisms* in the text. The literature search tracking sheet is presented in Table 2.

The literature search yielded a total of 59 unique items, including peer-reviewed journal articles, book chapters, and dissertations. Once the reference lists from each of the 59 articles were searched for additional citations, a further 11 articles were identified, brining the total number of texts for analysis to 70.

Table 2

Mechanisms of Mindfulness Literature Search Tracking Sheet

Date of Search	Database	Search Terms	Years	Hits	Omitted Duplicates
07.02.2008	PsycINFO	Mindfulness (TI) Mechanisms (Terms Anywhere)	All	32	-
07.02.2008	Science Direct	Mindfulness (Title) Mechanisms (Full Text)	All	32	7
07.02.2008	PubMed	Mindfulness Limits: mechanisms	All	16	14
11.02.2008	Reference lists	Mechanisms	All	11	-

Exclusion Criteria

The articles were sourced and read for mention of mechanisms. If an article recommended that the mechanisms of mindfulness be investigated in future research, the article was excluded as it failed to propose possible mechanisms. A further eight articles were omitted on this basis. In addition three foreign language articles were excluded. Full-text electronic or hard copies of the remaining 59 articles were then sourced. The electronic articles were searched using the term *mechanisms*, and the hard copies were read in full. Articles were excluded where

there was no reference to mechanisms of action (4) or the mechanisms discussed related to constructs other than mindfulness per se (2). Articles were also excluded in cases were the topic of investigation was a psychotherapy technique incorporating elements of mindfulness (MBCT, DBT and ACT) – in these works the proposed mechanisms were likely to be confounded by a more complex interplay of the psychotherapeutic mechanisms at work (13). These exclusions left a total of 40 texts for analysis.

Data Coding and Analysis

The mindfulness mechanisms proposed in the remaining 40 texts were then noted and are presented in Table 3. Data coding was conducted in the following manner: Mechanisms that were cited more than once were assigned a category name and number. Mechanisms that were cited only once, and could plausibly be attributed to one of the aforementioned categories, were accordingly assigned to those categories. In the case were a mechanism was proposed by the same author more than once (when this author was the first author) the mechanism was discounted. By way of example, 'cognitive flexibility' was proposed as a mechanism of mindfulness in four texts (Allen, et al. 2006; Herndon, 2008; Shapiro et al., 2006; Wells, 2002). As such a category was created titled *cognitive flexibility*, carrying four 'exact citations'. In addition to this, mechanisms that were thematically consistent with the description of cognitive flexibility were proposed in a further six texts: *cognitive deautomisation* (Martin, 1997), *cognitive change* (Baer, 2003; Bondolfi, 2005), *psychological flexibility* (Palm, 2005), *emotional flexibility* (Ortner, 2006) and *changing schemas* (Hamilton, Kitzman, & Guyotte, 2006). These mechanisms were therefore assigned to the 'cognitive flexibility' category and noted as 'thematically implied'. It was then concluded that a total of ten texts had cited mechanisms that could be defined under the heading 'cognitive flexibility'. The results of the full analysis are detailed in Table 4.

RESULTS

A review of the total 77 cognitive mechanisms proposed in the identified 40 texts isolated 10 categories of cognitive themes: (1) self-regulation, (2) exposure, (3) cognitive flexibility, (4) acceptance, (5) disidentification, (6) awareness/ insight, (7) reattribution, (8) attention, (9) metacognition, and (10) relaxation.

Table 3

Evidence Table of Proposed Mechanisms

Reference	Topic	Study Design	Mechanisms Cited	Category
Full text articles in peer-reviewed journals				
Kutz, Borysenko and Benson (1985)	Meditation and psychotherapy	Non-empirical Theoretical	Relabelling Decategorising Cognitive-affective splintering	7 7 -
Teasdale, Segal and Williams (1995)	Mindfulness and relapse prevention	Non-empirical Theoretical	Reattribution of mental events as events and not realities	7
Martin (1997)	Mindfulness	Non-empirical Theory-building	Deautomisation Disidentification	3 5
Valentine and Sweet (1999)	Mindfulness, meditation and attention	Empirical Quantitative	Distributed attention	8
Shapiro and Schwartz (2000)	Mindfulness	Non-empirical Theory-building	Self-regulation	1
Wells (2002)	GAD, metacognition and mindfulness	Non-empirical Commentary	Metacognition Undoing unhealthy beliefs Cognitive flexible Attentional control	9 - 3 8
Baer (2003)	Mindfulness	Meta-analysis Conceptual and empirical review	Exposure Cognitive change Self-management	2 3 1

			Relaxation	10
			Acceptance	4
Brown and Ryan (2003)	Naturally-occurring mindfulness	Empirical Five quantitative studies	Self-regulation Awareness/ insight Disengaging	1 6 4
DelMonte (2003)	Mindfulness	Non-empirical Theoretical	Disidentification	5
Hayes and Wilson (2003)	Mindfulness	Non-empirical Theoretical	Exposure	2
Horton-Deutsch and Horton (2003)	Mindfulness in overcoming intractable conflict	Empirical Survey	Awareness Self-realization Equilibrium	6 - -
Singh, Wahler, Adkins and Myers (2003)	Mindfulness based self-control for aggression	Empirical Case study	Self-regulation	1
Krasner (2004)	Mindfulness-based interventions	Non-empirical Commentary	Insight/ awareness	6
Salmon and colleagues (2004)	Mindfulness in clinical practice	Non-empirical Review	Self-regulation	1
Sugiura (2004)	Detached mindfulness	Non-empirical Theoretical	Detached objectivity	5
Baer, Fischer and Huss (2005)	Mindfulness-based cognitive therapy and binge eating	Empirical Case Study	Exposure Decentering Self-regulation	2 5 1
Bondolfi (2005)	Mindfulness and anxiety disorders	Non-empirical Theoretical	Exposure Cognitive change Self-management Relaxation Acceptance	2 3 1 11 4
Witkiewitz, Marlatt and Walker (2005)	Mindfulness-based relapse prevention	Empirical Quantitative	Reattribution of mental content	7
Allen and	Review of	Empirical	Metacognition	9

colleagues (2006)	mindfulness-based psychotherapies	Literature review	Presence to avoid rumination Inhibiting elaborative processing Acceptance Openness/ exposure Cognitive flexibility	- 1 4 2 3
Arch and Craske (2006)	Mindfulness attentional mechanisms	Empirical Experimental	Attentional switching Object detection	8 6
Hamilton, Kitzman and Guyotte (2006)	The link between mindfulness, CBT and positive psychology	Empirical Review	Strengthening metacognition Changing schemas Acceptance	9 3 4
Ostafin and colleagues (2006)	Mindfulness in reducing distress	Empirical Intervention study	Impermanence of thoughts and emotions as related to the self (regulation)	1
Ritschel (2006)	Mindfulness and DBT	Empirical Clinical intervention	Agency of hopeful thinking	-
Rothwell (2006)	Facets of mindfulness	Commentary	Experiential learning Emotional processing	2 1
Shapiro, Carlson, Astin and Freedman (2006)	Mechanisms of mindfulness	Non-empirical Theoretical	Reperceiving: - Self-regulation - Values clarification - Cognitive flexibility - Exposure	5 1 - 3 2
Bowen, Witkiewitz, Dillworth and Marlatt (2007)	Mindfulness and thought suppression	Empirical	Acceptance	4
Creswell, Baldwin, Eisenberger and Lieberman (2007)	Neural correlates of dispositional mindfulness in affect-labelling	Empirical Functional MRI	Labelling affect/ emotional regulation	1
Dobkin (2007)	Mechanisms of	Empirical	Reperceiving	5

	mindfulness based stress reduction	Clinical intervention		
Farb and colleagues (2007)	Neural correlates: narrative-focused vs. experiential-focused self-referential thought	Empirical Functional MRI	Objectifying the mind	5
Lakey, Kernis, Heppner and Lance (2007)	Mindfulness, authenticity and verbal defence	Empirical Survey	Non-judgment	4
Mackenzie, Carlson, Munoz and Speca (2007)	Mindfulness-based stress reduction mechanisms in an oncology setting	Empirical Qualitative	Opening to change Self-control Shared experience Personal growth	2 1 - -
Patel, Carmody, and Simpson (2007)	Mindfulness based stress reduction for OCD	Empirical Case study	Experiential openness Awareness/ observation Emotion regulation	2 6 1
Herndon (2008)	Mindfulness and cognition	Empirical Quantitative	External encoding Cognitive flexibility	- 3
Hofmann and Asmundson (2008)	Acceptance and mindfulness-based therapy	Non-empirical Review	Emotional regulation	1
Dissertations				
Henry (2003)	Mindfulness and public speaking anxiety	Theoretical	Exposure	2
Palm (2005)	Mindfulness and PTSD	Empirical Survey	Psychological flexibility	3
Ortner (2006)	Mindfulness and emotional flexibility	Empirical Survey	Emotional flexibility	3
Book chapters				
Block-Lerner,	Mindfulness and	_	Openness to experience	2

Orsillo and Plumb (2005)	experiential avoidance			
Hannan and Tolin (2006)	Acceptance and mindfulness therapy for OCD	_	Exposure Acceptance	2 4
Speca, Carlson, Mackenzie and Angen (2006)	Mindfulness based stress reduction and cancer	_	Self-regulation	1

Table 4

Most Commonly Proposed Mechanisms of Mindfulness

Coding	Category	Exact citations	Thematically implied	Repeated by first author	Total citations
1	Self-regulation	11	5	2	14
2	Exposure	8	4	1	11
3	Cognitive flexibility	4	6	0	10
4	Acceptance	6	2	0	8
5	Disidentification	2	5	0	7
6	Awareness/ insight	4	1	0	5
7	Reattribution	2	2	1	3
8	Attention	3	0	0	3
9	Metacognition	3	0	0	3
10	Relaxation	2	0	0	2
	Unattributable				*11*
	Total	45	25	4	77

DISCUSSION

It is clear from the qualitative systematic analysis of the current body of literature on mindfulness that relatively few cognitive mechanisms have been proposed and that most of the mechanisms that have, have been cited more than once. Only the four most cited mechanisms of the total 10 identified in this qualitative systematic analysis were selected for empirical investigation in Study Two, due to time required to complete the batch of questionnaires. The mechanisms most frequently

proposed included self-regulation (including emotional regulation), exposure, cognitive flexibility, and acceptance. A number of authors have categorised these mechanisms under the banner of metacognition (Allen, et al., 2006; Hamilton et al., 2006; Wells, 2002), which is defined as the knowledge and experiences we have about our own cognitive processes (Shimamura, 2000).

It is not surprising that mindfulness would be expected to achieve its positive outcomes through metacognitive processes, given that the ambition of enhancing heightened present-moment awareness is to recognise the relationship between bodily sensations and arising emotions in response to these events. This process involves 'watching' how the mind meanders. Nevertheless it is plausible, and even reassuring to note that numerous authors suggest metacognitive skills mediate the effect of mindfulness on positive health outcomes rather than define mindfulness itself, recalling that mindfulness has been suggested to operate *on* thoughts, feelings and other contents of conscious rather than *within* them (Brown & Ryan, 2004).

The Four Most Cited Mechanisms

Self-regulation

Looking at the top four proposed mechanisms individually, self-regulation may be described as a process of managing behaviours and emotions to respond adaptively and appropriately to events. Although there are several theories of self-regulation, there is general consensus regarding the regulatory process: first, one becomes aware of behaviour, then, behavioural adaptations are made in line with personal goals and standards, and finally, the outcomes of the behaviour are evaluated, and if effective, the behaviour is reinforced (Carver, 2007; Deci & Ryan, 1985; Kanfer & Stevenson, 1985; Karoly, 1993). A range of disorders have been noted as a result of disorders of self-regulation, or dysregulation, including impulse control disorder, addiction, attention and hyperactivity disorders and borderline personality disorder

(Dimaggio, Nicolò, Popolo, Semerari, & Carcione, 2006; Rodebaugh & Heimberg, 2007).

Based on what has been described about mindfulness in this thesis, it is plausible to assume that self-regulation is facilitated by the open awareness of mindfulness practiced. More specifically, mindfulness may enhance awareness of habitual patterns of responding to events that have been entrenched over time but may not necessarily be helpful or productive. This insight paves the way to choosing alternative, and healthier ways of responding. It has been proposed that the relationship between mindfulness and well-being is mediated by self-regulated activity that fulfils psychological needs of autonomy, competence and relatedness (Brown & Ryan, 2003). It has also been proposed that increased awareness of pain and stress responses assists in promoting coping resources (Kabat-Zinn, 1982). Learning to focus on the present moment is also said to develop control of attention, which is helpful in the recognition and adjustment of maladaptive behaviour (Linehan, 1993). Self-regulation has also been identified as a contributor to mental health by enhancing awareness of expectations that may otherwise distort the processing of new information (Borkovec, Alcaine, & Behar 2004).

Exposure

Exposure is a technique applied in cognitive behavioural therapy to reduce fear and anxiety through the identification of the cognitive, emotional and physiological arousal accompanying fear. The technique is believed to work through the process of systematic desensitisation or habituation that breaks the pattern of escape associated with the fear or anxiety (De Silva & Rachman, 1981). The efficacy of exposure in the treatment of a number of disorders has been well validated (e.g., Barlow & Craske, 2000). Exposure-based therapy has been shown to be helpful in the treatment of anxiety disorders (Krijn, Emmelkamp, Olafsson, & Biemond, 2004) and also prevent the progression from acute stress disorder to PSTD (Bryant et al.,

2008).

Exposure is a key element in the practice mindfulness. Mindfulness meditation involves focusing directly in sensations, pleasant or unpleasant, and assuming a non-judgmental attitude towards these sensations and towards the arsing emotions and thoughts regarding the sensations. In one of the first studies conducted on the therapeutic effects of mindfulness on chronic pain, Kabat-Zinn (1982) proposed that prolonged exposure to sensations of pain, without judgment of this pain, may lead to desensitisation and although the experience of pain may persist, the normal emotional reactivity to it would subside. Exposure has been cited, for the same reason, to act as a mechanism of mindfulness in the alleviation of symptoms associated with anxiety (Kabat-Zinn, 1992) and negative affect (Linehan, 1993).

Cognitive Flexibility

Cognitive flexibility is described as the ability to apply knowledge in different ways and adaptively in response to rapidly changing situations (Spiro & Jehng, 1990). Spiro and Jehng (1990) have theorised that cognitive flexibility is a function of the way knowledge is represented and the processes that influence these representations. The mental skill is reliant on the ability to adopt multiple perspectives and to respond flexibly to events as opposed to reacting stereotypically based on reinforced rigid patterns associated with over-identification with experiences (Shapiro et al., 2006).

In this way cognitive flexibility can fit neatly into the description above, whereby mindfulness highlights maladaptive responses, cognitive flexibility allows flexible responding to new information which facilitates the process of self-regulation. In the case of mindful awareness, cognitive flexibility is potentially 'turned inward' and mediates the relationship between mindfulness and its well-being outcomes by affording a more realistic impression of reality, absent of

personal bias. By way of example, it has been proposed that this decentered view of thoughts apprehends ruminative patterns characteristic of depressive episodes (Teasdale et al., 1995). Research showing the significant association between subjective well-being and a 'wider' attentional focus further supports this proposition (Eid & Larsen, 2007).

Acceptance

One of the most important and consistent themes in mindfulness, and one that runs through all of these arguments on proposed mechanisms, is non-judgment. Mindfulness is repeatedly described as a quality of awareness that is non-judgmental encouraging the unconditional acceptance of bodily sensations and mental operations. This justifies why acceptance is another frequently proposed mechanism of mindfulness. Although practitioners may describe the practice of mindfulness in ways that are subtly different, they share the fundamental tenet that mindfulness should be practiced with an attitude of acceptance (Baer, 2003).

Acceptance is considered instrumental in bringing about positive change in a number of psychotherapies: DBT, ACT and Relapse Prevention focus directly on nurturing acceptance as a central dialectic for change (Hayes et al., 1999; Heatherton & Baumeister, 1991; Linehan, 1993; Marlette & Gordon, 1985). These approaches are based on the premise that psychological suffering is caused by experiential avoidance of difficult mental or physical events and that accepting, and engaging in, such events brings about improved coping and restores health. It is possible that acceptance mediates the positive outcomes associated with mindfulness in the same way.

As it is no doubt clear all of these cognitive processes, or metacognitive processes, may be interrelated and it makes sense then that they work together to enhance mental health. In light of this exploration into mindfulness, it may be useful to look

at a description of how the mental state unfolds by recalling the process of meditation, to understand how these mechanisms may be set in motion. Mindfulness is a heightened present-moment awareness that is achieved though concentrated attention on the present moment and that facilitates insight (insight being noted as an outcome of mindfulness practice). Mindfulness opens awareness to physical and mental events and the relationship between these events (exposure) while nurturing a non-judgmental response to these events (acceptance), consideration of alternative responses (cognitive flexibility) and adjustment of thoughts and behaviour accordingly (self-regulation). Ultimately this process may plausibly achieve improved mental health.

The interrelationship between mindfulness and these mechanisms, and between the mechanisms themselves, is not yet clear and needs to be explored. The Shapiro model of the mechanisms of mindfulness (Shapiro et al., 2006) presents three inherent qualities of the mental state: *intention*, *attention* and *attitude.* These qualities are said to shift perspective, a process the authors have referred to as *reperceiving*. Reperceiving is then considered a meta-mechanism of mindfulness in that it overarches more direct mechanisms including exposure, values clarification, cognitive flexibility and self-regulation. The meta-mechanism of reperceiving is described in the same way as numerous authors have explained mindfulness: a process of disidentification from the contents of consciousness and viewing the moment-by moment experience with objectivity and clarity (Martin, 1997).

Returning to the current investigation, this qualitative systematic analysis has helped identify some of the most commonly proposed mechanisms of mindfulness. The findings provide some support for the Shapiro model, and the proceeding empirical investigation affords further insight into which of the proposed mechanisms mediate the relationships between mindfulness and its positive health indicators.

STUDY TWO: EMPIRICALLY TESTING THE PROPOSED MECHANISMS OF MINDFULNESS

Investigations into the mechanisms that mediate relationships between various mental states and behavioural styles, and those investigating the mechanisms that mediate the outcomes of prevention and treatment interventions, have grown tremendously over the years in the field of psychology (MacKinnon, Fairchild, & Fritz, 2007). Most of these studies have employed one of several statistical techniques that fall under the banner of *mediation analysis* to achieve their aims. Mediation analysis has also been recommended, and used, in the investigation of the mechanisms of mindfulness (Baer et al., 2008; Shapiro et al., 2006).

Explicitly, mediation is a process through which an intervening variable, or mediator variable (M), accounts to some extent for the effect of an independent variable (X) on a dependent variable (Y). In this way mediation is distinct from moderation, in which a moderating variable entirely changes the causal relationship between the independent and dependent variables.

In Study One of this thesis the most commonly proposed mechanisms to mediate the relationship between mindfulness and its positive outcomes were identified through a qualitative systematic analysis of the literature. In this study, the four most cited of these mechanisms, and including self-regulation, exposure, cognitive flexibility and acceptance, were empirically tested using mediation analysis.

METHOD

Study Design

This empirical investigation was designed as a matched-control clinical intervention study. The mediating effects of the four candidate mechanisms were studied using a pretest–posttest design. Specifically mediation was evaluated in (1) the relationship between mindfulness and *reduced symptoms of stress* (SOS) and (2) the relationship between mindfulness and *reduced mood disturbance* (MD). Reduced stress and mood disturbance are the two most documented outcomes of mindfulness training (Grossman et al., 2004).

The demonstration of mediation relies on the justification of a temporal precedence of an independent variable over a mediating variable and over a dependent variable. A longitudinal design was adopted in this study to display the causal relationship between mindfulness and its outcomes as well as the causal relationship between mindfulness and the four candidate mechanisms, before mediation was assessed. In other words it was important to establish that increases in mindfulness produced, and therefore preceded reductions in SOS and MD in order to test whether the proposed mechanisms mediated these dynamics. Although the effects of mindfulness on stress and mood have been well demonstrated in previous studies, it was necessary to ensure that the mindfulness intervention in this investigation brought about the same favourable outcomes.

Participants

A total of 206 participants were identified as suitable to take part in the study. Non-probabilistic convenience sampling was used to recruit 103 of these participants, who had enrolled to take part in MBSR training. Purposive criteria sampling was used to recruit an additional 103 control participants who were matched to the treatment group on the basis of moderating variables including gender, age and

education. Participants in the matched-control group were recruited using a snowballing technique and evaluated in terms of the moderating criteria. Advertisements requesting participation were distributed in several work and higher education environments. No compensation was offered to members in this group for taking part in the research but they were motivated to learn more about their mental health through the questionnaires. Exclusion criteria for the entire sample included (1) chronic mental or physical illness, and (2) meditation experience extending beyond a period of one-year. All participants were assured confidentiality, fully briefed on the study aims and requested to provide written informed consent to take part. The consent form is attached in Appendix A.

Procedure

Participants in the treatment and control groups completed a series of questionnaires before (Time I) and after (Time II) the treatment group underwent an 8-week MBSR intervention. The questionnaires measured mindfulness, SOS, MD and measures of the four candidate mechanisms. At Time I data were collected from participants in both groups with the exception of 15 participants in the treatment group. Two of the 15 participants were excluded due to chronic mental disorders and one due to having meditation experience extending beyond one year. The remaining 12 of these 15 participants declined to participate in the study. Following the first round of data collection, 31 participants dropped out of the study, 21 from the treatment group and 10 from the control group. A further 10 participants dropped out of the MBSR training, leaving a total number of 56 participants in the treatment group and 93 participants in the control group.

Participants in the control group were then once again matched to those in the treatment group prior to the second data collection (Time II) to bring the total number of participants included in the final analysis to 112. The demographics of this final group are detailed in Table 5 and a flowchart outlining the data collection

procedure is presented in Figure 1.

Participants in the treatment group underwent the 8-week MBSR intervention while the control group received no mindfulness training. The MBSR intervention involved weekly 2.5 hour group sessions and one full-day retreat (8 hours). The in-class sessions involved training in focusing attention on the breath and bodily sensations and instruction and practice in body scan and basic hatha yoga postures. Programme participants were also expected to practice exercises in focusing attention on the present moment, on a daily basis.

Table 5

Study Two Participant Demographics

Characteristics	**Details**	**Treatment Group (n = 56)**	**Control Group (n = 56)**	***t* statistic**	**p-level**
Gender	Female	40	42		
	Male	16	14		
Age in years	*M(SD)*	39.29 (9.19)	36.00 (12.42)	1.59	.11
	Range	21-64	18-56		
Years of education	*M(SD)*	12.11 (2.19)	11.95 (2.42)	0.37	.71
	Range	10-16	10-16		

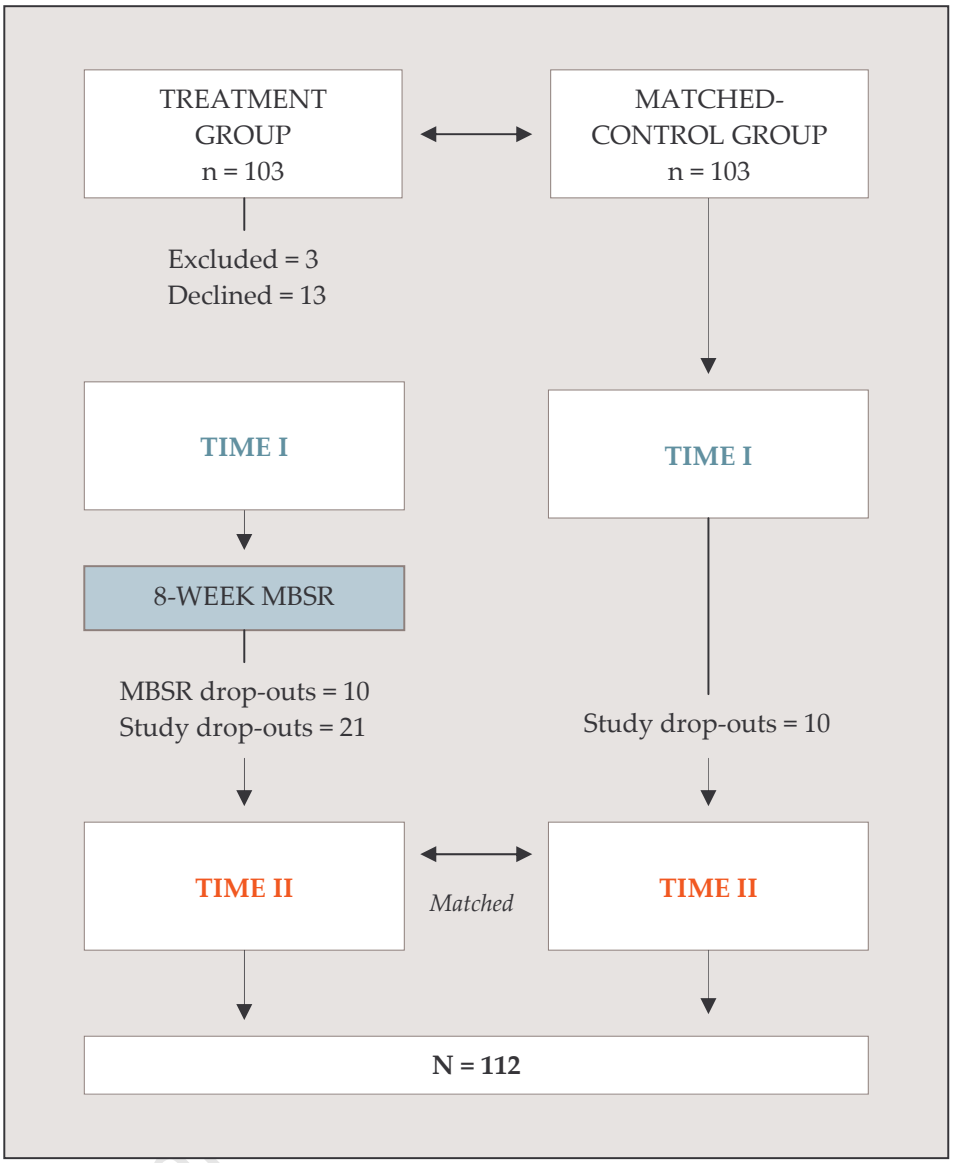


Figure 1. Study Two Data Collection Process

Instruments

Mindfulness

Five-Facet Mindfulness Questionnaire (FFMQ; Baer et al., 2006). This is a 39-item questionnaire that uses a 5-point Likert-type scale to measure mindfulness according to a 5-factor model of the construct. Items include, 'I am good at finding words to describe my feelings' and 'I am easily distracted'. The five factors are observe, describe, act with awareness, non-judgment and non-reaction. In the

present study these subscales were summed to produce a total mindfulness score. The questionnaire has been administered to students, meditators, non-meditators and highly educated population groups. In a non-meditating community sample the scale has a mean of 23.38 and a standard deviation of 6.26 and an internal consistency of alpha .72 to .92 (Baer et al., 2008). FFMQ scores were predicted to significantly increase in response to MBSR training.

Main Outcome Measures

Symptoms of Stress Inventory (SOSI; Leckie & Thompson, 1979*).* This is a 94-item questionnaire that uses a 5-point Likert-type scale to measure physical, psychological and behavioural responses to stressful situations. Items include, 'During the past week have you been bothered by rapid or racing heart beats' and 'Have you experienced feeling faint'. The questionnaire is divided into 12 subscales: peripheral manifestations, cardiopulmonary symptoms of arousal, upper respiratory symptoms, central-neurological symptoms, gastrointestinal symptoms, muscle tension, habitual patterns, depression, anxiety and fear, emotional irritability (anger) and cognitive disorganisation. In the present study the subscales were summed to report a total score of SOS and the measure was used to assess the effects of MBSR training on the experience of stress. The questionnaire has been administered in clinical and non-clinical populations and has sound test-retest reliability (r = .83) and internal consistency (alpha = .97). The scale mean in a non-clinical population is .86 with a standard deviation of .66. It was predicted that SOS would decrease significantly in response to MBSR training.

Profile of Mood States (POMS; McNair, Lorr, & Droppelman, 1971*).* This is a 65-item questionnaire that uses a 5-point Likert-type scale to assess six affective dimensions: tension, depression, anger-hostility, vigor, fatigue and confusion-bewilderment. Together these yield a measure of Total Mood Disturbance (TMD).

The questionnaire is predominantly used to assess mood changes resulting from interventions and has been widely administered in clinical and non-clinical populations with sound test-retest reliability (r = .65 to .74) and internal consistency (alpha = .90 and above). Although there is a lack of general population norms for the POMS, the reported mean for a normative patient sample with no reported disorders was 92.6 (McNair et al., 1971). In the present study it was predicted that TMD would decrease significantly following MBSR.

Mediator Measures

Self-Regulation Questionnaire (SRQ; Brown, Miller, & Lawendowski, 1999*).* This is a 63-item questionnaire that uses a 5-point Likert-type scale to measure domains of self-regulation including receiving relevant information, evaluating the information and comparing it to norms, triggering change, searching for options, formulating a plan, implementing the plan and assessing the plans effectiveness. Items include, 'I doubt I could change even if I wanted to' and 'I put off making decisions'. The questionnaire was used in this study to assess the proposed mechanism of mindfulness *self-regulation*. The SRQ has been administered in clinical and non-clinical populations and has sound test-retest reliability (r = .94) and internal consistency (alpha = .91). The population mean for the scale is 226 with a standard deviation of 15.1. In the present study it was predicted that scores of the SRQ would increase in response to MBSR training.

NEO-Five Factor Inventory (NEO-FFI; Costa & McCrae, 1992*).* This is a 60-item questionnaire that uses a 5-point Likert-type scale to measure the five domains of personality in accordance with the 5-factor model of personality. These five personality factors are: neuroticism, extraversion, openness to experience, agreeableness, and conscientiousness. The openness to experience factor of the NEO-FFI was used in this study to assess the proposed mechanism of mindfulness

exposure. Items include, 'Poetry has little or no effect on me' and 'I have a lot of intellectual curiosity'. Although the concepts of 'openness to experience' and 'exposure' may have different theoretical underpinnings, in mindfulness these concepts have been described in the same way. An open orientation to experience has been cited as one component of mindfulness in a two-component model of the mental state (Bishop et al., 2004). In this theoretical paper an open orientation to experience is considered as central in the practice of mindfulness practice and described as an active process in which one chooses to attend to present-moment experiences with an attitude of receptivity and openness. This description is consistent with how Baer and colleagues (2003) outline the role of exposure in mindfulness. These authors refer to exposure as an intentional and prolonged observation of present moment events without trying to avoid or escape them, in order to reduce associated fear responses and avoidance behaviours.

The openness factor of the NEO-FFI has a reported normative population mean of 27.03 and standard deviation of 5.84. The NEO-FFI has been widely administered in clinical and non-clinical populations with sound test-retest reliability (r = .75 to .83) and internal consistency (alpha = .68 to .86). In the present study it was predicted that scores on the openness to experience dimension of the NEO-FFI would increase in response to MBSR training.

Cognitive Failures Questionnaire (CFQ; Broadbent, Cooper, Fitzgerald, & Parks, 1982*).* This is a 25-item questionnaire that uses a 5-point Likert-type scale to measure absent-mindedness, or errors made due to inattention. The questionnaire was used in this study to assess the proposed mechanism of mindfulness *cognitive flexibility*. Items include 'Do you bump into people' and 'Do you lose your temper and regret it'. While the CFQ was not designed as a measure of cognitive flexibility per se, it has been used to assess the construct in the absence of a more appropriate alternative ((Baer, Smith, Hopkins, Krietemeyer, & Toney, 2006). The CFQ reports

difficulties in everyday activities that correspond to problems with perception, attention and memory retrieval, all of which are critical skills in cognitive flexibility. Cognitive flexibility relies on attention and perceptual processes: the environmental conditions that interfere with the task at hand need to be correctly perceived and attention needs to be paid to the novelty of the situation so that routine responses can be re-evaluated. Memory retrieval plays a role in this process whereby past, habitual behaviour is considered in order to be adapted. When a person is cognitively inflexible he/she acts in a non-functional way and performs tasks erroneously (Wallace, Kass, & Stanny, 2002). In addition, the two concepts share the same neural substratum: higher order executive functioning including attention, planning and reasoning, which are implicated in both behaviours, is carried out by the prefrontal cortex (Schmitz et al., 1993).

The scale has been administered in non-clinical populations and has sound test-retest reliability (r = .80 to .82) and internal consistency (alpha = .89) with a reported population mean of 44 and standard deviation of 10.1 (Broadbent et al., 1982). In the present study it was predicted that cognitive failures would decrease in response to MBSR training.

Acceptance and Action Questionnaire (AAQ; Hayes et al., 2004*).* This is a 16-item questionnaire that uses a 7-point Likert-type scale to measure willingness to accept undesirable thoughts and feelings while acting in a manner congruent with values and goals. The AAQ was used in this study to assess the proposed mechanism of mindfulness *acceptance*. Items include 'It's okay to feel depressed or anxious' and 'I am not afraid of my feelings'. The questionnaire has been used in various contexts and in both clinical and non-clinical samples with slight variations in its application. In this study the questionnaire was administered as a 16-item dual-factor solution, which is considered the most suitable for non-clinical population groups (Bond & Bunce, 2003). The dual-factor scale has shown sound

test-retest reliability (r = .79) and internal consistency (alpha = .87) with a normative population mean of 58.61 and standard deviation of 12.65 (Bond & Bunce, 2003). In the present study it was predicted that AAQ scores would increase in response to MBSR training.

Data Analysis

As already stated, mediation is an attempt to test the mechanisms through which an independent variable (X) may affect a dependent variable (Y). This process is pictorially depicted in Figure 2.

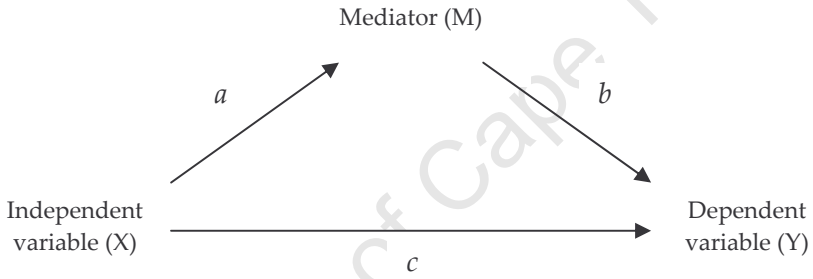


Figure 2. The Mediation Model

A variety of statistical methods have been designed to test mediation. These methods can be broadly categorised in three approaches: (1) the causal steps approach, (2) the difference in coefficients and (3) the product of coefficients. The causal step approach relies on a series of regression equations to evaluate the statistical significance of the relationships between X, M and Y. The difference in coefficients procedure evaluates the effects of a mediator variable by comparing the relation between the X and Y before and after adjusting for M, and the product of coefficients procedure tests the significance of a mediating variable by dividing the estimate of the M effect by its standard error and comparing this value to the

standard error of the normal distribution (MacKinnon, Lockwood, Hoffman, West, & Sheets, 2002).

The causal step approach is the most commonly applied method used to test mediation in psychological research (MacKinnon et al., 2007), and of three varieties within this approach, the Baron and Kenny (1986) method is the most widely adopted. For mediation to be assumed, this method relies on three prerequisites, (1) that a significant relationship exists between X and Y (path *c*), (2) that a significant relationship exists between the X and M (path *a*), and (3) that the significant relationship exists between the M and Y (path *b*), when controlling for X. In a slight variation of this method, developed by Judd and Kenny (1981a, 1981b), mediation is assumed when each variable in the causal chain effects the subsequent variable, controlling for all variables that precede it. The third causal step method, the Test of Joint Significance (TJS), is slightly simpler requiring only that the relationships between the X and M, and M and Y when controlling for X, are jointly significant (Cohen & Cohen, 1983).

Most recently the TJS method has been shown to have the best compromise between type I and type II errors (MacKinnon et al., 2007) and the best statistical power of all 14 existing methods to test mediation (MacKinnon et al., 2002). This technique is endorsed by authors who argue for eliminating the evaluation of the relationship between X and Y in the test of mediation (Frazier, Tix, & Barron, 2004; Kenny, Kashy, & Bolger, 1998). In addition, the first two causal step procedures require significantly large samples to achieve a statistical power of .8 (Fritz & MacKinnon, 2007). The TJS was used in this research study on account of these favourable findings.

In the data analysis, primary analyses were conducted to establish whether the MBSR training brought about significant changes in mindfulness and whether these changes resulted in reductions in SOS and MD. These analyses were conducted to ensure that the current sample group displayed a comparable

response to mindfulness training as those documented by previous studies. These analyses, as stated, were necessary to justify further mediation analysis using this dataset.

Pretest-posttest analyses were also conducted on the four candidate mechanisms for the purpose of producing mediator descriptives. Data from both the control and treatment groups were included in the final mediation analysis, an appropriate technique in the TJS (MacKinnon et al., 2002). Participant change scores were used in the multiple regression equations to reduce the likelihood that baseline and post-treatment outlier scores would confound the mediation results.

Although the output of the multiple regression testing does provide estimates of effect sizes and confidence intervals for each path, these estimates have been noted to be a biased in terms of the magnitude of the indirect effect (Mallinckrodt, Abraham, Wei, & Russell, 2006). Reporting the significance of mediated effects and confidence intervals is nevertheless required when reporting research findings (Wilkinson & American Psychological Association Task Force on Statistical Inference, 1999). In the present study the Sobel formula[3] (1982) was used to calculate the significance of the mediated effect, both to meet these standard requirements as well as to assess the mechanistic role of the candidate mediators as thoroughly as possible. The Sobel equation yields a *z* statistic that can be evaluated for statistical significance using the probably scales on the standard normal distribution. The standard errors derived from the Sobel formula were also used to calculate confidence intervals (95%) using critical values for normal distribution (1.96) (MacKinnon et al., 2002).

[3] $\sqrt{a^2 seb^2 + b^2 sea^2}$ (where *sea* is the standard error for the regression coefficient of path *a* and *seb* is the standard error of the regression coefficient of path *b*).

RESULTS

The data analyses conducted in this investigation were all concerned with testing the proposed mediation models depicted in Figures 3 and 4 respectively. In Model A the four candidate mediators identified in Study One were proposed to mediate the relationship between mindfulness and reduced SOS. In Model B the mediators were proposed to mediate the relationship between and mindfulness and reduced MD. In the model testing, the candidate mediators were tested individually, a technique that is considered a satisfactory way of testing multiple-mediator models (MacKinnon, n.d.), and has been applied in related research (Baer et al., 2008).

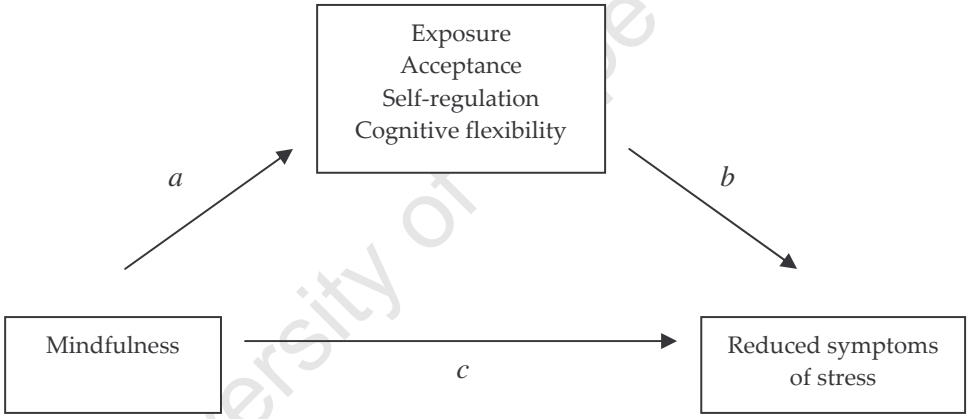


Figure 3. Proposed Mediation Model A

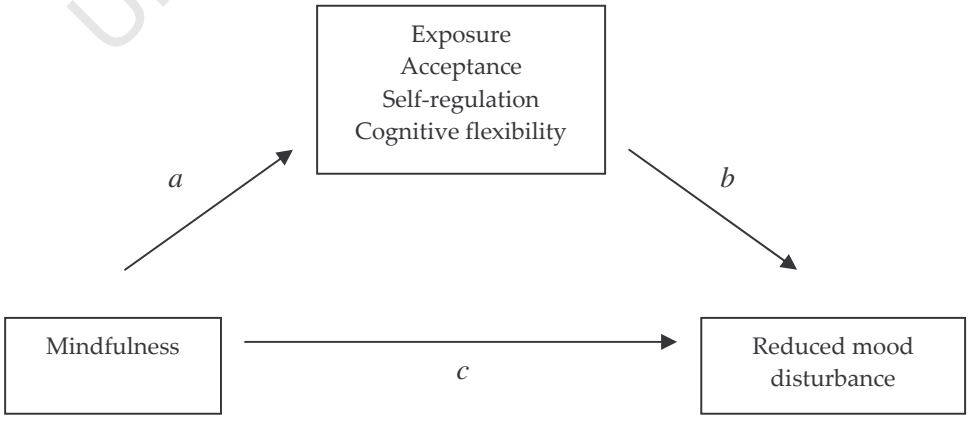


Figure 4. Proposed Mediation Model B

Treatment and Control Group Profiles

The control group presented at baseline with a significantly higher level of mindfulness than the treatment group ($t(110) = -2.94$, $p = .004$). While this finding is of qualitative interest, suggesting that those who seek out mindfulness training may be less mindful than the general population, the group baseline differences were not considered a limitation in this study because the interest was in exploring the effects of mindfulness training on baseline mindfulness levels, regardless of how high or low these levels.

The treatment group scored significantly higher on the measure of exposure (openness to experience) than the control group at baseline ($t(110) = 2.97$, $p = .004$). Again, this is qualitatively interesting suggesting that individuals who seek out mindfulness training may be more experientially open but the group difference was not considered problematic for the same reason as cited above.

There were no significant differences between the groups in terms of MD and SOS at baseline, or in their measures of the remaining proposed mechanisms, including acceptance, cognitive flexibility and self-regulation. Baseline means and standard deviations are presented in Table 6.

The Effect of MBSR on Mindfulness

A 2 (group) x 2 (time) repeated-measures analysis of variance (ANOVA) was performed to establish whether the MBSR intervention enhanced levels of mindfulness. This was an important point to establish prior to conducting any analyses to demonstrate potential effects associated with increases in mindfulness. Significant interaction effects were found ($F(1,110) = 42.77$, $p < .001$) in this analysis. While significantly higher levels in mindfulness were noted in the control group prior to the MBSR intervention, analyses of simple main effects revealed significant increases in mindfulness in the treatment group following the intervention ($F(1,110)$

= 85.44, $p < .001$) but not in the control group. The group means and standard deviations are noted in Table 6 and graphically depicted in Figure 5. Tables of means and standard deviations, ANOVA summary tables, graphs of cell means and analyses of simple main effects for all analyses are carried in Appendix D.

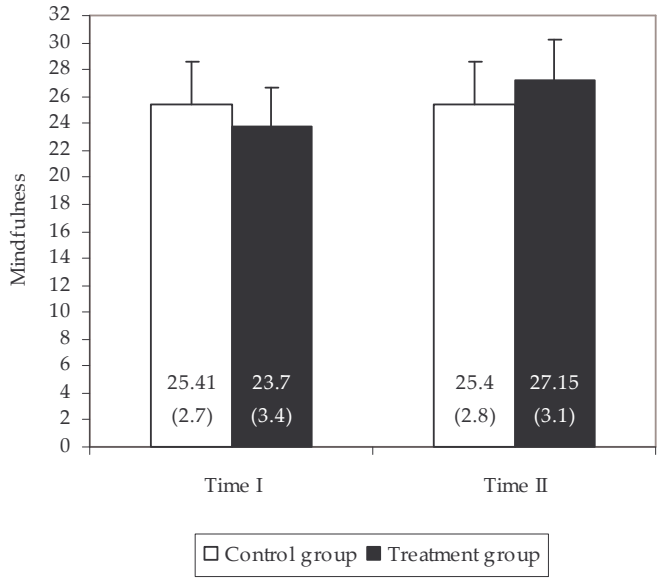


Figure 5. Mindfulness Group Means and Standard Deviations

The Effect of MBSR on the Main Outcomes

Further 2 (group) x 2 (time) repeated-measures ANOVA were conducted to determine the effects of mindfulness training on the main outcomes. As already reported, there were no significant differences between the groups in SOS and TMD at Time I testing.

Significant interaction effects were observed in the ANOVA of SOS ($F(1,110) = 12.15$, $p = .0007$). An examination of simple main effects confirmed that SOS significantly decreased in the treatment group following MBSR training ($F(1,110) = 28.05$, $p < .001$), but not in the control group.

While no interaction was present in the analysis of MD, a pairwise comparison of the means using the Turkey test revealed significant decreases in MD

in the treatment group following the MBSR intervention (p = .011). No significant changes were noted in the control group. Group means and standard deviation are noted in Table 6 and graphically depicted in Figure 6.

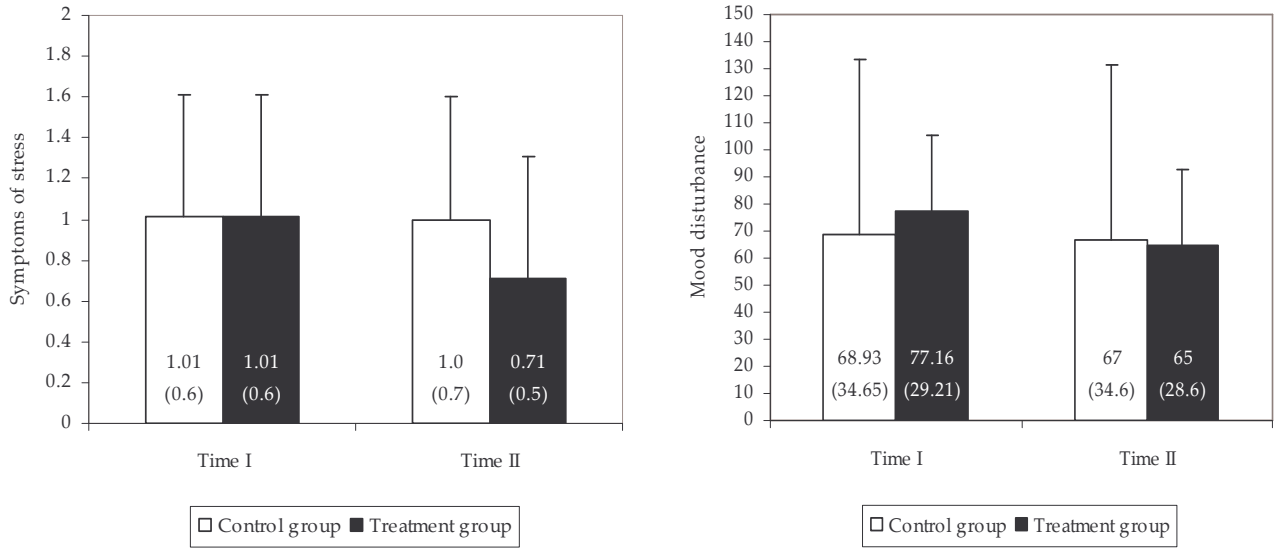


Figure 6. Symptoms of Stress and Mood Disturbance Group Means and Standard Deviations

The Effect of MBSR on Mediator Variables

Further 2 (group) x 2 (time) repeated-measures ANOVA revealed significant interaction effects on the candidate mediators acceptance (F(1,110) = 9.54, p = .003), cognitive failures (F(1,110) = 30.51, p < .001) and self-regulation F(1,110) = 9.53, p = .003). Further one-way ANOVAs using repeated measures confirmed that the MBSR training intervention brought about significant increases in acceptance (F(1,110) = 17.16, p < .01) and self-regulation (F(1,110) = 35.19, p < .001) and decreases in cognitive failures (F(1,110) = 54.08, p < .001) in the treatment group. No significant changes where noted in the control group following the 8-week period.

Table 6

Group Means and Standard Deviations

		Treatment Group		Control Group	
		Pre-MBSR	Post-MBSR	Time I	Time II
	Mindfulness (FFMQ)	23.7 (3.4)	27.15 (3.1)***	25.41 (2.7)	25.4 (2.8)
Main outcomes					
	Symptoms of stress (SOSI)	1.01 (0.6)	.71 (0.5)***	1.01 (0.6)	1.0 (0.7)
	Mood disturbance (POMS)	77.16 (29.2)	65 (28.6) *	68.93 (34.7)	67 (34.6)
Mediators					
	Exposure (NEO)	42.96 (7.7)	44.30 (6.9)	38.61 (7.9)	38.73 (7.3)
	Cognitive errors (CFQ)	45.70 (12.9)	35.61 (13.9) ***	41.05 (15.5)	41.68 (13.2)
	Acceptance (AAQ)	69.23 (9.6)	73.38 (10.8)**	71.71 (8.2)	71.52 (8.2)
	Self-regulation (SRS)	215.79 (22.7)	220.95 (20.5)***	219.68 (20)	217.41 (18.2)

Note. Values are given as mean and (sd)
* p < .05, ** p < .01, *** p < .001

Mediation Analyses

Mediator Effects

The TJS was used to test the mediation models A and B (Figures 3 and 4). A correlation matrix of the change scores on mindfulness, main outcomes and the four mediators, is presented in Table 7. The multiple regression coefficients related to mediation paths, mediated effects and confidence intervals are tabulated in Table 8.

Table 7.

Correlation Matrix of Change Scores on Mindfulness, Main Outcomes and Four Mediators

Variable	1	2	3	4	5	6	7
1. Mindfulness	---	-.30**	-.49***	.27**	.63***	-.55***	.39***
2. Mood disturbance	-.30**	---	.51***	-.21*	-.44***	.23*	-.27**
3. Symptoms of stress	-.49***	.51***	---	-.23*	-.48***	.49***	-.29**
4. Exposure	.27**	-.21*	-.23*	---	.23*	-.19*	.33***
5. Acceptance	.63***	-.44***	-.48***	.23*	---	-.42***	.42***
6. Cognitive failures	-.55***	.23*	.49***	-.19*	-.42***	---	-.26**
7. Self-regulation	.39***	-.27**	-.29**	.33***	.42***	-.26**	---

Note: * p < .05, ** p < .01, *** p < .001

Analysis of path a

Path *a* represents the relationship between mindfulness and the mediators and the related correlations coefficients are therefore the same for Model A and B. As shown in Table 7 and 8, multiple regression analyses indicated that levels of mindfulness significantly related to those of the four candidate mediators.

Analysis of path b

Individual multiple regression equations were conducted to examine the relationships between each of the mediator change scores and change scores of the outcome variables. Examination of the path *b* regression coefficients in Model A revealed that acceptance (β = -.290, $t(109) = -2.81$, $p = .006$) and cognitive failures (β = .309, $t(109) = 3.25$, $p = .002$) significantly predicted reduced SOS scores, when controlling for the effects of mindfulness. Examination of the path *b* regression coefficients in Model B revealed that only acceptance significantly predicted reduced MD scores, when controlling for the effects of mindfulness (β = -.414, $t(109) = -3.76$, $p = .0003$). These regression results are presented in Table 8 with the respective Sobel *z* statistics and confidence intervals.

Mediated effects

Based on the assumptions of the TJS acceptance and cognitive flexibility can be considered mediators in the relationship between mindfulness and SOS in Model A, since both the respective paths *a* and *b* were jointly significant (Figure 7). Likewise acceptance can be considered a mediator in the relationship between mindfulness and MD in Model B, since both the related paths *a* and *b* were jointly significant (Figure 8).

The significance of these mediating relationships was further supported by the Sobel test, which showed acceptance to be a significant mediator in the

relationship between mindfulness and SOS at p = .006, and in the relationship between mindfulness and MD at p = .0006. The Sobel test also reported the significance of cognitive failures as a mediator in the relationship between mindfulness and MD at p = .002.

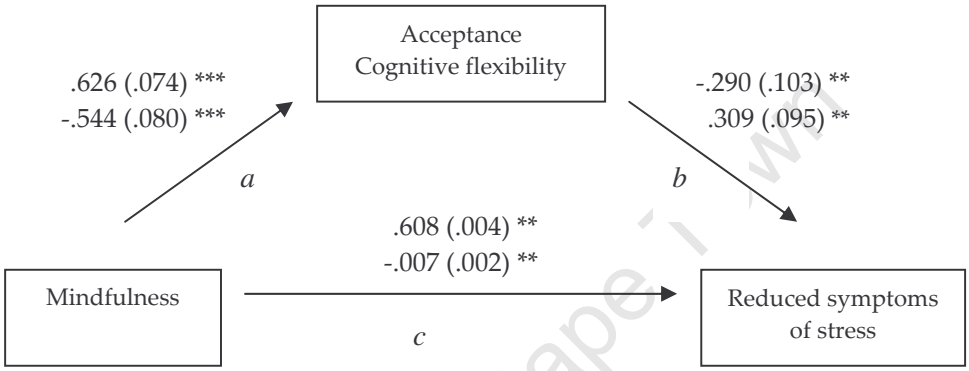
Table 8

Mediation Results Table

Mediator candidate	**(*a*) Effect of mindfulness on mediators**	**(*b*) Effect of mediators on outcomes**	***(c)* Mediated effect**	**Lower CI**	**Upper CI**	**Sobel Z statistic**	***p* value**
Self-regulation							
SOS	.390 (.088)***	-.116 (.090) *-.004 (.003)*	.386 (.001)	.384	.388	-1.28	.202
MD	.390 (.088)***	-.179 (.098) *-.396 (.217)*	-.006 (.092)	-.185	.173	1.69	.092
Exposure							
SOS	.274 (.092)***	-.103 (.086) *-.011 (.009)*	.263 (.003)	.258	.268	-1.13	.258
MD	.274 (.092)***	-.410 (.094) *-.970 (.648)*	-.696 (.199)	-1.085	-.307	-1.34	.181
Cognitive failures							
SOS	-.544 (.080)***	.309 (.095)** *.013 (.004)*	-.007 (.002)	-.012	-.002	-2.93	.002**
MD	-.544 (.080)***	.088 (.109) *.224 (.276)*	-.122 (.151)	-.418	.174	-0.81	.420
Acceptance							
SOS	.626 (.074)***	-.290 (.103)** *-.018 (.006)*	.608 (.004)	.600	.616	-2.83	.0059**
MD	.626 (.074)***	-.414 (.110)** *-1.57 (.419)*	-.944 (.199)	-1.506	-.382	-3.43	.0006***

Note. CI, confidence interval; ns, non significant
Unstandardised regression coefficients related to *b* paths are reported in italics below their Beta values
The mediated effect (*c*) is the product of *a* and *b* unstandardised regression coefficients
Normal 95% confidence intervals were computed using estimate ± a critical value of 1.96 × *SE*
* p < .05, ** p < .01, *** p < .001

Based on the results of the mediation analysis acceptance and cognitive flexibility are mechanisms that mediate the relationship between mindfulness and reduced SOS (Model A depicted in Figure 7) and acceptance is the mechanism that mediates the relationship between mindfulness and reduced MD (Model B depicted in Figure 8).



Note. Coefficients for acceptance are listed above and those for cognitive failures, below

Figure 7. Mediation Model A

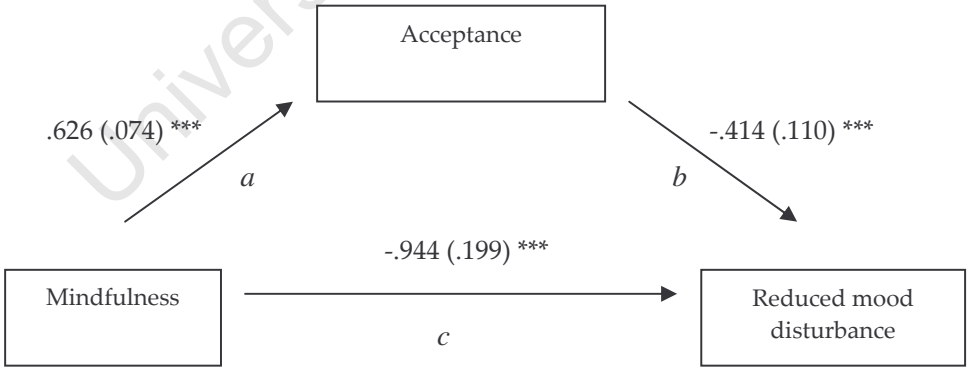


Figure 8. Mediation Model B

DISCUSSION

The cultivation of mindfulness through practice has a long history, as outlined in the opening chapters of this thesis. Mindfulness practitioners frequently report the health benefits of nurturing heightened present-moment awareness and in more recent years a number of these self-reports have been supported by an amassed body of empirical research. The growing application of mindfulness training in the healthcare setting has inspired investigations into the benefits of various related interventions, explicit detail regarding the constituents of mindfulness, and more recently, the mechanisms of mindfulness. The two research studies in this chapter were conducted to advance our understanding of the mechanisms of mindfulness and add to the growing knowledge base.

Commonly proposed mechanisms of mindfulness were extracted in the qualitative systematic analysis of the literature. In the empirical testing of the mediating roles of four of these proposed mechanisms, in both the relationship between mindfulness and reduced SOS and the relationship between mindfulness and reduced MD, it became evident that two mechanisms significantly mediated the outcomes of mindfulness: acceptance and cognitive flexibility.

Acceptance was shown to mediate the relationship between mindfulness and reduced SOS (Model A) and mindfulness and reduced MD (Model B). As stated in the discussion of Study One, of the four proposed mechanisms, acceptance is probably the most intuitively associated with mindfulness, not least of all because mindfulness is described as heightened present-moment awareness that is *non-judgmental* (Kabat-Zinn, 1994).

Of particular relevance to this study is the fact that acceptance, or non-judgment, is also considered to be a *factor* of mindfulness according to the 5-factor model of the mental state (Baer, et al., 2006). It is reasonable to assume that the

application of the FFMQ in this research would therefore account for the highly significant correlation between mindfulness and acceptance. In Baer's study of the psychometric properties of the FFMQ, she suggested that further longitudinal research investigating the change in the five factors with enhanced mindfulness would shed light on the how such training may contribute to improved well-being. The results of this longitudinal study strongly suggest that acceptance may be better understood as a mechanism of mindfulness, mediating the relationship between the mental state and its positive outcomes. This is proposed because the statistical technique of multiple regression, employed in the TJS to explore mediation, is designed to demonstrate causation, not merely correlation. In the series of regression equations conducted in the TJS analysis, acceptance was shown to be a significant outcome of mindfulness when entered as a dependent variable, and was also shown to bring about significant reductions in SOS and MD when entered as an independent variable, while controlling for the effects of mindfulness. Based on these findings, enhanced acceptance in response to mindfulness training brings about reductions in SOS and MD.

Acceptance is a foundation of mindfulness practice (Kabat-Zinn, 1994) and includes acceptance of negative events, bodily sensations, emotions and thoughts (Allen, 2006). But the acceptance that is so commonly referred to as pivotal to mindfulness is dissimilar to 'resignation' and implies a non-judgmental attitude towards transitory episodes rather than an indifference towards them. This non-judgment is thought to negate attachment or aversion to passing events (Bowen et al., 2006) and so stands in contrast to experiential avoidance, which is associated with maladaptive responses in cases of prolonged pain and distress (Orsillo et al., 2004).

In the context of mindfulness, acceptance has also been referred to as a form of desensitisation which has been proposed to reduce negative affect and improve overall psychological health (Allen, 2006). It may also be worth noting, given the

origins of mindfulness practice, in Buddhist philosophy acceptance (otherwise known as non-striving) is considered critical to health. This stance opposes many Western medical and psychological approaches to health, which strive to change and avert affliction. Attempts to manipulate or control mental events have been shown to predict poor long-term outcomes (Wilson & Murrell, 2004). In mindfulness the aim is, in contrast, to accept reality as it is, accepting negative emotions, accepting pain, accepting adverse conditions.

The mechanistic action of acceptance in positive health is well established. In DBT acceptance is noted as the key to positive outcomes (Linehan, 1993) and in ACT the experience of thoughts and emotions as they arise without judgment is considered the dialectic for behaviour change (Hayes et al., 1999). Acceptance is also practiced through mindfulness in Relapse Prevention therapy (Marlette & Gordon, 1985) and has been cited as a mechanism for improving the symptoms of binge eating (Heatherton & Baumeister, 1991).

Cognitive flexibility was a second significant mediator in the relationship between mindfulness and reduced SOS. The metacognitive construct was described in the discussion of Study One as the ability to adapt cognitive processing strategies to respond flexibly in novel situations. It is reasonable to assume that such cognitive flexibility relies on enhanced awareness to bring maladaptive cognitive schemata into view before alternatives may be considered and behavioural choices adapted. Once awareness of our physical and mental reactions to events is enhanced through mindfulness, such cognitive flexibility may assist in improving our selection of appropriate ways to respond, affording new behavioural styles that are helpful in the regulation of emotion and stress.

It is noteworthy that Langer (1989) interpreted the process of mindfulness in a similar way. Langer noted that mindfulness engenders (1) alertness to multiple perspectives and (2) novelty to foster improved self-regulation. Langer also described how mindlessness exacerbates learned helplessness and leads to low self-

esteem. Enhancing mindfulness has also been suggested to change information processing patterns that are associated with emotional distress through improving focus and attention (Bowen et al., 2006).

Findings for self-regulation and exposure (openness to experience) were unexpected. Both of these proposed mechanisms were highly correlated with mindfulness and reduced SOS and mindfulness and reduced MD. However neither construct significantly determined reduced SOS and MD when entered as independent variables in regression equations. One may, however, consider self-regulation to be an end product of mindfulness awareness, acceptance and cognitive flexibility, as improved decision-making enables more appropriate behavioural choices. Equally, exposure would presumably be fostered by enhanced awareness.

Based on this argument it was thought that self-regulation and exposure may be outcomes of mindfulness training, mediated themselves by acceptance and cognitive flexibility. However, based on the fact that only self-regulation improved significantly in response to mindfulness training, secondary TJS analysis was conducted to test an additional mechanistic model of mindfulness in which self-regulation was postulated as an outcome. The TJS confirmed that acceptance significantly mediated the relationship between mindfulness and improved self-regulation ($\beta = .296$, $t(109) = 2.71$, $p = .008$). This secondary finding presents an opportunity for further research.

The primary limitations of this empirical investigation are implicit to mediation analysis itself. Although the choice of the TJS was justified based on its recommended use over all other 14 methods of mediation analysis (MacKinnon et al., 2002; Mallinckrodt et al., 2006) the technique is associated with several limitations: the TJS does not require the testing of the X – Y relationship and therefore does not offer a reliable estimate of the size of the indirect effect of the independent variable on the dependent variable, or the standard errors to calculate

confidence intervals. As a result, additional techniques were needed to provide these results and complement the overall findings. As yet there is no test of mediation that achieves all of these results in a single analysis.

It would be recommended to test more of the 10 proposed mechanisms that were identified in the qualitative systematic analysis in future research – this was not possible in the present study due to the lengthy time required to complete the battery of questionnaires. Of particular interest would be the potential mediating role of *insight* in the relationship between mindfulness and improved psychological health since Buddhist scriptures maintain that mindfulness facilitates insight and together the two mental states achieve positive mental health (Nyanaponika, 1949). It would also be recommended to conduct an investigation to explore how these mediator relationships hold over time by introducing a third round of testing six months after mindfulness training. Employing measures other than self-report would also be beneficial in validating the findings of this study.

Nevertheless this research presents one of the first attempts to empirically establish the mechanisms of mindfulness and offers a solid foundation on which to base further investigation.

CHAPTER THREE

THE NEUROLOGICAL MECHANISMS OF MINDFULNESS

STUDY THREE: THE NEURAL SUBSTRATES OF MINDFULNESS

The study of the human brain has never been better equipped with neuroimaging techniques allowing an increasingly detailed viewing of the working brain. A growing interaction between psychology and neuroscience is seeing the application of techniques including functional MRI, single photon emission computer tomography (SPECT) and also proton emission tomography (PET), significantly advance the quantification of psychological processes. Although self-reports and observational studies have been undeniably informative to our current understanding of the human mind, the more robust analysis made possible through the application of these neuroimaging techniques is affording a deeper understanding of human behaviour.

With particular relevance to the study of mindfulness, neuroimaging may help to validate and dispel some common assumptions regarding the psychological processes associated with the mental state and its mechanisms of action. Explicitly, most of what is known about mindfulness has been learnt through self-report surveys and it stands to reason that demonstrating the functional anatomy of the mental state will afford a less biased expose of mindfulness as well as new insights into how it may operate.

THE STUDY OF MECHANISMS

Mechanisms of action may be studied through various means. Once a primary causal relationship has been established between two or more variables, in this case mindfulness and reduced stress and mindfulness and reduced mood disturbance, the mechanisms at work in these casual relationships can be investigated further. In psychological research the study of mechanisms typically take the form of the first two studies in this thesis, namely identifying potential mechanisms and testing them empirically using mediation statistical techniques.

Another way of gaining insight into the mechanisms of action, however, is the evaluation of the physiological and neurological changes that occur either during, or as a consequence of, this causal relationship. Following the latter procedure, the mechanisms of mindfulness may therefore be studied by evaluating the physiological and neurological alterations that occur during the mental state compared to a resting state. As already mentioned these measures are more objective than self-reports, simply because physiological changes are difficult to consciously control.

Numerous physiological changes may be expected to occur in the body and brain during mindfulness, like alterations in respiration and heart rate variability, as already investigated (Takahashi et al., 2005). In the present study, functional MRI was employed to explore the changes in brain function that take place during mindfulness meditation, thus affording a preview into its mechanisms of action. Mindfulness meditation, or state mindfulness, was investigated because it may be considered an intense expression of the mental state, as explained in the description of state and trait mindfulness in the literature review of Chapter One.

THE NEUROSCIENCE OF MEDITATION STATES

Although a number of studies have investigated the health benefits of various types of meditation, and some of these have studied related alterations in brain function and anatomy, few translate to mindfulness per se. Again, meditation is a catchall phrase for a number of mental control techniques that differ in terms of their aims, methods and applications, and therefore also target specific underlying processes and engage specific neural circuitry (Lutz et al., 2007). The diversity of meditation practices becomes self-evident when reviewing the considerably discrepant findings in meta-analyses of meditation studies employing EEG, ERP and neuroimaging techniques (Cahn & Polich, 2006; Ivanovski & Malhi, 2007).

Specific meditation styles that engender mindfulness, or open awareness, include Zen meditation and insight meditation inherited from the Thai and Burmese Theravada Buddhist traditions; both forms are aimed at gaining insight into habits and assumptions about identity and emotions. To reiterate, these forms of meditation differ from concentration meditation were attention is focused on a single object to still the mind. To date neuroscientific studies on concentration meditation practices far outnumber those on mindfulness meditation; nonetheless a handful of exceptional studies that have focused on mindfulness are summarised in Table 8. These studies, although themselves somewhat contradictory in their findings, in general report changes in both brain function and physical structure in response to mindfulness practice.

In a study of five mindfulness meditation practitioners assessing functional changes associated with meditation compared to a relaxation state, in a 45-s blocked on-off design, magnetic signal increases were reported in the dorsolateral prefrontal cortex and the anterior cingulate cortex, with signal decreases in the occipital cortex (Baerentsen, 2001). A later study using the same block design to assess functional changes associated with a Zen form of mindfulness meditation, in which

practitioners were asked to count their breaths during the meditation block and engage in random thoughts during rest, reported signal increases in the dorsolateral prefrontal cortex (with a right hemisphere bias) and bilateral basal ganglia, and signal decreases in the right anterior superior occipital gyrus and anterior cingulate cortex (Ritskes et al., 2003). The discrepancy in these findings may be a result of different meditation techniques being investigated. The meditation style was unspecified in the first study, but the exercise of counting breaths employed in the second study could be considered a focused mental activity, more closely associated with a concentration meditation practice (traditional mindfulness meditation broadens attention). These studies also lack standardised phenomenological descriptions regarding outcomes of meditation practice (Cahn & Polich, 2006). Cahn & Polich (2003) have noted the need for further investigation based on these limitations and the preliminary nature of the research.

A functional imaging study comparing insight meditation with the relaxation practice of Kundalini yoga, using a control-group design, reported signal increases in the dorsal cingulate cortex and right temporal lobe during the insight meditation compared to a control block in which random numbers were generated (Lazar et al., 2003). Similar findings, in part, were noted in a study investigating the neural correlates of dispositional mindfulness during affect labelling, in which widespread prefrontal cortical activation was noted in addition to reduced bilateral amygdala activity during affect labelling compared to a gender labelling control task (Creswell et al., 2007). In addition a strong negative association was found between prefrontal cortex and right amygdala activity in participants with higher mindfulness scores.

More recently, a group of MBSR participants showed marked reductions in activity in the medial prefrontal cortex and increased engagement of the right lateral prefrontal cortex, insula, secondary somatosensory cortex and inferior parietal lobule, compared to a novice group, during an experiential-focused self-reference

task (Farb et al., 2007). These results were related to an increased capacity to disengage from narrative generation in favour of present-centred self-awareness. Extended self-reference (narrative focused), linking experiences across time, and momentary self-reference (experiential focused) are considered two distinct forms of self-referential thought, with the latter considered the default state of self-reference. These investigators suggest that present-moment experience may reflect the neural origin of identity because the neural regions engaged in experiential focused self-reference, experienced in mindfulness, are evolutionarily older than those activated in narrative focused self-reference. The relevance of this postulation will be elaborated on in the discussion of the present research findings.

In terms of brain structure, a structural magnetic resonance imaging (sMRI) study reported increased cortical thickness in brain regions involved in attention, interoception and sensory processing. Specifically the prefrontal cortex and right anterior insula were significantly thicker in participants with extensive insight meditation experience compared to controls, and, cortical thickness correlated with meditation experience (Lazar et al., 2005).

Table 9

Mindfulness Meditation Studies using Neuroimaging Techniques

Authors	**Study**	***N***	**Design**	**Findings**
Baerentsen (2001)	Mindfulness meditation	5	fMRI Rest vs. meditation	SI: DLPFC, ACC SD: OC
Ritske and colleagues (2003)	Zen meditation	11	fMRI Rest vs. meditation	SI: DLPFC, BG SD: ACC, aSOG(r)
Lazar and colleagues (2003)	Mindfulness meditation/ Kundalini	33	fMRI Control task vs. meditation	SI: dACC, TL(r)
Lazar and colleagues (2005)	Insight meditation	20	sMRI Meditators vs. controls	Increased cortical thickness in PFC, aINS(r)
Creswell and colleagues (2007)	Trait mindfulness	27	fMRI Affect vs. gender labelling	SI: PFC SD: AMG(bi)
Farb and colleagues (2007)	Trait mindfulness	-	fMRI Extended vs. narrative self-reference	SI: PFC(r), INS, SII, PL SD: mPFC

Note. fMRI, functional magnetic resonance imaging; sMRI, structural magnetic resonance imaging; SI, signal increase; SD, signal decrease
BRAIN REGION (hemisphere); ACC, anterior cingulate cortex; aINS, anterior insula; AMG, amygdala; aSOG, anterior superior occipital gyrus; BG, basal ganglia; dACC, dorsolateral anterior cingulate cortex; DLPFC, dorsolateral prefrontal cortex; INS, insula; mPFC, medial prefrontal cortex; OC, occipital cortex; PFC, prefrontal cortex; PL, parietal lobe; SII, secondary somatosensory cortex; TL, temporal lobe

It is obvious that the functional neuroimaging studies cited here report diverse findings, most likely due to their differing experimental designs and control tasks, recalling that functional MRI is a subtractive measure measuring signal changes during an experimental condition against those during a control condition – in other words the control tasks are a critical consideration in this type of research in that the brain regions engaged in these tasks strongly influence the findings related to the experimental condition. In addition, *state mindfulness* has not been the topic of investigation in all of these studies and some of the more recent research focuses on

the effects of *trait mindfulness* on cognitive task performance. In summary, although these studies cast light on the effects of mindfulness on cognition, the diversity of research methods and applications of the mindfulness state under study have done little to advance the knowledge base on the neural substrates of mindfulness per se.

Nonetheless, if one might make a crude attempt to isolate consensual findings from these studies regarding the neural basis of mindfulness, one may isolate signal increases in the dorsolateral prefrontal cortex (higher cognitive functions like planning and reasoning) and the anterior cingulate cortex (implicated in emotional processing).

Challenges in conducting empirical research on meditation extend beyond the heterogeneity of meditative states to difficulty in controlling (a) the degree of practitioner expertise, (b) techniques used to achieve the meditation state, and (c) the nature of control tasks employed. In the current study of mindfulness meditation, participants were recruited on the basis of their mindfulness meditation experience and techniques used in the meditation and control sessions were carefully considered to hold these variables constant. This study is informed by research that has investigated brain function associated with state mindfulness (Baerentsen, 2001; Ritske et al., 2003) and by the defining features and perceived outcomes of mindfulness in Buddhist traditions. To reiterate, mindfulness in the latter traditions is considered open awareness facilitating insight into habits and assumptions about identity and emotions, acting to regulate emotion (Gethin, 1998). In the present study it was therefore hypothesised that mindfulness meditation would produce significant signal changes in regions of the brain associated with emotion regulation. These regions include the dorsolateral prefrontal cortex, anterior cingulate cortex, orbitofrontal cortex and amygdala (Davidson, Putnam, & Larson, 2000).

METHOD

Participants

Ten healthy right-handed mindfulness practitioners (3 female, 7 male) aged 35-55 years participated in the study. Each participant had undergone an 8-week MBSR intervention and practiced daily mindfulness meditation for a minimum of four years. Participants had no history of psychiatric disease and screening questionnaires confirmed there were no significant differences in the range of mindfulness scores (FFMQ; Baer et al., 2006), symptoms of stress (SOSI; Leckie & Thompson, 1979), or mood disturbance (POMS; McNair et al., 1971). Participant demographics have been outlined in Table 9. Table 9 also carries the *p* values related to the difference in the sample groups' mean scores on questionnaires itemised below, compared to reported population norms. Informed consent was obtained from the participants (Appendix B) and ethical approval to conduct the study was granted by the University of Cape Town, Faculty of Health Sciences Research Ethics Committee and the Committee for Human Research at Tygerberg Hospital.

Instruments

Mindfulness Measure

Five-Facet Mindfulness Questionnaire (FFMQ; Baer et al., 2006). This is a 39-item questionnaire that uses a 5-point Likert-type scale to measure mindfulness according to a 5-factor model of the construct. The five factors are observe, describe, act with awareness, non-judgment and non-reaction and these subscales were summed to produce a total mindfulness score. The questionnaire has been administered to students, meditators, non-meditators and highly educated population groups. In a non-meditating community sample the scale has a mean of 23.38 and a standard deviation of 6.26 and an internal consistency of alpha .72 to .92

(Baer et al., 2008). In this study it was predicted that the sample group mean score would be significantly higher than the mean of the community sample of 23.88.

Main Outcome Measures

Symptoms of Stress Inventory (SOSI; Leckie & Thompson, 1979*).* This is a 94-item questionnaire that uses a 5-point Likert-type scale to measure physical, psychological and behavioural responses to stressful situations. The questionnaire is divided into 12 subscales: peripheral manifestations, cardiopulmonary symptoms of arousal, upper respiratory symptoms, central-neurological symptoms, gastrointestinal symptoms, muscle tension, habitual patterns, depression, anxiety and fear, emotional irritability (anger) and cognitive disorganisation. The subscales were summed to report only the total symptoms of stress (SOS) score and the measure was used to assess the effects of MBSR training on the experience of stress. It was predicted that SOS would decrease significantly as mindfulness increased. The questionnaire has been administered in clinical and non-clinical populations and has sound test-retest reliability (r = .83) and internal consistency (alpha = .97). The total scale mean in a non-clinical population is .86 with a standard deviation of .66. In this study it was predicted that the sample group mean score on the SOSI would be lower than the non-clinical population mean of .86.

Profile of Mood States (POMS; McNair et al., 1971*).* This is a 65-item questionnaire that uses a 5-point Likert-type scale to assess six affective dimensions: tension, depression, anger-hostility, vigor, fatigue and confusion-bewilderment. Together these yield a measure of Total Mood Disturbance (TMD). The questionnaire is predominantly used to assess mood changes resulting from interventions and has been widely administered in clinical and non-clinical populations with sound test-retest reliability (r = .65 to .74) and internal consistency (alpha = .90 and above). In this study it was predicted that the sample group mean score on the POMS would be lower than 73.05, the normal population mean of the sample in Study Two (*N* = 112).

Table 10

Study Three Participant Demographics

Characteristics	Details	Treatment Group (*N* = 10)	Population Norms	*t* statistic	p-level
Gender	Female	3	-	-	-
	Male	7			
Age in years	*M(SD)*	41 (6.9)	-	-	-
	Range	35 – 55			
Years of education	*M(SD)*	16.81 (2.1)	-	-	-
	Range	12 – 19			
Mindfulness	*M(SD)*	29.02 (4.2)	23.38 (6.26)	3.62	.006
(FFMQ)	Range	26.2 – 32.4	-		
Symptoms of stress	*M(SD)*	.63 (0.73)	.86 (0.66)	-1.57	.15
(SOSI)	Range	.0 – 1.6	-		
Mood disturbance	*M(SD)*	59.5 (18)	73.05 (31.95)	-2.38	.04
(POMS)	Range	30 – 93	-		

Procedure

All participants were screened by a radiographer to ensure that the MRI procedure would be safe for them. In addition, an audio recording of the sound produced by the scanner was distributed to participants two weeks prior to their scanning sessions, in order for them to practice to reach their meditation state with the noise interference. Each participant was run through the experimental procedure, which lasted approximately one hour. Before entering the scanner, participants completed the abovementioned questionnaires and were given a full verbal and written description of the imaging procedure.

Meditation Protocol

The functional scanning session commenced with a 2-minute control task, characterised by the random generation of numbers. The purpose of this task was to induce focused-attention to contrast against the meditation state, which was characterised by open awareness. Subjects where then signalled to perform a 12-minute mindfulness meditation in which they were requested to open awareness to

present-moment bodily sensations, thoughts and emotions without judging or reacting to these mental and physical events. The meditation period was followed by a second 2-minute control task of the same description as the first.

While the mindfulness practitioners required a minimum of 12-minutes for the mindfulness meditation, the meditation block was divided into three 4-minute blocks for region-of-interest (ROI) analyses, to offset the possible effects of (a) BOLD signal drift, (b) movement artefacts and (c), the effects of alteration in respiration patterns.

Functional MRI Data Acquisition

Scans were acquired using a 3T Allegra MRI scanner (Siemens Medical Systems, Erlangen, Germany). High-resolution anatomical images were acquired in the sagittal plane using a three-dimensional inversion recovery gradient echo sequence (160 slices, TR = 2300 ms, TE = 3.93 ms, TI = 1100 ms, resolution 1.3 x 1 x 1 mm^3, 256 mm FOV). During the fMRI protocol 484 functional volumes sensitive to blood oxygen level dependent contrast were acquired with a T2*-weighted gradient echo, echo planar imaging sequence (TR = 2000 ms, TE = 30 ms, 34 interleaved slices, 3 mm thick, gap 0.9 mm, matrix size 64 x 64, resolution 3.125 x 3.125 x 3 mm^3). During the first two minutes (60 volumes) of scanning subjects were instructed to undertake the first control and then cued by a beep to perform the 12-minute meditation (360 volumes). A second beep signalled the final 2-minute (60 volumes) control task.

Data Analysis

All fMRI analyses were performed using Brain Voyager QX (Brain Innovation, Maastricht, The Netherlands). Four dummy images in each run were excluded from all analyses. Images were motion corrected relative to the first volume with trilinear estimation and interpolation. Images were corrected for different slice acquisition

times and linear trends, spatially smoothed using a Gaussian filter (FWHM 4 mm), and temporally smoothed with a high pass filter of 3 cycles/point. One data set, belonging to a 33-year old male, exceeded movement criteria 3mm displacement, 3.0º rotation within a functional run and was rejected, leaving a total of nine participant functional scans. Each subject's functional data were co-registered to his/her high-resolution anatomical MRI, rotated into the AC-PC plane and normalized to Talairach space using a linear transform calculated on the anatomical images. The 3.125 x 3.125 x 3 mm^3 fMRI voxels were interpolated during Talairach normalization to 3x3x3mm^3.

Whole-brain group analysis: A primary analysis was performed with a fixed-effect analysis of variance using the general linear model with one predictor for mindfulness meditation convolved by the standard hemodynamic function. The six motion correction parameters were added as predictors of no interest. Activations during mindfulness meditation were examined by comparing activations during the meditation block with the control task (before and after meditation). The whole-brain analysis was repeated with three predictors, one for each 4-minute period (120 volumes) of the 12-minute meditation, convolved by the standard hemodynamic function and six motion correction parameters as predictors of no interest. An examination comparing brain activation patterns during each of the three meditation periods to the two control tasks was conducted in an attempt to reduce the potential effects of signal drift, movement artifacts and alterations in respiration over the 12-minute period, on BOLD signal. These analyses produced no significant differences to results obtained using a single predictor for the entire meditation block. The voxelwise threshold was set to $p < 0.001$ (voxel-wise Bonferroni corrected for whole-brain multiple comparisons, min t statistic 7.6). Clusters are reported if their extent is greater than 200 contiguous voxels, where the voxel size refers to the 1x1x1 mm^3 resolution of the iso-voxeled structural images.

Region of interest (ROI) analysis: ROI analyses were performed for all clusters

that were identified in the whole-brain analysis to further interrogate signal changes over time during meditation. For this analysis, the 12-minute meditation block was divided into three periods of four minutes each. Random effects analysis of variance was performed of the average signal in each cluster for each participant using the general linear model with three predictors, one for each 4-minute period (120 volumes) of the 12-minute meditation, convolved by the standard hemodynamic function and six motion correction parameters as predictors of no interest. The beta values are a measure of the percentage signal change during a particular period of meditation compared to the control task.

Linear regression analyses were conducted to test for linear trends in the relationships between the beta values across the three meditations for each region. These analyses were performed to identify whether signal changes in these regions intensified during the course of the meditation. It was hypothesized that the signal changes would intensify during the meditation in all regions identified in the whole-brain analysis. This assumption was in line with practitioner reports that the experience of mindfulness intensifies as the meditation progresses and would serves to confirm the involvement of the functionally defined regions identified.

RESULTS

Sample Group Demographics

It was confirmed that the sample group presented with a significantly higher level of mindfulness than the reported population mean of 23.88 ($t(9) = 3.62$, $p = .006$) and also presented with a significantly lower level of TMD than the population mean of Study Two ($t(9) = -2.38$, $p = .04$). Although the mean SOS score for the sample group was lower than the reported population norm of .83, the difference was non significant.

Whole-Brain Analysis

Consistent with self-reports from mindfulness practitioners, which note experiences of reduced self-focus during mindfulness meditation, pronounced decreases in activity were observed during state mindfulness in midline cortical structures associated with interoception (Kabat-Zinn, 1994). These structures have been graphically depicted and tabulated in Figure 9 and Table 11, respectively. They include the right and left anterior insula, left ventral anterior cingulate cortex, right prefrontal cortex and the right and left precuneus. A significant signal increase was also noted in the right posterior cingulate cortex, which may suggest inhibition in the area given that signal increase can be indicative of increased neuronal inhibition (Ritter & Villringer, 2002). This interpretation may be supported not only in its consistency with the remaining findings but also be due to the fact that autobiographical memory recall, a function associated with the posterior cingulate cortex, is inhibited in mindfulness meditation in favour of maintaining focus on the present moment.

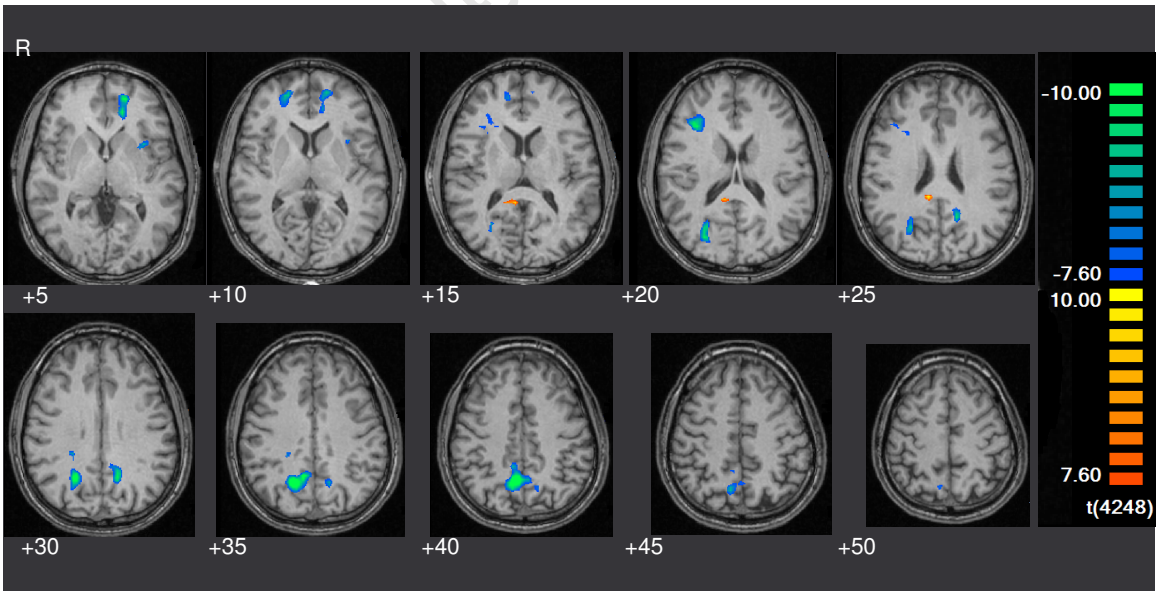


Figure 9. Signal Changes Associated with Mindfulness Meditation

Table 11

Clusters Showing Decreased and Increased Activity during Mindfulness Meditation

Region	Brodmann area	Talairach coordinates (mm) Mean x	Mean y	Mean z	Voxels	Max *t*
Frontal						
Left ventral ACC	24	-15	45	5.9	1663	-10.98***
Right PFC	46	19	48	11	612	-9.36***
Insula						
Right anterior INS	14	33	25	20	1460	-10.18***
Left middle/ anterior INS	14	-36	12	3.7	388	-9.36***
Parietal						
Left PCu	7	-14	-57	31	1230	-12.06***
Right PCu	7	14	-61	34	5680	-12.61***
Right posterior TL		24	-37	32	207	-10.59***
Right PCC	23	9.1	-41	20	403	10.87***

Note. ACC, anterior cingulate cortex; PFC prefrontal cortex; INS, insula; PCC, posterior cingulate cortex; PCu, precuneus; TL, temporal lobe
* p < .05, ** p < .01, *** p < .001

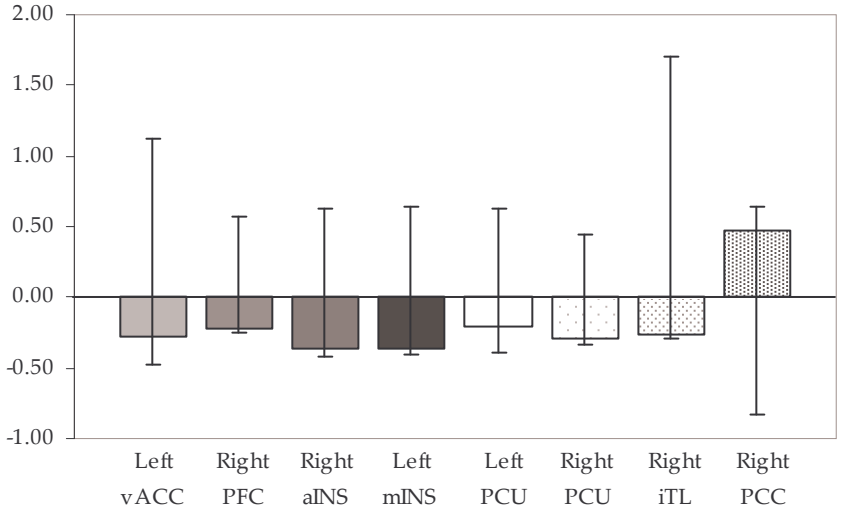


Figure 10. Regional Signal Changes in the Meditation Compared to Control (where the control signal is 0).

Region of Interest (ROI) Analyses

In each of the regions identified in the whole-brain analysis, the beta values were averaged across participants for each of the three meditation periods. The relationship between these values and the meditation periods were analysed using linear regression, to establish whether these signal changes increased (and decreased in the case of the right posterior cingulate cortex) over the 12-minute meditation period. The regression results are presented in Table 12.

Linear trends were noted in all of the regions and in the expected directions (except for the left ventral anterior cingulate cortex where signal changes decreased during the meditation). The regression coefficients for these linear trends, however, were non significant. The linear regressions for each region are depicted in Figure 10.

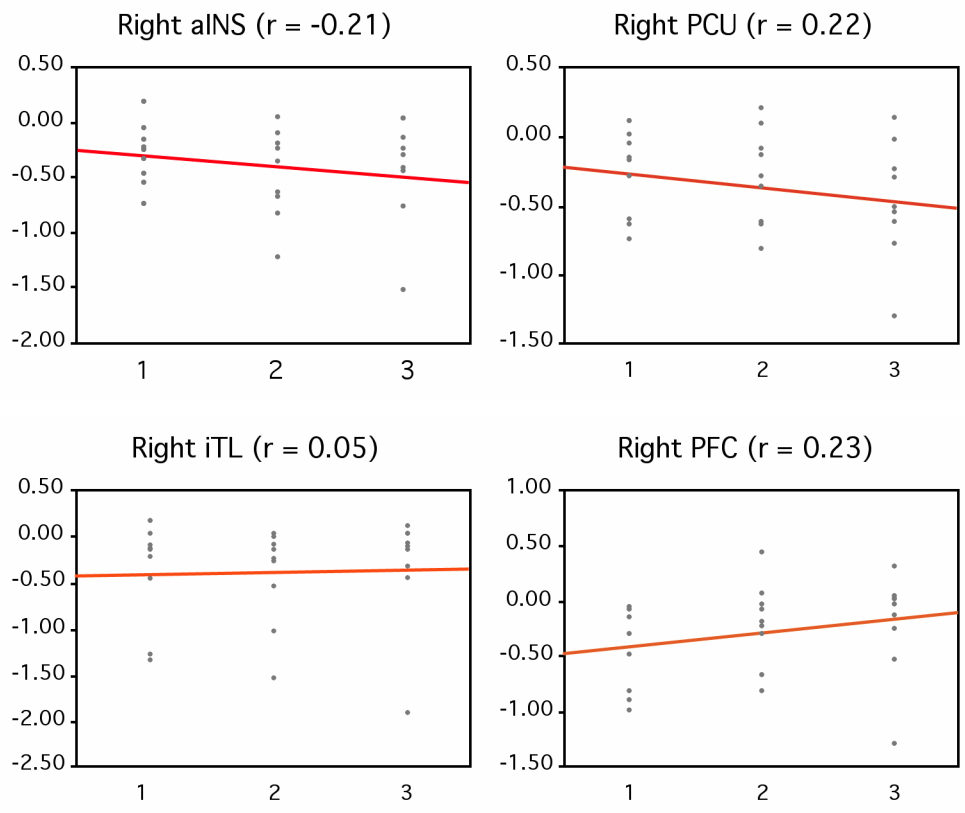
Interestingly, the four participants involved in mindfulness training on a daily basis showed the most consistent signal changes in all the functionally defined regions. The relationships between the signal changes in each brain region of each of the nine participants, are graphically depicted in Appendix E (the data series for each of the four participants mentioned above are highlighted in red). It is also apparent from these graphs that percentage signal change was relatively consistent between subjects and over time, adding further support the role of these regions in state mindfulness.

Table 12

Linear Regression of Percentage Signal Changes during Mindfulness Meditation

	Mediation		
Region of Interest	**R^2**	**R**	**p-level**
Frontal			
Left ventral ACC	0.0004	0.02	0.92
Right PFC	0.05	0.23	0.24
Insula			
Right anterior insula	0.05	-0.21	0.28
Left middle insula	0.03	-0.17	0.40
Parietal			
Left PCu	0.01	-0.09	0.68
Right PCu	0.05	0.22	0.28
Right posterior TL	0.03	0.05	0.81
Right PCC	0.01	0.11	0.58

Note. PCC, posterior cingulate cortex; PCu, precuneus



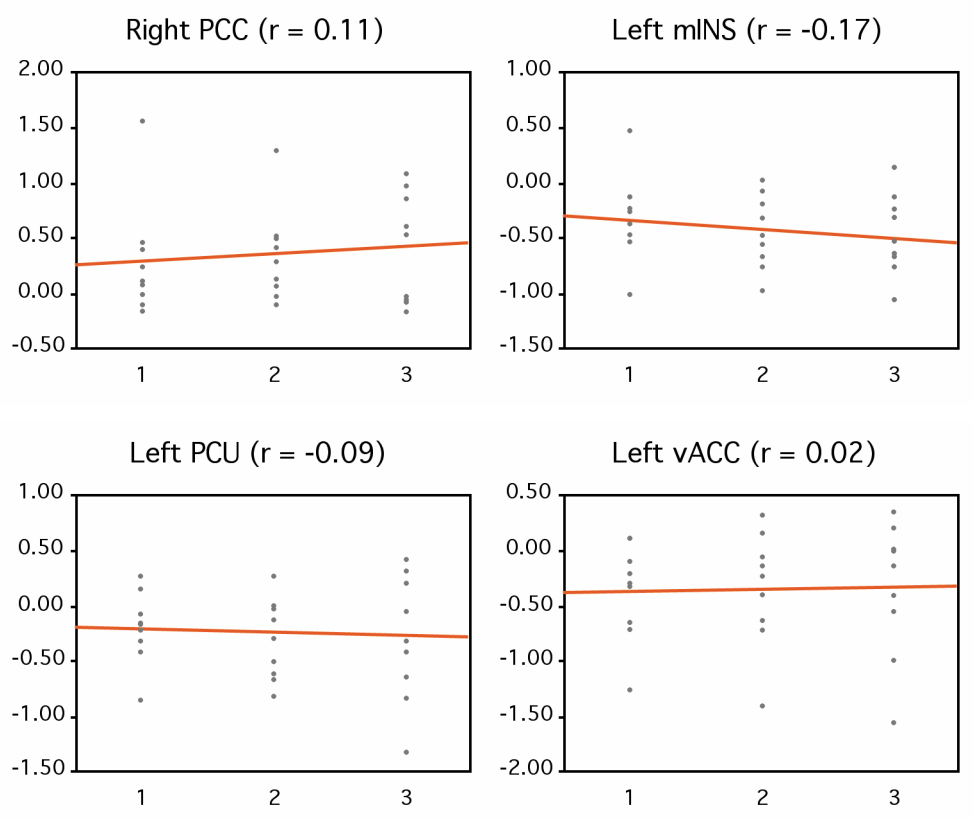


Figure 11. Percent Signal Change Averaged Across Participants in ROI Shown as a Function of Time of Mindfulness Meditation

DISCUSSION

The brain regions identified in this study have all been implicated in processes of self-referential thought and the attribution of subjective significance to emotions. The insula plays a key role in the experience of emotion by processing convergent information to produce an emotionally relevant context for sensory experience (Jabbi, Bastiaansen, & Keysers, 2008). Damasio (1999) first identified this brain region as a critical component of the proto-self: The posterior region mapping bodily sensations and the anterior region recasting these sensations as social emotions (Damasio, 1999). In later research, activity in the anterior region of the insula was further associated with affective autobiographical recall and related subjective emotional experience (Damasio et al., 2000), awareness of the feelings of

others (Jabbi et al., 2007), and most importantly, in the generation of social emotions (Gray, Harrison, Wiens, & Critchley, 2007). These findings are supported by theories that emotional processing occurs in a hierarchical manner with basic emotions generated at a phenomenological level through the integration of physiological arousal and valence, and secondary, or social emotions, generated at an appraisal level through the cognitive representation of bodily states (Russell, 2003).

Based on this functional anatomy, it is suggested that the significant signal decreases noted in the anterior insula in this study may reflect an interruption in the subjective appraisal of bodily sensations that produce 'higher' emotions, or social emotions. In other words, mindfulness meditation is suggested to apprehend the subjective appraisal of bodily sensations and so inhibit the arising social emotions. This interpretation of the signal decreases in this region is consistent with the increased sensitivity to bodily events described by practitioners during mindfulness meditation (posterior insula), but the lack of judgment regarding these events (anterior insula).

Interestingly, lesions to the right anterior insula have been shown to result in significant reductions in addictive behaviour (Naqvi, Rudrauf, Damasio, & Bechara, 2007) and less intense emotional reactivity (Gray et al., 2007). Moderation of insula activity is also associated with reduced emotional susceptibility (Iaria et al., 2007). These findings may highlight a mechanism through which mindfulness fosters psychological health.

The role of the anterior cingulate cortex in the processing of emotion has been well-established and the region may be considered an interface between emotion and cognition (e.g. Allman, Hakeem, Erwin, Nimchinsky, & Hof, 2001; Casey et al., 2002; Damasio, 1999; Lane et al., 1998). While the anterior, posterior and dorsal areas of this region have shown to be associated with executive, evaluative and cognitive functions respectively, the ventral area plays a central role in emotion

(Casey et al., 2002) and in particular, conditioned responses to emotion (Bush et al., 2000). In lesion studies it has been shown that damage to the anterior cingulate cortex results in reduced emotionality (Cohen et al., 1999) whereas over-activation of the region has been shown to be associated with a number of psychiatric disorders (Allman et al., 2001).

Based on this functional anatomy, signal decreases in the anterior cingulate cortex noted during mindfulness meditation are suggested to indicate improved cognitive flexibility, with particular reference to the role of unchecked emotions in this process. This lends support to the finding in Study Two that cognitive flexibility is a mechanism of mindfulness and it has already been outlined in previous chapters that mindlessness is associated with conditioned responses whereas mindfulness is associated with improved cognitive flexibility, a skill that facilitate adaptive responding to situations.

The prefrontal cortex plays is critical role in executive functioning and metacognition and reduced activity in this region has been associated with reduced narrative self-focus (Beauregard et al., 2001; Farb et al., 2007). Together with the signal decrease in the precuneus, which plays a role in first-person perspective taking (Cavanna & Trimble, 2006), this pattern may signify a more open and accepting orientation to momentary experiences, another defining feature of mindfulness. In line with this interpretation, it is also suggested that significant neuronal activity in posterior cingulate cortex, which signifies autobiographical memory recall (Ryan et al., 2001), signals increased inhibition of the region as opposed to increased activation, which supports the fact that participants remained focused to the present-moment without contemplating on past (or future) events, an express aim of the practice.

Relating the Results to Previous Studies

It is of interest to note that, in the present study, signal decrease was noted in the

insula during mindfulness meditation, but in the study by Farb and colleagues (2007), this region showed signal increase during experiential focused tasks (related to momentary self-reference) compared to narrative focused tasks (related to extended self-reference) in individuals trained in mindfulness. The discrepancy may however be a result of the different tasks conducted during functional imaging in the studies. In the study by Farb and colleagues (2007), participants were required to engage in self-referential thought, which by definition, is an exercise calling for subjectivity. Based on what has been described about the insula in this discussion, and in particular its role in subjective emotional experience, this region could be expected to be recruited in self-referential thought, whether narrative or experientially focused. In this study, and in contrast, participants were asked to practice mindfulness meditation without engaging in any specific cognitive task in order to isolate mindfulness itself. In the present study, mindfulness was shown to apprehend subjectivity.

In the only other functional imaging study of mindfulness meditation versus a resting state, signal increase was reported in frontal, temporal and parietal regions of the brain during the onset of meditation (45 seconds) compared to a rest state (the activities of the rest state were unspecified) (Baerentsen, 2001). Signal decreases were also noted in the visual cortex. The brief meditation period scanned in Baerentsen's study, however, makes the findings difficult to compare to those of the present study – Baerentsen's study captured the neural regions engaged at the *onset* of the meditation as opposed to those related to a more prolonged mindfulness meditation. As stipulated in the aims of the method section of this study, practitioners typically require a more extended period of meditation to achieve a state of mindfulness.

The findings of the ROI analyses provided further support for the fact that functionally defined regions in the whole-brain analysis were involved in state mindfulness because they showed the predicted linear increases and decreases in

signal change during the course of the 12-minute meditation (with the exception of signal changes in the ventral anterior cingulate cortex). Although these relationships were non significant, it is possible that statistical significance may be achieved in a larger sample group. Although the intensity of the signal decreases in the ventral anterior cingulate cortex decreased during the course of the 12-minute meditation, as opposed to increased, this is an informative finding in itself. The finding may suggest that as state mindfulness intensifies so the cognitive evaluation of arising emotions lessens. In other words, as the meditation practice progresses so does the attenuation of cognitive activity in relation to emotions.

The ROI analyses also revealed that the four participants in the sample group involved in mindfulness training on daily basis, showed the most consistent patterns of signal changes in the functionally defined regions (Appendix E), which further supports the functional role of the regions identified in the whole-brain analysis.

In Conclusion

The findings of this study show that mindfulness meditation has an overall 'quietening' effect on brain regions associated with subjective and cognitive appraisal of emotions. As a result, the findings lend some support for a theory suggesting that an overarching mechanism of mindfulness is *disidentification* (Martin, 1997). Disidentification can be described as a process that arrests any permanent sense of self and suspends related habitual thoughts and behavioural patterns and momentary events/ thoughts are merely registered, without ensuing judgment or cognitive elaboration. Through disidentification, practitioners are open to consider thoughts and feelings as nothing more than transitory mental events that are separate from the self. Moreover, it may be suggested that the two mechanisms of mindfulness identified in Study Two, acceptance and cognitive flexibility, may be outcomes of disidentification.

Interestingly, activity in several of the midline cortical structures highlighted in this research, is indicative of the default state of resting attention (Gusnard, Akbudak, Shulman, & Raichle, 2001). Resting attention is defined as a state in which the environment is continually being surveyed and events are assessed in relation to their impact on self to maximize the potential for survival. In contrast, overactivity in several of the midline cortical structures identified in this study, and associated with interoception, has been linked to neuroticism (Critchley, Wiens, Rotshtein, Öhman, & Dolan, 2004; Eisenberger, Lieberman, & Satpute, 2005). In this regard, mindfulness may be seen as the converse of anxiety, a 'letting-go' of cognitive elaboration and catastrophising, which may additionally free up attentional reserves to persistently refocus on unfolding events. This notion is additionally supported by research that has shown mindfulness training to bring about symptom reduction in anxiety disorders (Astin, 1997; Miller et al., 1995; Roemer et al., 2006).

By refraining from subjective appraisal, as evident here in the form of decreased activity in associated brain regions, mindfulness may indeed afford a less personally biased experience of each passing moment, consistent with practitioner reports and the outcomes associated with mindfulness practices described by Eastern philosophers as *bare attention*. Based on the findings of this study, state mindfulness is proposed to be a unique form of higher-order information processing in which subjective assessment of transient events is silenced in favour of maintaining objectivity and to gain insight into the nature of emotion.

Cahn & Polich (2003) recently noted that no studies have yet isolated or characterised the neurophysiology that make explicit how meditation induces altered experiences of the self. The results of this study offer a preview of that process. To overcome some of the limitations of this study, future research should apply comparable methods but use longitudinal designs, in which participants are scanned before and after mindfulness training. Such a design could demonstrate

how patterns of brain activity change over time and in response to mindfulness training. It would also be informative to investigate the capacity for mindfulness in patients with functional deficits in the regions identified in this study. Lastly, comparing the neural activation and deactivation patterns associated with present-moment awareness in experienced meditators versus non-mediators would also be helpful to validate the findings of this study.

STUDY FOUR: MINDFULNESS AND THE DAMAGED BRAIN

With exploration of the neural substrates of mindfulness in its infancy, findings that have emerged from neuroscience studies employing neuroimaging and neuroelectric techniques are largely inconsistent. This pilot study aimed to resolve some of these discrepant findings and contribute to the current body of knowledge regarding the neural basis of mindfulness. Brain-lesion studies using clinical-anatomical correlation methods are well placed to complement functional imaging findings in that they provide an expose of how the performance of a cognitive, or mental, task is affected in patients with damage to related brain regions. The converse is also true and brain-lesion studies stand to inform functional imaging research. With good reason then, a comprehensive analysis is made possible when both of these techniques are used to explore the neural substrates of a mental state.

Several studies have been conducted to investigate the neural correlates of mindfulness but no brain-lesion studies have yet been undertaken to corroborate their findings. Studies using EEG methods to explore mindfulness meditation in advanced practitioners have shown increased alpha amplitude and alpha activity spreading frontally, decreased alpha frequency (Kasamatsu & Hirai, 1966) and increased theta coherence and temporal gamma coherence (Farber et al., 2004). Studies of meditation in novice practitioners have reported increased frontal alpha coherence (Murata et al., 2004) and increased frontal theta and low alpha power (Takahashi et al., 2005). In an EEG study investigating the effects of MBSR training on trait mindfulness, findings revealed significantly increased left frontal activation after an 8-week intervention, a pattern associated with positive affect (Davidson at al., 2003). To sum, power increases in theta and alpha bands and overall frequency

slowing appear reliable across investigations.

Briefly revisiting the body of functional imaging research on mindfulness meditation outlined in the previous chapter, signal increases in the dorsolateral prefrontal cortex and anterior cingulate cortex have been observed in more than one investigation (Baerentsen, 2001; Lazar et al., 2003; Creswell et al., 2007; Farb et al., 2007). The functional imaging study in this thesis failed to substantiate these findings and reported significant signal *decreases* in these and other midline cortical structures: right and left insula, left ventral anterior cingulate cortex, right prefrontal cortex and the right and left precuneus, with significant signal increase noted in the right posterior cingulate cortex.

This brain-lesion study was informed by the current body of literature on the neural correlates of mindfulness meditation cited above, and also stood to test some of the related findings, but its primary aim was to test the findings of Study Three in this thesis. Fortuitously consensual findings in the current body of literature, and in Study Three, reported the recruitment of prefrontal and anterior cingulate cortices in mindfulness; the critical exception being that studies in the current body of literature reported signal *increases* in these regions and Study Three reported signal *decreases*. Therefore to support the findings of the imaging study of this thesis, patients with damage to the identified midline cortical structures were expected to yield *higher* levels of mindfulness compared to control subjects, because damage to those regions was expected to translate in reduced function.

One important point should be raised regarding the problems inherent in the interpretation of signal *increase* in functional imaging. Signal increase does not discriminate between increased neuronal excitation or increased neuronal inhibition. In other words signal increase may indicate increased functional *activity* or increased functional *inhibition* because excitatory and inhibitory synaptic activities are both associated with increased metabolic demands, which both stimulate magnetic signal through the increased presence of regional oxygenated

blood (Ritter & Villringer, 2002). This means that concluding increased activation of brain regions during a cognitive task, based on signal increases in these regions, rests on the assumption that this signal increase is associated with increased activity and not with increased inhibition. An assumption of this kind is mostly informed by existing knowledge of not only the functional anatomy of the brain regions but also the nature of the cognitive task under study. This is an important consideration in the study of meditation because meditation techniques typically require the inhibition of thought processes. Specifically in the case of mindfulness meditation, a practitioner is required to *inhibit* cognitive elaboration and memory recall in favour of continually returning attention to the present moment. Logically, the more inexperienced the practitioner, the more such active inhibition is required to 'still' a wandering mind.

The discrepancy between increased excitation and inhibition may challenge some of the interpretations of findings from previous functional imaging studies of mindfulness meditation, which have almost all concluded functional activity of regions showing signal increase. Studying the impact of brain damage to areas identified in imaging studies on mindfulness, as the current study aimed to do, may resolve this uncertainty and possibly even urge the reconsideration of such interpretations.

METHODS

Study Design

This study was designed as a brain-lesion investigation and used clinical-anatomical correlation methods to test whether damage to the brain regions identified in Study Three, showing decreased activity during mindfulness meditation, would produce significantly increased levels of mindfulness compared to the mindfulness levels of a control group. Levels of mindfulness were tested in

six patients with stroke damage of a comparable extent. Four of these patients sustained damage to the midline cortical structures identified in Study Three: two to anterior cortical midline regions as a consequence of anterior cerebral artery (ACA) stroke damage, and two to posterior cortical midline regions as a consequence of posterior cerebral artery (PCA) stroke damage.

The mindfulness levels of these patients were compared with those of two control subjects who sustained brain damage resulting from middle cerebral artery (MCA) stroke (i.e., damage to regions other than those identified in Study Three).

Participants

Six patients (3 females and 3 males), ranging in age from 52 to 70 (M = 63.83; SD = 6.43) were recruited from a private specialist neurology practice at Gatesville Hospital in the Western Cape. Two of these patients had sustained damage to the prefrontal cortex and/or anterior cingulate cortex resulting from ACA stroke (referred to as the ACA group) and two had sustained damage to the posterior cingulate cortex and/or precuneus resulting from PCA stroke (referred to as the PCA group).

The control group included two patients with MCA stroke damage to the left temporal and temporal/parietal lobes (referred to as the MCA group). All patients in the study were tested at least two months after brain injury, following the initial critical recovery period. The mean time from the date of stroke to the date of testing in this sample group was 11 months. There were no reported premorbid psychiatric disorders or substance abuse in the sample group. Patient demographics are outlined in Table 12 and CT or MRI brain scans are depicted in Figure 11.

Instruments and Tests

Psychological Questionnaires

Five-Facet Mindfulness Questionnaire (FFMQ; Baer et al., 2006*)*. This is a 39-

item questionnaire that uses a 5-point Likert-type scale to measure mindfulness according to a 5-factor model of the construct. The five factors are observe, describe, act with awareness, non-judgment and non-reaction and these subscales were summed to produce a total mindfulness score. In a non-meditating community sample the scale has a mean of 23.38 and a standard deviation of 6.26 and an internal consistency of alpha .72 to .92 (Baer et al., 2008).

Profile of Mood States (POMS; McNair et al., 1971*).* The POMS is a 65-item questionnaire that uses a 5-point Likert-type scale to assess six affective dimensions (tension, depression, anger-hostility, vigor, fatigue and confusion-bewilderment). Together these subscales yield a measure of Total Mood Disturbance (TMD). The questionnaire has a sound test-retest reliability (r = .65 to .74) and internal consistency (alpha = .90 and above).

Neuropsychological Screening Instruments

Orientation – Mini-Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975*).* The Orientation test is a subset of the MMSE, which is a simplified scored form of the cognitive mental status examination. In this test subjects are asked questions regarding time (date, day, month, year and season) and place (state, town, country, hospital and ward number or floor). One point is awarded for each correct answer to yield a possible 10-point total. This test is widely administered in neuropsychological assessment as a measure of orientation to person, place and time.

Digit Span Task – Wechsler Adult Intelligence Scale (WAIS; Wechsler, 1955*).*
The Digit Span Task is a subset of the WAIS and is used to assess working memory. The test has two components, a digit span forward (DS-F) and a digit span backward (DS-B). An examiner verbally presents digits at a rate of one per second

and at the end of the sequence subjects are asked to repeat these digits, either verbatim in the case of the DS-F, or in reverse order in the case of the DS-B. The number of digits increases by one until a subject consecutively fails two trials of the same digit span length. The average DS-F for normal adults is 6-7 and the average DS-B is 3-4 (Wechsler, 1981).

Serial 7's – Mini-Mental State Examination (MMSE; Folstein et al., 1975*).* The Serial 7's is a subset of the MMSE and a test of attention and concentration. Subjects are asked to either count backward from 100 in serials of seven [93, 86, 79, 72, 65], or spell 'world' backwards [D-L-R-O-W]. One point is awarded for each correct answer and the examiner stops after five answers are provided.

Babcock Story Recall Test (BSRT; Babcock & Levy, 1940*).* The BSRT is a 21-unit story assessing verbal memory skills. Subjects are read a brief story which they are asked to recall on two occasions, once immediately following the reading and once again after a 20-minute delay. Scores range between 0 and 21 and published norms are 9.2 for immediate recall and 7.2 for delayed recall (Lezak, 1995).

Proverbs Test – Delis-Kaplan Executive Function Scale (D-KEFS; Delis, Kaplan, & Kramer, 2001*).* The D-KEFS is a broad assessment of executive functioning including several tests, one of which is the Proverbs Test. This test assesses the ability to think abstractly and consists of five common and three uncommon proverbs that subjects are required to interpret. Two scores are obtained for each proverb interpretation: one for accuracy (0-2) and one for abstraction (0 or 2). These scores are added to yield a total achievement score which may vary between 0 and 32.

Procedure

Participants were assessed in individual sessions lasting approximately 30 minutes. They were informed of the study and its aims and asked to provide written consent to take part. The consent form is attached in Appendix C. A brief history was taken from each subject followed by the administration of the neuropsychological test battery. This set of neuropsychological tests was selected to ensure that the groups were comparable in terms of general executive functioning and therefore offset the possibility that mindfulness levels would be compromised by related functional deficits. Mindfulness, as discussed in previous chapters, engages metacognitive skills and, as such, deficits in executive functioning would be likely to comprise not only the ability to answer the questionnaires accurately, but also levels of mindfulness.

Predictions

The orientation test was conducted to ensure that all groups would be comparable in terms of general orientation, which would otherwise impact significantly on their mindfulness scores. It was also important to establish that all groups would be comparable in both DS-F and DS-B, and on the BSRT to ensure there were no disorders of working memory and verbal memory. It was also predicted in this study, that the groups would show no significant differences in attention and concentration (Serial 7s), and no differences in general abstract reasoning (Proverbs Test).

The POMS and FFMQ surveys were administered following the neuropsychological tests. It was predicted that the groups would be comparable on the affect scale (POMS) but that the mindfulness levels of the ACA group and PCA group would be higher than those of the MCA group.

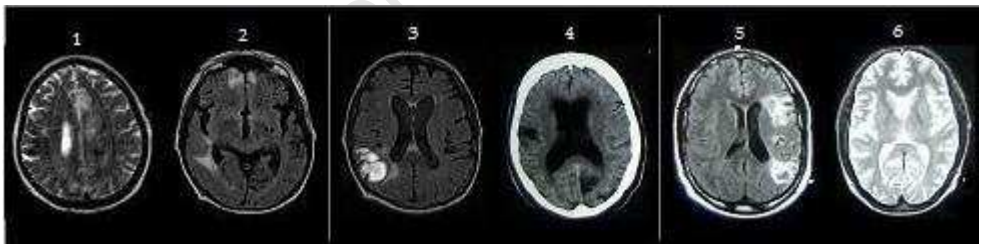
RESULTS

Nonparametric statistics were used to analyse whether any significant differences emerged between the three groups on all tests and questionnaires. In addition to this, participant raw scores, and group means, are tabulated in Table 14 to evaluate at face-value. To reiterate, this was a pilot study to determine whether further brain-lesion investigations may be warranted.

Table 13

Study Four Patient Demographics

Subject	Stroke Damage	Laterality	Years of Education	Sex	Age	Time from insult to testing	Handedness
1	ACA	Left	10	F	67	4 months	R
2	ACA (prior PCA)	Bilateral	11	M	70	7 months	R
3	PCA	Bilateral	10	F	63	18 months	R
4	PCA	Right	10	F	68	16 months	R
5	MCA	Left	10	M	52	93 months	R
6	MCA	Left	10	M	63	8 months	R



Note. 1-2 = ACA stroke subjects; 3-4 = PCA stroke subjects; 5-6 = MCA stroke subjects.

Figure 12. Study Four Patient Scans

Cognitive and Affective Group Comparisons

The Kruskal-Wallis one-way analysis of variance confirmed that there were no significant difference between the groups in terms of their cognitive profiles with no

significant difference in mean scores of Orientation, DS-F and DS-B, BSRT, Serial 7's, and Proverbs Test. The PCA group did however present with a significantly higher TMD.

Table 14

Cognitive and Affective Raw Scores and Group Means and Standard Deviations

Subject	Orient.	DS-F	DS-B	BSRT#1	BSRT#2	S7's	Proverbs	TMD
1	9	5	3	4	5	5	16	21
2	9	7	4	6	6	4	24	29
ACA mean	9(0)	6(1.4)	3.5(.7)	5(1.4)	5.5(.7)	4.5(.7)	20(5.7)	25(5.7)
3	9	6	3	4	6	6	19	73
4	10	6	3	2	4	5	16	78
PCA mean	9.5(.7)	6(0)	3(0)	3(1.4)	5(1.4)	5.5(.7)	17.5(2.1)	75.5(3.5)*
5	9	5	4	3	4	6	14	48
6	9	5	3	4	4	3	12	40
MCA mean	9(0)	5(0)	3.5(.7)	3.5(.7)	4(0)	4.5(.7)	13(1.4)	44(5.7)

Note. Values are given as mean and (sd)
* p < .05, ** p < .01, *** p < .001

Mindfulness Group Comparisons

The Kruskal-Wallis one-way analysis of variance revealed that the groups failed to differ significantly in terms of their mindfulness levels ($H(2, N=6) = .074$, $p = .96$). Group means and standard deviations have also been graphically depicted in Figure 12.

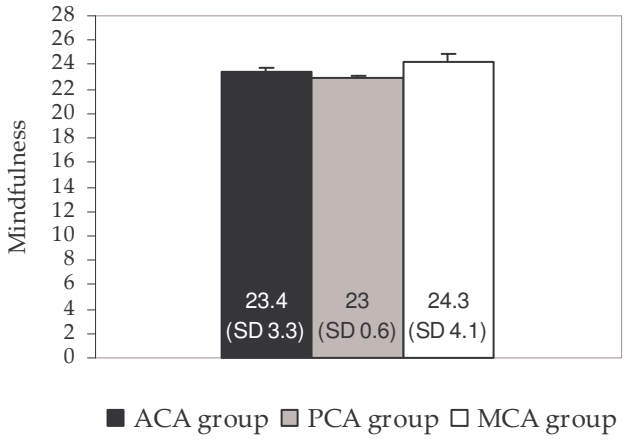


Figure 13. *Mindfulness Group Means and Standard Deviations*

DISCUSSION

The aim of this brain lesion-study was to test whether damage to the regions of the brain identified as having shown significant signal decreases during mindfulness meditation in functional MRI (Study Three), would result in increased levels of mindfulness. Explicitly, if these regions were under-active in a state of mindfulness, then damage compromising their functional integrity should result in elevated levels of mindfulness. From the results of this study, however, it was apparent that patients with sustained damage to the frontal and parietal regions of the brain as a consequence of ACA and PCA stroke, showed no significant difference in their levels of mindfulness to the level of mindfulness in the control group. In fact the MCA group showed slightly higher levels of mindfulness than the ACA and PCA groups, all be the increase non significant. It is also evident that none of the groups differed significantly from general population norms for mindfulness ($t(5) = .15$, $p = .89$). It is possible, however, that a larger sample group may have produced significant differences in mindfulness to the normal population, because a larger sample would have increased the power of the statistical analysis.

This investigation was deigned as a pilot study to assess the merit of further investigation into the effects of damage to the brain on mindfulness. Although the results failed to support the findings of Study Three, the fact that the MCA groups, in other words the control group, achieved slightly higher levels of mindfulness that the ACA and PCA stroke groups, may warrant further investigation employing a larger sample group. That said, a major limitation of the present study, and the brain-lesion method itself, is the inability to assess the effects of damage to multiple brain regions simultaneously due to the challenge of findings such pathologies. Most cognitive or mental states recruit a network of brain regions and mindfulness appears to be no different, showing to quieten several midline cortical regions associated with interoception. This study was only able to report the effects of localised damage to some of regions identified as involved in mindfulness as opposed to the full network of regions highlighted in Study Three. This limitation would be likely to restrict even larger-scale brain-lesion investigations in the mechanisms of mindfulness.

CHAPTER FOUR

DISCUSSION

The evolution of society has brought us to a point in time where the growing quantification and dispersion of knowledge is dramatically altering the way we live. Increased access to information exposes us to the possibilities of achieving personal expression and fulfilment without depending on an immediate community. Individualism has flourished in this environment, and so have reciprocal innovations in technology, science and communication. But contemporary advancements have brought inevitable consequences. The quickened pace of life demands new levels of efficiency and the related pressure is escalating the prevalence of stress-related disorders: Multi-tasking is non-negotiable in this age of information and the inescapable barrage of incoming stimuli compromises our ability to attend with focus and clarity and reduces overall mental performance (Just et al., 2001; Kieras, Meyer, Ballas, & Lauber, 2000; Rubinstein, Meyer & Evans, 2001). In fact, attention deficit disorders have been described as the brain syndromes of today's information age (Restak, 2004).

Against the backdrop of these modern-day realities, the growing interest in mindfulness is both paradoxical and valuable. Arguably there is no other time in history that being in the moment has been more difficult and perhaps because of this, more helpful.

Research spanning over the last three decades has supported the application of mindfulness training to elevate stress tolerance and assist in the treatment of a

number of mental and physical disorders (Grossman et al., 2004). Based of the purported benefits, the application of mindfulness training has grown exponentially and continues to justify further study into the mental state's efficacy and mechanisms.

Along this line of enquiry, this thesis aimed to illustrate how mindfulness may bring about positive outcomes by investigating its cognitive and neural mechanisms. The research was conducted to understand more about the nature of mindfulness but also, more generally, to contribute to the understanding of optimal well-being. The series of investigations in this body of work explored the mechanisms through which mindfulness may operate by extracting from the literature, and then testing, the most commonly proposed cognitive mechanisms, which then informed neuroscientific investigations into the brain regions that subserve mindfulness.

THESIS FINDINGS

The majority of previous investigations into mindfulness have concentrated on the efficacy of mindfulness training in bringing about improved well-being, primarily in clinical population groups. The purpose of such research has been to validate the role of mindfulness training in the treatment of a number of disorders. Authors of such studies, as well as those of more theoretical studies aiming to define and elucidate the factor-structure of the mental state, have also proposed mechanisms through which mindfulness may achieve its positive outcomes. A number of authors have stated the need to study the mechanisms of mindfulness empirically (Baer et al., 2006; Davidson et al., 2003; Lazar et al., 2000; Shapiro et al., 2006).

In this thesis, a qualitative systematic analysis of the literature revealed that *self-regulation*, *exposure*, *cognitive flexibility* and *acceptance* were the four most commonly proposed mechanisms of mindfulness, either directly or thematically

implied, in a collection of 42 texts that met specified inclusion criteria. The empirical investigation that tested these cognitive mechanisms revealed that *acceptance* and *cognitive flexibility* significantly mediated the relationship between mindfulness and reduced stress, and that *acceptance*, mediated the relationship between mindfulness and affect.

Acceptance of events, whether mental, physical or those taking place in the outside world, has been noted as pivotal to the practice of mindfulness (Allen et al., 2006; Kabat-Zinn, 1994). Acceptance, or non-judgment as it is commonly referred to in the context of mindfulness, is considered a strategy to promote well-being by preventing attachment and aversion to objects. Attachment has been shown to promote efforts to manipulate or control events, relating to poor adaptability and poor overall psychological health (Wilson & Murrell, 2004). Aversion has been proposed to promote experiential avoidance, a behavioural style closely linked to neuroticism (Orsillo et al., 2004).

Cognitive flexibility is a metacognitive construct and a mental strategy characterised by efficiently and effectively responding to novel situations. This mechanism has been proposed to assist in improving the selection of appropriate ways of responding and accommodating new behavioural styles that are helpful in the regulation of emotion and stress (Bowen et al., 2006).

Acceptance and cognitive flexibility may both be considered metacognitions because they rely of higher-order mental processes. From a neuropsychological point of view, metacognition engages higher-order cortical structures in the brain, which are involved in planning and decision-making. In the neuroimaging study of this thesis, significant increases in neural activity were therefore expected in the prefrontal cortex, an area responsible for carrying out executive functioning. This prediction was further endorsed by previous functional imaging studies that showed increased activity in this region during a variety of meditation types (Baerentsen, 2001; Creswell et al., 2007; Farb et al., 2007; Ritske et al., 2003).

Contrary to these contradictions, a predominant picture of signal decrease was noted, not only in prefrontal regions but also in a number of other midline cortical and paralimbic regions associated with interoception. These regions included the ventral medial anterior cingulate cortex, prefrontal cortex, insula and precuneus. Signal increase was also noted in the posterior cingulate cortex. Based on what is understood about the functional anatomy of these regions, the findings may be interpreted as suggesting that mindfulness has a modulatory effect on the *evaluation* of the internal state of the body and the *subjective appraisal* of the arising emotions (Allman et al., 2001; Beauregard et al., 2001; Casey et al., 2002; Cavanna & Trimble, 2006; Damasio, 1999; Ryan et al., 2001).

The findings of the imaging study offer support for the theory that mindfulness achieves its positive health outcomes through a process of *disidentification*. To reiterate, disidentification is described as a process in which mental events are observed as disconnected from the self, or as mere transitory processes with no subjective significance (Martin, 1997). Through disidentification, emotions, and even other cognitive process, are consciously registered but the ensuing analytical elaboration regarding their subjective relevance is apprehended.

Although the brain-lesion study in this thesis was unable to offer supporting evidence for the functional imaging findings, it is presumed that mindfulness subdues the identified areas of the brain *collectively*, and the effect of damage to isolated regions fails to impact on overall mindfulness. Apart from making intuitive sense, this notion may be supported by the fact that a number of mental functions engage a distributed network of brain regions.

The Findings in Context of Current Theory

In considering the findings of the thesis studies collectively, there may appear to be discontinuities in the evidence. Specifically, while Study Two and Study Three offer some compelling results, they do offer quite different insights into the mechanisms

of mindfulness. Study Two provided supporting evidence for the mediating roles of acceptance and cognitive flexibility in the relationship between mindfulness and its outcomes, whereas Study Three showed that a total of eight brain regions were recruited in state mindfulness, some indirectly related to these two mechanisms (insula, anterior cingulate cortex and prefrontal cortex) and the others unrelated. However, when these results are evaluated against the backdrop of current theories, they serve to endorse elements of the proposed model of the mechanisms of mindfulness offered by Shapiro and colleagues (2006). The former model was used to guide the studies in this thesis at the theoretical level, as already mentioned in the preceding chapters, and to reiterate, the model hypothesizes that mindfulness achieves its positive outcomes by shifting perspective, in a process referred to as *reperceiving*. The authors consider reperceiving to be a meta-mechanism overarching more direct mechanisms that mediate the relationship between mindfulness and its outcomes, including *self-regulation*, *exposure*, *cognitive and behavioural flexibility* and *values clarification*.

The findings in this thesis support the idea that a meta-mechanism (disidentification) overarches more direct mechanisms (acceptance and cognitive flexibility). In relation to the former model, it is proposed here that disidentification may be considered the hallmark of the new perspective achieved through the process of reperceiving. This notion may be supported by the fact that Shapiro and her colleagues (2006) described reperceiving comparably to the psychological constructs *detachment*, *deautomisation* and *decentering*. Detachment is the expanding of attentional space and adopting a phenomenological attitude towards events to distance one self from them emotionally (Bohart, 1983), while deautomisation is the undoing of habitual cognitive and behavioural responses (Deikman, 1982), and decentering is described as stepping back from experience to view it more objectively (Safran & Segal, 1990). These concepts also share much in common with disidentification.

In addition the findings of Study Two in this thesis provide empirical evidence for the mediating role of one of the direct mechanisms proposed in the model presented by Shapiro and colleagues (2006), that being cognitive flexibility. It may be said then that the findings in the collection of studies in this thesis share a number of commonalities with the former model as well as offer some revisions, which are graphically illustrated in Figure 13 and 14.

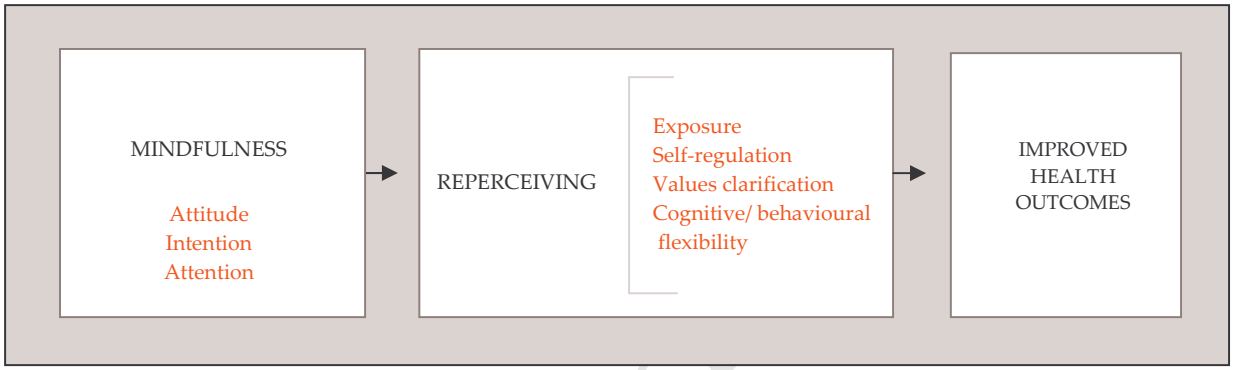


Figure 14. Theoretical Model of Mindfulness (Shapiro et al., 2006)

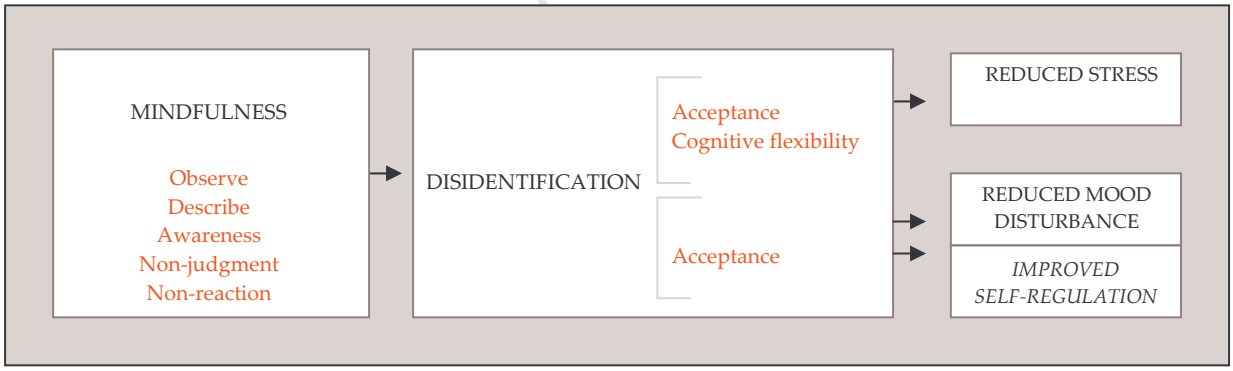


Figure 15. A Model of the Mechanisms of Mindfulness in the Current Thesis

In the above model presenting the relationship between mindfulness, its mechanisms and outcomes, the mental state is presented as multifaceted, embracing the factors: *observe, describe, act with awareness, non-judgment* and *non-reaction.* According to this model, mindfulness brings about improved health

outcomes through a process of *disidentification*, which acts through the more direct mechanisms: *acceptance* and *cognitive flexibility*. The model presents three distinct systems that together and sequentially contribute towards well-being. There is first the activities that guide the mindfulness practice, second, the states and cognitions that naturally evolve in response to these activities, and third, the outcomes that result from these states and cognitions. These three elements are represented by the three individual boxes in the diagram (Figure 14).

To illustrate the model by way of example: (1) Mindfulness practice involves (a) attending to the breath, which anchors the mind in the present moment, (b) noticing momentary physical and mental events as they arise (observe and describe) without judgment (non-judgment), and (c) letting these events pass without reaction (non-reaction). (2) In response to these activities perspective shifts (otherwise described as reperceiving) with the practitioner becoming an observer of passing events, watching them rise and fall without identifying with them (disidentification). This new perspective makes it easier to accept passing events because they are not considered to relate to the self and are therefore less threatening (acceptance). This new perspective also affords a less biased, more objective view of reality, fostering improved decision-making and behavioural responses (cognitive flexibility). (3) Mental states characterised by acceptance and cognitive flexibility result in reduced stress and mood disturbance, and enhanced self-regulation, which together, bring about improved mental well-being.

A DISCUSSION OF THE MODEL

Disidentification and Health

In this discussion, supported by the research findings in this thesis, mindfulness is

suggested to achieve its positive outcomes through the process of disidentification, which endorses acceptance and cognitive flexibility. It would stand to reason then that the process of disidentification, which may also be understood as objectification, fosters improved mental health.

In an expose of the effect of mindfulness on the brain and mental health, Schwartz and Begley (2003) described mindfulness as a state of consciousness arising as a result of mental force that directs and focuses attention and sets the stage for the quality of feelings towards the contents of consciousness[4]. Schwartz used the term *meta-awareness* to define the mindfulness state, and maintained that this awareness discriminates self from the sensory experiences associated with contents of consciousness. Such discrimination allows contents to be examined in a novel way; a way that brings their real characteristics into light (Schwartz, 1999) Said differently, the act of disengaging the self from habitual responses to the contents of consciousness is a form of behavioural monitoring that apprehends stereotypically psychological schemata.

Growing objectivity allows the development of fresh insight that improves overall decision making and guides inhibition in the regulation of emotion (Schwartz, 1999). More grandly perhaps, Hayes and colleagues (1999) have theorized that disidentification from emotional experiences, in terms of their subjective importance, deconstructs the perception of self as an enduring entity and the self begins to be experienced as a dynamic, experiential, ever-changing system of concepts, images, sensation and beliefs. In the Abhidharma, the deconstruction of self is considered an intended consequence of mindfulness practice and occurs as the practitioner realizes that there is no self or agent experiencing the feeling state, and that feeling states merely rise and disappear in an impersonal process. This

[4] The *contents of consciousness* refer to information regarding the outside world being received by the brain through perceptual modalities. The *levels of consciousness* refer to the background level of awareness determined by the state of the body's internal milieu and within which the contents of consciousness take place.

deconstruction of the self, as a predictable entity, is considered fundamental to the achievement of psychological health in Buddhist teachings (Nyanaponika, 1949): Subjectivity masks a clear perception of reality and a true perception of reality promotes an appreciation of impermanence and connectivity (Goleman & Epstein, 1983). With an appreciation of impermanence, openness and adaptability to change is made possible and with an appreciation of connectivity with all that surrounds us, mental health is improved. Adaptability to change and connectivity have both been empirically linked to improved mental well-being (e.g., Austin, Saklofske, & Egan, 2005; Cacioppo & Patrick, 2008).

Outside of the Buddhist tradition, disidentification has also been cited as an effective from of emotion management, contributing to overall well-being (Hayes et al., 2004; Linehan, 1993; Marlett & Gordon, 1985; Teasdale et al., 1995). Most basically disidentification has been described by these authors as a process that apprehends attachment and aversion; attachment to positive emotions and the objects associated with these emotions, and aversion to negative emotions and the objects related to them – attachment and aversion considered to be closely linked to poor psychological health.

Although we learn an incalculable number of skills from the time we are born that help us function independently, and even sometimes effectively, in the world, we receive little formal instruction on how best to manage our mental life. Mindfulness has been described as a continuation of the human developmental process in fostering the mental shift from subject to object (Hayes et al., 1999; Shapiro et al., 2006). The process of gaining objectivity regarding the internal experience is considered key in development and growth across the lifespan, and a prerequisite to reaching full emotional maturity, as illustrated by Kegan's subject-object theory (1982, p. 34):

> Liberating ourselves from that in which we were embedded, making what was subject into object so that we can "have it" rather than "be had" by it is the most powerful way I know to conceptualize the growth of the mind.

The findings of this thesis endorse the role of mindfulness in strengthening the observing self and the ensuing shift in ones relationship to the contents of mind, which affords clarity, perspective, objectivity and ultimately equanimity.

Emotional Well-Being Revisited

In the introduction to this thesis it was proposed that well-being brought about by mindfulness differs from the traditional psychological concept of subjective well-being. Subjective well-being in psychological science is typically considered the self-rated prevalence of positive affect over negative affect (Diener & Lucas, 2000). Rather, it is proposed, and supported by the findings in this thesis, that the well-being associated with mindfulness is characterised by emotional equanimity. In this state of well-being, characterised by emotional equanimity, there is less emphasis on the prevalence of one emotional state over another but rather on the relationship with, and management of these affects as they occur cyclically and inevitably.

Emotional equanimity is a concept that has received scarce attention in Western psychological science but it is considered the true nature of mind in Buddhism (Goleman, 2004). In Buddhism equanimity is described as the mind at rest. This description may be erroneously interpreted as a state associated with inactivity, but it may be better understood as an 'unafflicted' mind. According to the Abhidhamma, emotional equanimity is a natural by-product of mindfulness and is considered the highest state of being, in which aversion to the objects of emotion, or attachment to these objects, is pacified in favour of maintaining emotional balance.

Buddhist philosophy is not the only forum that has given credit to emotional equanimity. In 5th century BCE the Stoics of Greece hailed the balancing of passions

as a virtuous way of life. Later in *The Regimen of Health*, Maimonides (1135-1204) stated that every effort should be made to maintain a balanced soul, not only in the sick but the healthy too, relieved of what he termed the *passions of the psyche* that cause anxiety. Balancing the passions of mind continued to be a topic of debate during the Renaissance and early modern periods, becoming a more influential intellectual interest, specifically in its relation to health. In the 17th century Burton (1621, p. 288) noted the dire role of unchecked emotions in illness in The Anatomy of Melancholy:

> The mind most effectually works upon the body, producing by his passions and perturbations miraculous alterations cruel diseases and sometimes death itself.

Of course, the fact that emotional equanimity may be a healthy state of mind is consistent with the more general concept of homeostatic balance, which is the innate activity of a living organism to regulate its internal environment to maintain a stable and constant condition for the best chance of survival (Cannon, 1932).

Mindfulness and the Emotional Brain

In light of these propositions, it is prudent to consider the effect of mindfulness on emotional processing from a neurological point of view, and against the backdrop of the functional imaging findings. Borrowing from current theory in affective neuroscience, emotions are considered as brain representations of body states, playing a homeostatic function in maintaining consistency of the internal milieu (Damasio, 1999). Explained differently, other sensory modalities like vision and hearing function by nerve activation patterns corresponding to the external world, but emotions, function by nerve activation patterns corresponding to the internal world and assist in maintaining homeostatic balance. The process of emotion commences with changes in the body state occurring in response to an event in the

external environment, or even in response to thought, and information regarding these bodily changes is sent to the brain via the nervous and endocrine systems. Subcortical structures participate in the generation of implicit emotional responses, below the threshold of consciousness, and are expressed in action tendencies. Once the emotion and action tendencies have been generated, the phenomenal awareness of the emotion arises as information ascends from limbic to paralimbic structures in the brain (anterior cingulate cortex, insula, temporal pole and orbitofrontal cortex). Once emotion becomes explicit, or conscious, so the feeling of emotion is experienced. The feeling of the emotion is evaluative in nature and higher neocortical regions serve to contemplate these feelings in terms of their subjective significance (Damasio, 1999).

It is proposed that mindfulness, as a state of awareness, intervenes at the point when information regarding internal events reaches the threshold of consciousness and they are evaluated to determine their subjective relevance. In other words, once action tendencies and feeling states have been generated and served their biological function (to direct behaviour with the aim of maintaining physiological balance), mindfulness heightens awareness of the relationships between (a) the bodily state and (b) the arising emotion and (c) the subsequent feeling of the emotion. Acceptance of the arising emotion, in appreciation of its transitory nature, apprehends further cognitive and subjective appraisal of the feeling state. The emotion is noticed and then let go of to direct attention to the present moment. It is suggested then that the intensity of the emotion, or feeling state, is unaffected by mindful awareness, only the ensuing cognitive elaboration.

In the absence of cognitive elaboration, emotional balance, or equanimity, may be restored between positive and negative affective states while insight is gained into the nature of emotion and feeling as it pertains to the bodily state.

LIMITATIONS AND DIRECTIONS FOR FURTHER RESEARCH

The empirical work in this thesis provides impetus for further study, not only to verify the results but to test the proposed model of the mechanisms of mindfulness presented in Figure 15. In particular the relationship between disidentification and acceptance and cognitive flexibility needs to be further explored, recalling that disidentification was one of the commonly proposed mechanisms identified in the qualitative systematic analysis of the literature in Study One. Future research should also test this model using alternative factor-structures of mindfulness – this is one major discrepancy that does exist between the model of the mechanisms of mindfulness presented in this thesis and that presented by Shapiro and colleagues (2006). Shapiro purports three axioms, or behaviours inherent to mindfulness; *intention*, *attention* and *attitude*. Using a mindfulness scale that taps these axioms to assess their relationship with the mechanisms proposed in this thesis would be insightful, both in terms of mindfulness and its means of action.

It would also be advisable to empirically test more of the commonly proposed mechanisms of mindfulness identified in the qualitative systematic analysis in this thesis.

In addition, discrepancies exit in the neuroimaging findings of the mindfulness state produced over the years. Because of this, close attention will need to be given to structuring the protocols of such studies and the careful selection of participants to maintain consistency across studies; this would mean that the results of such research were truly comparable and serve to add to the knowledge in the field. What became evident from the ROI analysis in Study Two was that the greatest signal change in response to the mindfulness meditation occurred in the first 6-minutes of meditation and therefore employing a shorter meditation may be justified in future imaging research. A shorter meditation block would also allow

for better control over BOLD signal drift and movement artefacts. Lastly, it would also be of interest to assess whether the changes in brain function noted in response to state mindfulness would manifest as a result of mindfulness training, as well as hold stable over time. Issues such as these could be addressed in longitudinal studies.

IN CONCLUSION

The findings of the studies in this thesis help to validate some commonly held perceptions in the field regarding the way in which mindfulness brings about its positive outcomes. Most typically, mindfulness has been described as a process that nurtures the ability to 'step back' from immediate experiences and view them more objectively by taming emotional reactivity. This 'distancing' has previously been presented as the means through which mindfulness may reduce stress, or improve stress coping (Baer et al., 2005; DelMonte, 2003; Dobkin, 2007; Martin, 1997; Shapiro et al., 2006).

The findings of the studies in this thesis also offer insights into the key elements of change in mindfulness training and clinical work. These insights may be informative in the tailoring of existing interventions, structuring of new interventions and, more generally, guiding the clinical application of mindfulness.

It is my conclusion that mindfulness training may indeed be an effective means of managing mental life and emotions, leading to overall improved well-being. This thesis has added to the accumulating body of evidence supporting the efficacy of mindfulness training and the health benefits of being mindful. The findings of this thesis also support the role of willed-mental control in bringing about optimal well-being, and importantly, the role of objectivity in this process.

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APPENDIX A

STUDY TWO CONSENT FORM

STUDY ON THE MECHANISMS OF MINDFULNESS

Conducted as part of a PhD Thesis in

THE DEPARTMENT OF PSYCHOLOGY at the UNIVERSITY OF CAPE TOWN

Mindfulness may be defined as heightened present-moment awareness. Over the last two decades the scientific community has learnt much about mindfulness training and its efficacy in bringing about well-being. The primary interest of this study is *how* mindfulness achieves such positive outcomes. This mindfulness research study, in which you are invited to take part, has been designed to investigate the neural and cognitive mechanisms of mindfulness.

Your participation in this study is voluntary and should you agree to assist, your data and identity will remain strictly confidential. In taking part you will be required to complete the attached questionnaires on two occasions; once today, and once again in eight weeks time. The completion of these questionnaires will take you approximately 40 minutes. Your participation will be greatly appreciated. Should you have any questions, please contact Victoria Ives-Deliperi on 084 712 9675.

Personal Information

Date .....

Name .....

Age .....

Gender .....

Education level .....

Meditation experience .....

I consent to take part in this research study (signature) .....

APPENDIX B

STUDY THREE CONSENT FORM

STUDY ON THE MECHANISMS OF MINDFULNESS

Conducted as part of a PhD Thesis in

THE DEPARTMENT OF PSYCHOLOGY at the UNIVERSITY OF CAPE TOWN

Mindfulness may be defined as heightened present-moment awareness. Over the last two decades the scientific community has learnt much about mindfulness training and its efficacy in bringing about well-being. The primary interest of this study is *how* mindfulness achieves such positive outcomes. This mindfulness research study, in which you are invited to take part, has been designed to investigate the neural and cognitive mechanisms of mindfulness.

As a participant, you will be required to undergo Magnetic Resonance Imaging (MRI) and complete three questionnaires, on one single occasion. You will receive an audio tape recording of the sound of the MRI scanner two weeks prior to your testing session so that you may practice your meditation with the related sound interference. On the day of your testing, you will be asked to refrain from consuming tea, coffee, alcohol or any other central nervous system stimulant. You will be screened by a radiologist to ensure the MRI is safe for you and you will be required to complete several questionnaires. The total session will last one hour. During the scanning you will receive verbal signals via headphones to direct your activities:

- You will be asked to relax for 15-minutes.
- Two 15-minute scanning intervals will then be conducted following identical procedures:
    1. Control: Silently generate a random list of numbers for 2-minutes.
    2. Meditation: Engage in a 12-minute mindfulness meditation.
    3. Control: Silently generate a random list of numbers for 2-minutes.

CONSENT

Participation in this study is completely voluntary, and you are free to choose not to complete the questionnaires, or *opt out* of the imaging research at any stage. However you are kindly requested to participate as you will help us understand more about the relationship between psychological health, improved functioning and heightened awareness. Your data and individual identity will be kept strictly confidential. Please read the attached MRI Information Sheet before signing this consent.

Date .....

Name .....

Age .....

Gender .....

Education level .....

Meditation experience .....

I hereby consent to participate in this research study with full knowledge and understanding of the nature of the research project and what is expected of me.

Signature .....

MAGNETIC RESONANCE IMAGING INFORMATION SHEET

Before taking part in this study you will be required to have an interview with a radiologist on the day of your scan to make sure that the MRI procedure is safe for you. Please feel free to raise any questions/ concerns you may have at this time, and prior to signing the consent form.

SAFETY AND METAL OBJECTS

The MRI scanner is a powerful magnet. Because metal objects are strongly attracted to the magnet, any metal objects you are carrying or wearing must be removed prior to the MRI scan to avoid potentially severe injury.

UNEXPECTED FINDINGS

In rare cases, researchers discover unexpected findings related to a participant's MRI scan in which case the scan is referred to a radiologist for further analysis and further tests may be recommended in order to determine the nature and significance of the unexpected finding, in which case the participant will be referred to a General Practitioner of their choosing.

ONGOING DISCLOSURE OF POTENTIAL HARMS

If new findings about the potential harms of the MRI technique become available during the time of the study, the researcher will inform you.

CONTACT DETAILS

Should you have any further queries you may contact:

Victoria Ives-Deliperi: 084 712 9675

The Faculty of Health Sciences Research Ethics Committee: 021 406 6492

Professor Mark Solms: mark.solms@uct.ac.za

APPENDIX C

STUDY FOUR CONSENT FORM

STUDY ON THE MECHANISMS OF MINDFULNESS

Conducted as part of a PhD Thesis in

THE DEPARTMENT OF PSYCHOLOGY at the UNIVERSITY OF CAPE TOWN

Mindfulness may be defined as heightened present-moment awareness. Over the last two decades the scientific community has learnt much about mindfulness training and its efficacy in bringing about well-being. The primary interest of this study is *how* mindfulness achieves such positive outcomes. This mindfulness research study, in which you are invited to take part, has been designed to investigate the neural and cognitive mechanisms of mindfulness.

In taking part you will be required to undergo a brief neuropsychological testing and complete two questionnaires. Testing will take approximately 45 minutes. Your participation will be greatly appreciated but is completely voluntary. If you do choose to participate your data and individual identity will be kept strictly confidential.

Date .....

Name .....

Age .....

Gender .....

Education level .....

Meditation experience .....

I consent to take part in this research study (signature) .....

APPENDIX D

STUDY TWO STATISTICS

Normality of Data

Levene's Test of Homogeneity of Variances *F*(1,110)

Variable	Time	F ratio	p-level
Mindfulness	I	1.85	0.18
	II	0.05	0.82
Symptoms of Stress	I	0.61	0.44
	II	4.19	0.05
Total Mood Disturbance	I	0.39	0.53
	II	0.82	0.37
Openness to Experience	I	0.02	0.89
	II	0.17	0.89
Acceptance	I	1.76	0.19
	II	5.18	0.05
Cognitive Failures	I	1.32	0.25
	II	0.41	0.53
Self-regulation	I	1.24	0.27
	II	1.21	0.27

ANOVA Tables and Graphs

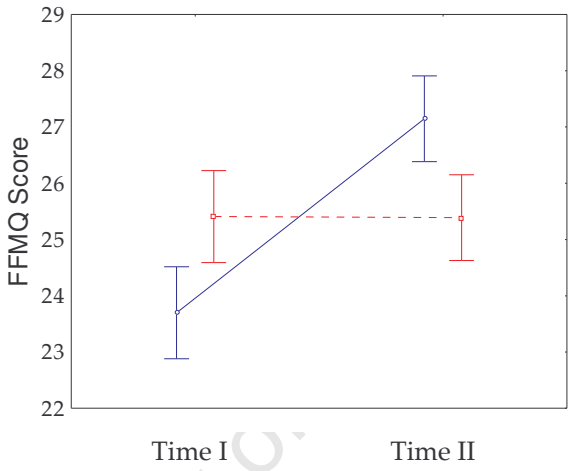
1. Effect of MBSR on Mindfulness

Table of Means and Standard Deviations

Mindfulness	Time I	Time II	
Treatment group	23.7	27.2	25.5
	(3.4)	(3.1)	
	n = 56	n = 56	
Control group	25.4	25.4	25.4
	(2.7)	(2.8)	
	n = 56	n = 56	
	24.6	26.3	

ANOVA Summary Table

Source	SS	df	MS	F ratio	p-level
Between subjects					
A (Condition)	0.0	1	0.03	0.00	0.96144
Error (w/in gps)	1524.61	110	13.86		
Within subjects					
B (Time)	164.74	1	164.74	41.82	0.00000
Interaction (AB)	168.47	1	168.47	42.77	0.00000
Error (Bx subjects w/in gps)	433.33	110	3.94		



Note: — Treatment Group; --- Control Group

Graph of Cell Mean Profiles

Analysis of Simple Main Effects

Source	SS	df	MS	F ratio	p-level
A @ B1	81.91	1	81.91	9.20	.002705
A @ B2	86.59	1	86.59	9.73	.002025
Within cells error term	1957.9	220	8.899		
B @ A1	333.20	1	333.20	85.44	.00000
B @ A2	0.01	1	0.01	0.003	.959426
Error (B x subjects w/in gps)	433.3	110	3.9		
	81.91	1	81.91	9.20	.002705

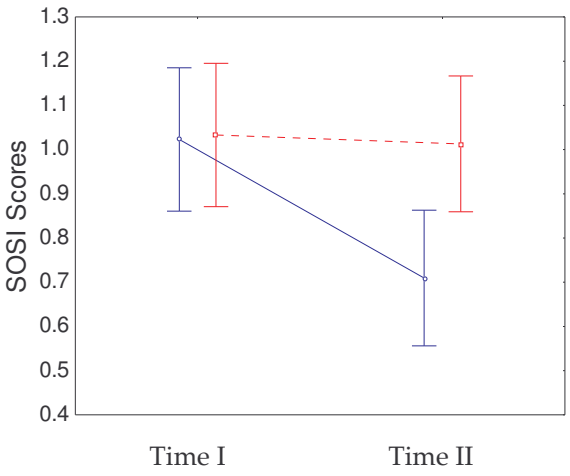
2. Effect of MBSR on Symptoms of Stress (SOS)

Table of Means and Standard Deviations

Symptoms of Stress	Time I	Time II	
Treatment group	1.02	0.71	0.87
	(0.59)	(0.5)	
	N = 56	n = 56	
Control group	1.03	1.01	1.02
	(0.64)	(0.65)	
	N = 56	n = 56	
	1.03	0.86	

ANOVA Summary Table

Source	SS	df	MS	F ratio	p-level
Between subjects					
A (Condition)	1.38	1	1.38	2.25	.1364
Error (w/in gps)	67.24	110	0.61		
Within subjects					
B (Time)	1.56	1	1.56	15.69	.000133
Interaction (AB)	1.21	1	1.21	12.15	.000708
Error (Bx subjects w/in gps)	10.92	110	0.10		



Note: — Treatment Group; --- Control Group

Graph of Cell Mean Profiles

Analysis of Simple Main Effects

Source	SS	df	MS	F ratio	p-level
A @ B1	0.003	1	0.003	0.008	.929346
A @ B2	2.58	1	2.58	7.26	.007595
Within cells error term	78.16	220	0.36		
B @ A1	2.79	1	2.79	28.05	.000001
B @ A2	0.01	1	0.01	0.11	.73650
Error (B x subjects w/in gps)	10.92	110	0.10		

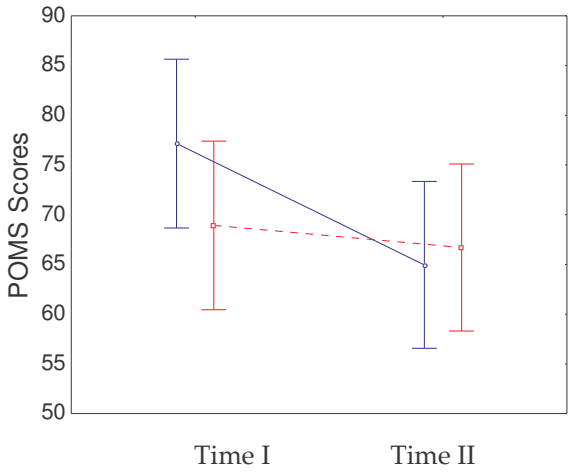
3. Effect of MBSR on Total Mood Disturbance (TMD)

Table of Means and Standard Deviations

Mood Disturbance	Time I	Time II	
Treatment group	77.16	64.96	71.06
	(29.21)	(28.55)	
	N = 56	n = 56	
Control group	68.93	66.71	67.82
	(34.65)	(34.57)	
	N = 56	n = 56	
	73.05	65.84	

ANOVA Summary Table

Source	SS	df	MS	F ratio	p-level
Between subjects					
A (Condition)	588.25	1	588.25	0.37	.54687
Error (w/in gps)	177180.49	110	1611.73		
Within subjects					
B (Time)	2907.36	1	2907.36	6.90	.009842
Interaction (AB)	1395.00	1	1395	3.31	.07152
Error (Bx subjects w/in gps)	46340.13	110	421.27		



Note: — Treatment Group; --- Control Group

Graph of Cell Mean Profiles

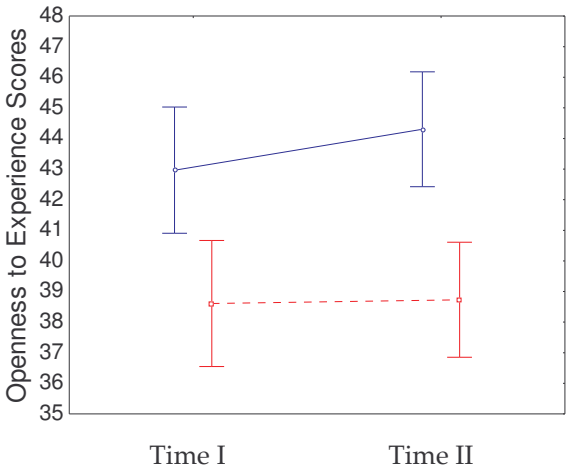
4. Effect of MBSR on Exposure

Table of Means and Standard Deviations

Exposure	Time I	Time II	
Treatment group	42.96	44.3	43.63
	(7.68)	(6.86)	
	N = 56	n = 56	
Control group	38.61	38.73	38.67
	(7.88)	(7.32)	
	n = 56	n = 56	
	40.79	41.52	

ANOVA Summary Table

Source	SS	df	MS	F ratio	p-level
Between subjects					
A (Condition)	1380.07	1	1380.07	13.55	.000361
Error (w/in gps)	11200.77	110	101.83		
Within subjects					
B (Time)	30.02	1	30.02	3.35	.0698698
Interaction (AB)	20.64	1	20.64	2.30	.131869
Error (Bx subjects w/in gps)	985.34	110	8.96		



Note: — Treatment Group; --- Control Group

Graph of Cell Mean Profiles

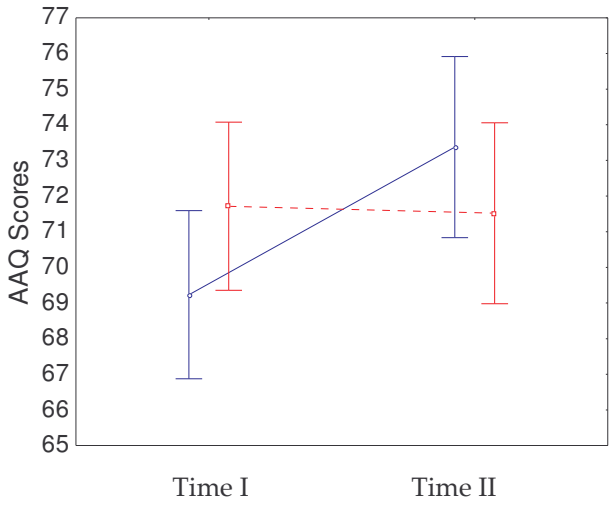
5. Effect of MBSR on Acceptance

Table of Means and Standard Deviations

Acceptance	Time I	Time II	
Treatment group	69.23	73.38	71.13
	(9.57)	(10.84)	
	n = 56	n = 56	
Control group	71.71	71.52	71.62
	(8.2)	(8.15)	
	n = 56	n = 56	
	70.47	72.45	

ANOVA Summary Table

Source	SS	df	MS	F ratio	p-level
Between subjects					
A (Condition)	5.47	1	5.47	0.04	.845721
Error (w/in gps)	15813.67	110	143.76		
Within subjects					
B (Time)	218.04	1	218.04	7.89	.005876
Interaction (AB)	263.61	1	263.61	9.54	.002543
Error (Bx subjects w/in gps)	3038.85	110	27.63		



Note: — Treatment Group; --- Control Group

Graph of Cell Mean Profiles

Analysis of Simple Main Effects

Source	SS	df	MS	F ratio	p-level
A @ B1	172.5	1	172.5	2.01	.15737
A @ B2	96.6	1	96.6	1.13	.28958
Within cells error term	18853	220	85.695		
B @ A1	480.6	1	480.6	17.16	.000068
B @ A2	1.1	1	1.1	0.039	.843221
Error (B x subjects w/in gps)	3039	110	28		

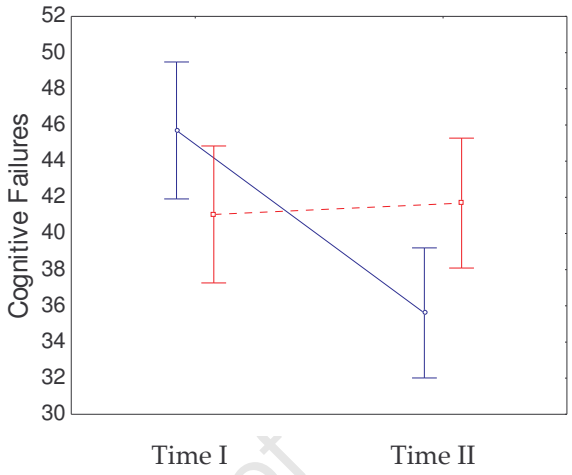
6. Effect of MBSR on Cognitive Failures

Table of Means and Standard Deviations

Cognitive Failures	Time I	Time II	
Treatment group	45.7	35.61	40.66
	(12.98)	(13.94)	
	N = 56	n = 56	
Control group	41.05	41.68	41.37
	(15.5)	(13.19)	
	N = 56	n = 56	
	43.38	38.65	

ANOVA Summary Table

Source	SS	df	MS	F ratio	p-level
Between subjects					
A (Condition)	28.57	1	28.57	0.09	.771039
Error (w/in gps)	36927.41	110	335.70		
Within subjects					
B (Time)	1254.02	1	1254.02	23.80	.000004
Interaction (AB)	1607.14	1	1607.14	30.51	.000000
Error (Bx subjects w/in gps)	5794.84	110	52.68		



Note: — Treatment Group; --- Control Group

Graph of Cell Mean Profiles

Analysis of Simple Main Effects

Source	SS	df	MS	F ratio	p-level
A @ B1	603.6	1	603.6	3.11	.07928
A @ B2	1032.1	1	1032.1	5.32	.022076
Within cells error term	42722	220	194.191		
B @ A1	2850.2	1	2850.2	54.08	.000000
B @ A2	10.9	1	10.9	0.21	.650183
Error (B x subjects w/in gps)	5795	110	52.7		

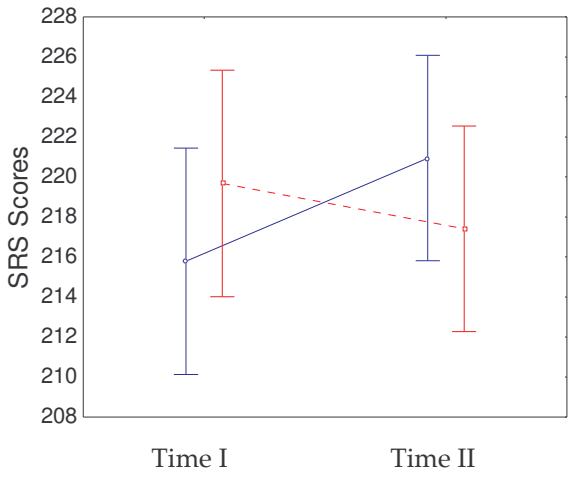
7. Effect of MBSR on Self-regulation

Table of Means and Standard Deviations

Self-regulation	Time I	Time II	
Treatment group	215.79	220.95	218.37
	(22.68)	(20.51)	
	N = 56	n = 56	
Control group	219.68	217.41	218.55
	(19.98)	(18.21)	
	N = 56	n = 56	
	217.74	219.18	

ANOVA Summary Table

Source	SS	df	MS	F ratio	p-level
Between subjects					
A (Condition)	1.79	1	1.79	0.00	.961219
Error (w/in gps)	82703.77	110	751.85		
Within subjects					
B (Time)	117.16	1	117.16	1.45	.231899
Interaction (AB)	772.57	1	772.57	9.53	.002559
Error (Bx subjects w/in gps)	8918.27	110	81.08		



Note: — Treatment Group; --- Control Group

Graph of Cell Mean Profiles

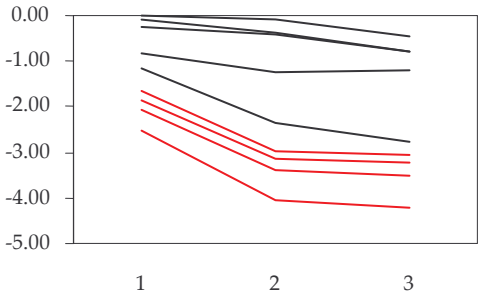
Analysis of Simple Main Effects

Source	SS	df	MS	F ratio	p-level
A @ B1	424	1	424	1.02	.314079
A @ B2	1032.1	1	1032.1	2.48	.116886
Within cells error term	91622	220	416.46		
B @ A1	2850.2	1	2850.2	35.19	.000000
B @ A2	10.9	1	10.9	0.14	.714009
Error (B x subjects w/in gps)	8918	110	81		

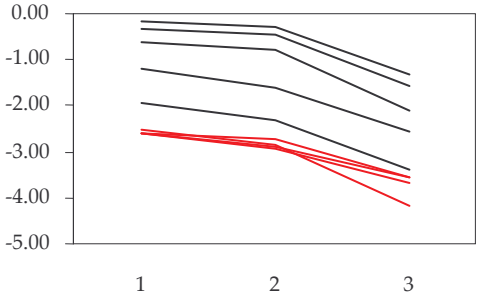
APPENDIX E

STUDY THREE STATISTICS: SCATTERPLOTS

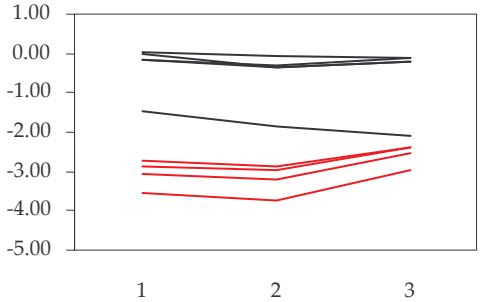
Right anterior insula



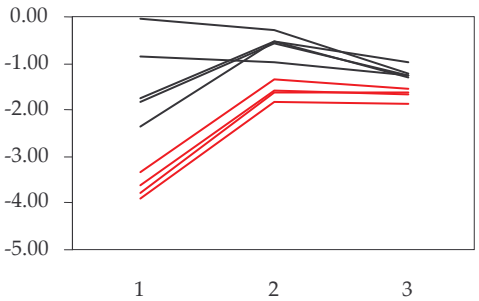
Right precuneus



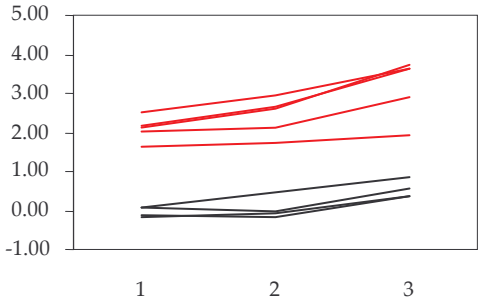
Right temporal lobe



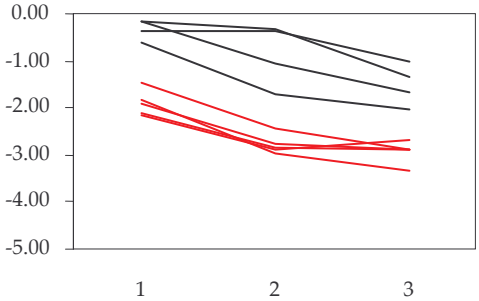
Right prefrontal cortex



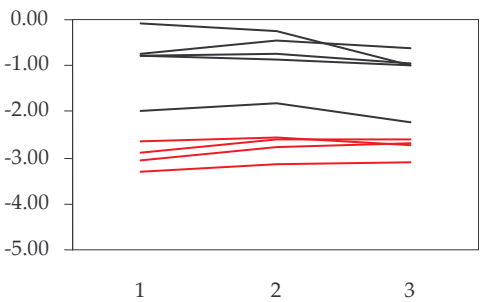
Right posterior cingulate cortex



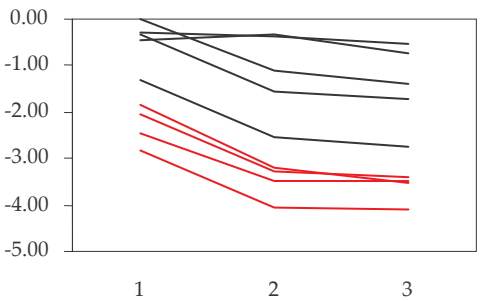
Left precuneus



Right anterior cingulate cortex



Left insula



APPENDIX F

PHOTOGRAPHIC IMAGES OF FUNCTIONAL IMAGING

Note: Images of the Magnetic Resonance Imaging (MRI) Procedure at the Cross-University Brain Imaging Centre (CUBIC)