A randomised controlled trial of a mindfulness-based mobile app evaluating mindfulness, perceived stress, wellbeing and emotion reactivity

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ABSTRACT

The prevalence of university students experiencing high levels of stress, and the adverse effects of stress, provide a rationale for preventative services to reduce stress. Mindfulness-based therapies have shown promise attenuating stress and improving psychosocial wellbeing in student populations. Research has highlighted improvements in mood, stress and emotion regulation with mindfulness practice. The portability and ubiquity of mobile phones make them a promising target for health interventions. Few studies have tested the efficacy of mindfulness based mobile apps (MBMAs) and the viability of this format of delivery remains largely unknown. Some preliminary results suggest benefits. It is proposed that a MBMA may provide feasible and effective mental health support for students.

Methods: To assess the efficacy of a MBMA, a sample of n54 university students new to mindfulness participated in a RCT. The study compared 7-days of mindfulness practice with an MBMA to an active control. It was hypothesised that mindfulness would reduce on measures of perceived stress, negative affect and emotion reactivity, and increase mindfulness and positive affect compared to the control.

Results: No significant group differences were found for perceived stress or wellbeing. Both groups demonstrated a significant parallel decrease in negative affect with a large effect size. The mindfulness group reported significantly more *acting with awareness* compared to the control with a small effect size. Both groups demonstrated a significant parallel increase in mindfulness on FMI, FFMQ full scale and *Non-React* with large effect sizes. The mindfulness group reported significantly less emotion reactivity after listening to anger stories compared to the control with medium effect sizes. No significant differences to fear stories, facial EMG or Emotion Stroop were detected.

Conclusion: The results of this study failed to provide support for the use of a MBMA to reduce student stress. Results indicate a MBMA intervention for seven days may cultivate the ability to *act with awareness*. The results provide partial support that a MBMA may

reduce emotion reactivity. However, these findings should be viewed in the context of the failure to detect differences in the other measures of interest and the low power of the study. App interventions may require more time to generate beneficial effect in a non-meditating sample.

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ABBREVIATIONS

ACT	Acceptance and Commitment Therapy
ANOVA	Analysis of Variance
BPD	Borderline Personality Disorder
DBT	Dialectical Behaviour Therapy
ECG	Electrocardiogram
EMG	Electromyography
FEMG	Facial Electromyography
FMI	Freiburg Mindfulness Inventory
FFMQ	Five Facet Mindfulness Questionnaire
MBCT	Mindfulness Based Cognitive Therapy
MBMA	Mindfulness Based Mobile Application
MBSR	Mindfulness Based Stress Reduction
MBT	Mindfulness Based Therapy
MBI	Mindfulness Based Intervention
M-health	Mobile Health
MDD	Major Depressive Disorder
NA	Negative Affect
PANAS	Positive and Negative Affect Scale
PA	Positive Affect
PSS	Perceived Stress Scale
RCT	Randomised Controlled Trial
RDEES	Range and Differentiation of Emotional Experience Scale
SAM	Subjective Affective Manikin
WQ	Workload Questionnaire

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LITERATURE REVIEW

1.1 STRESS & STUDENT HEALTH

Stress and health

Psychological stress represents a significant health burden as it contributes to poor health behaviours, psychological imbalance and increased morbidity and mortality. A large body of research has examined the role of stress in the causation and exacerbation of disease. High levels of psychological stress have been correlated with immune dysfunction (Cohen, Tyrrell, & Smith, 1991; Lacey et al., 2000), anxiety and depression (McKinzie, Altamura, Burgoon, & Bishop, 2006), and maladaptive coping behaviours including substance abuse (Nation & Heflinger, 2006) and unhealthy eating patterns (Adam & Epil, 2007; Groesz et al., 2012). Stress may moderate ill health by eliciting negative affective states, which then exert direct effects on physiological processes or behavioural patterns that influence disease risk (Cohen & Janiki-Deverts, 2012). Inextricably linked to anxiety, stress plays a pivotal role in mental disorders, consequently, stress-inducing changes in lifestyle patterns place a substantial burden on mental health (Fink, 2016).

Stress is difficult to define and has a large research base across physiological and psychological domains. Originating from an engineering term based on the weight on a structure, *stress* was the area over which load or weight impacted (Lazarus, 1993). This term was adopted by physician Hans Selye which he defined in biological terms as 'the nonspecific response of the body to any demand' (Selye, 1936). Selye influenced our current understanding of stress by defining a General Adaptation Syndrome (GAS) which outlined three phases of the physiological response to stressors: autonomic nervous system activation, resistance through adaptation to the stressor, and finally exhaustion and damage to the organism if the stressor persists (Lazarus, 1993; McCarty, 2016). Selye recognized the dual nature of the stress response; generating adaptive changes in the short-term (i.e., inhibition of inflammation and mobilisation of energy sources), whereas prolonged activation can produce changes that are maladaptive (i.e., enlarged adrenal glands). Selye's conceptualisation of stress emphasised the physiological response as opposed to the

environmental triggers of stress. Current psychological definitions of stress include the subjective experience of stress in response to perceived environmental stressors.

The Lazarus transactional model of stress distinguishes stress as the interaction between the appraisal of the stressor (i.e., severity) and one's perceived ability to cope (Folkman, Lazarus, Dunkel-Schetter, DeLongis, & Gruen, 1986; Lazarus & Folkman, 1984). Lazarus has defined stress as a reaction to personal harms and threats of various kinds that emerge from person-environment relationships (Lazarus, 1993). A key factor in the Lazurus model of stress is *appraisal* as the cognitive mediator of stress reactions. Lazarus describes appraisal as a universal process in which people constantly evaluate the significance of what is happening for their personal well-being (Lazarus, 1993). This model of stress includes the perception of stress (the individual appraisal that the environmental stressor exceeds available resources), appraisal (one's perception and assessment of the situation), and coping (effortful or purposeful thoughts and actions to manage or overcome stressful situations (Chao, 2012). From this perspective stressors are highly subjective, influenced by individual perception and shaped by environmental, physical, psychological, and social forces (Britt, Mendiola, Schink, Tibbetts, & Jones, 2016).

Stress impacts health in a number of ways. The negative impacts of stress on health increase when an individual perceives stressful life events are beyond their ability to cope, and not the stressful life event per se (Lazarus & Folkman, 1984 as cited in Cohen & Janiki-Deverts, 2012). In this way, the magnitude of the stressor and its physiological consequences are influenced by the individual's perception of their ability to cope with the stressor (Fink, 2016). High perceived stress can lead to a feeling of fear and anxiety, and depending on the circumstances, can lead to sympathetic nervous system activation or the *fight or flight* response which is the rapid, neurally mediated reaction to acute stress. Physiological and neurochemical approaches have identified two major neuroendocrine systems that respond to stress, the hypothalamic-pituitary-adrenal axis and the sympathetic-adrenomedullary limb of the autonomic nervous system (Fink, 2016). In response to stress, autonomic nervous system activation generates changes in cardiovascular reactivity and the immune system including the release of corticosteroids and cytokine production.

Physiological changes in response stress may increase the risk of illness. Equally, the strategies that people use to cope with stressors will mediate the affects of stress on health.

Coping with stress involves varied strategies ranging from overt behaviours to covert mental attitudes (Chao, 2012). Coping has been defined as the constantly changing cognitive and behavioural efforts to manage internal or external taxing demands (Folkman et al., 1986). This involves what a person actually thinks and does under stress, the influence of cognitive appraisal, and whether a person is successful or not at coping (Holinka, 2015). Coping also functions to regulate emotions and to alter the troubled person-environment relationship that is causing the stress (Holinka, 2015). Heightened reactivity to daily stress, or the tendency to respond to stress with heightened levels of negative effect (stress sensitivity), are important risk factors for negative mental health outcomes (Snippe, Dziak, Lanza, Nyklíček, & Wichers, 2017; Wichers et al., 2009). Some coping strategies are functional, whereas others have detrimental effects on health and wellbeing (Carver, Scheier, & Weintraub, 1989). Some individuals will respond to stress for example with increased smoking and alcohol consumption, or changes in eating behaviours and disrupted sleep. These behavioural changes may then mediate the effects of stress on health.

Stress and student health

University students have a high prevalence of daily stressors due to assignment and examination deadlines, financial concerns and demographic factors (Kerrigan et al., 2017; Regehr, Glancy, & Pitts, 2013). Many university students are experiencing new responsibilities that come with transitioning to adulthood; including living away from home, working to fund independent life and study, and adopting new social roles (Brougham, Zail, Mendoza, & Miller, 2009; Clarke, 2012). It has been estimated that approximately 60% of students have reported clinical levels of stress (Stallman, 2010). Stress is a significant predictor of adverse effects on physiological and psychological health in university students (Lacey et al., 2000; McKinzie et al., 2006). Research has shown that in response to stressors, young university students often employ more maladaptive emotion-focused coping that may include binge drinking or other drug use (Brougham,

2009). Poor health behaviours exacerbate the negative effects of stress on health, leading to more stress and creating a vicious cycle (Brougham, 2009).

Stress is positively correlated with psychological distress in university students and can manifest as anxiety and depressive symptoms (McKinzie et al., 2006). The onset of psychological distress, in the form of depression and anxiety, often occurs in young adulthood and signifies a vulnerable psycho-developmental stage, especially among women (Bernhardsdóttir & Vilhjálmsson, 2013; Stallman, 2010). International research has demonstrated high rates of anxiety and depression among university students (Bayram & Bilgel, 2008; Bernhardsdóttir & Vilhjálmsson, 2013; Regehr et al., 2013), and research in the New Zealand and Australian populations echo these trends (Stallman, 2012; Wynaden, Wichmann, & Murray, 2013). Student mental health problems are becoming more serious and complicated and the need for counselling services has increased (Bernhardsdóttir & Vilhjálmsson, 2013).

Compared to the large numbers of students reporting clinical levels of stress, few students experiencing stress related psychological distress receive treatment (Bernhardsdóttir & Vilhjálmsson, 2013; Garlow et al., 2008; Wynaden et al., 2013). Several barriers to seeking support for stress or mental health concerns for students have been documented in the literature, such as stigma, lack of resources and underestimation of problem severity (Garlow et al., 2008). In part, low treatment rates are related to help-seeking behaviours among students (Regehr et al., 2013). One study suggested the most common barriers to treatment are: (1) a preference for dealing with stress alone (73%); (2) the belief that stress is normal in university (52%); (3) not seeing their needs as serious (52%); and (4) not having time for treatment (47%) (Downs & Eisenberg, 2012).

Research has highlighted the responsibility of university health services to provide adequate support for students dealing with psychological demands associated with higher education (Regehr et al., 2013). A review and meta-analysis of 24 studies, involving 1,431 students, concluded that universities should employ preventative health initiatives that have the potential to reach larger groups of students, and not merely rely on individual counselling services to meet student needs (Regehr et al., 2013). Results from this review

provided evidence that cognitive, behavioural, and mindfulness interventions were effective in reducing stress in university students (Regehr et al., 2013). New Zealand universities are limited by resources to deliver psychological services to students and there is a need to develop cost-effective and efficacious psychological health supports relevant to New Zealand students (Stallman, 2012).

The prevalence of students experiencing high levels of stress, and the negative flow on effects of stress, provide a rationale for preventative services to promote wellness and help university students respond to stress in adaptive ways. Delivering support to students dealing with stress may alleviate some of the burden on the wider mental health system, by stemming the development of anxiety and depression in this population. Mindfulness-based interventions have been implemented in student populations and have generally been found to have a positive impact on stress and wellbeing (Creswell, Pacilio, Lindsay, & Brown, 2014; Kerrigan et al., 2017; Pascoe, Thompson, Jenkins, & Ski, 2017; Zimmaro et al., 2016). It is proposed that self-directed mindfulness training with a smartphone app may provide cost effective and practicable support to students coping with the demands of work, study and psycho-developmental challenges.

1.2 CONCEPTUALISING MINDFULNESS

Defining mindfulness

The concept of mindfulness is firmly rooted in ancient Buddhist practices. Buddhism is a centuries old plural tradition that includes many different forms of mindfulness (Dreyfus, 2011). Buddha lived in the fifth century BC and taught a body of principles and practices with the aim of sustaining human beings in their quest for happiness and spiritual freedom (Bodhi, 2013). Mindfulness in Buddhist traditions is part of a system of training that leads to insight and overcoming suffering (Bodhi, 2013). Mindfulness has been adopted in Western psychology as an approach for 'increasing awareness and responding skilfully to mental processes that contribute to emotional distress and maladaptive behaviour' (Bishop et al., 2004).

Over the last few decades, mindfulness has become a popular focus in Western medical and psychological research literature. The incorporation of mindfulness into contemporary psychology and clinical practice has been the subject of a vast number of studies and as a construct, mindfulness has been conceptualised in varied ways. Mindfulness has been difficult to define within the literature given its multi-factorial nature and deep roots in Buddhist tradition, where translation into Western concepts has at times been problematic. How mindfulness is conceptualised and measured within Western psychology is central to the advancement of the field and to understanding how mindfulness elicits the clinical benefits observed. Brown (2007) argues that there is a need for conceptual agreement on the meaning of mindfulness to create a stable platform of research (Brown, Ryan, & Creswell, 2007). Whereas, other authors argue that agreement on a unified definition of mindfulness is untenable and should not hamper further research efforts in an area that is still evolving (Bach, Hayes, & Levin, 2015). Given the complex and at times competing definitions of mindfulness in the literature, an in-depth discussion of the various understandings of mindfulness is beyond the scope of this review. Rather, this section aims to introduce to the reader an overview of current definitions of mindfulness within Western psychology and how these relate to cultivating mindfulness in clinical practice.

Most commonly referenced in the literature is the definition by Kabat-Zinn (1990) who defined mindfulness as, 'the awareness that emerges through paying attention on purpose, in the present moment and nonjudgmentally, to the unfolding of experience moment by moment' (Kabat-Zinn, 2003a). Bishop et al., (2004, p232) expanded on this definition, writing that mindfulness is a 'kind of non-elaborative, non-judgemental, present-centred awareness in which each thought, feeling or sensation that arises in the attentional field is acknowledged and accepted as it is'. Bishop et al., (2004) proposed a two-component model of mindfulness: (1) the self-regulation of attention on immediate experience, allowing for increased recognition of mental events, (2) an orientation to experience characterised by curiosity, openness, and acceptance. As can be seen from each of these definitions, there are several aspects to mindfulness practice that require careful attention when operationalising the construct.

Kabit-Zinn summarised mindfulness as particular qualities of attention and awareness that can be cultivated and developed through meditation (Kabat-Zinn, 2003a). Shapiro and Carson (2017) write that what can be confusing when conceptualising mindfulness is that mindfulness is viewed as both a process (i.e., directing attention in mindful practice) and an outcome (mindful awareness, or a way of being). They describe mindful awareness as a way of relating to all experience, whether it be positive, negative, or neutral, in an open, receptive way, without the desire to change how it is (Shapiro & Carlson, 2017). They have presented a model of mindful practice that includes three components: intention, attention and attitude (Shapiro & Carlson, 2017). These three elements of mindfulness form an operational definition for mindfulness that describes: attentional control (i.e., focus on the breath or noticing the quality of the mind), the intention of attentional control (i.e., motivation for practice, which may change over time) and attitudes that are being trained (i.e., an attitude of non-judgment, or to decenter from negative thinking) (Alsubaie et al., 2017; Shapiro & Carlson, 2017).

Drawing on various clinical definitions of mindfulness, Bach, Hayes and Levin (2015, p11) proposed five features that stand out. Firstly, drawn from Kabat-Zinn (1990), to direct attention to the present in a flexible, fluid, and purposeful way. Second, to foster a non-judgmental approach that involves observing, describing and participation (Dimidjian &

Linehan, 2003) or decentering (Teasdale et al., 2002). Third, described by Bishop et al., (2004) as an attitude of curiosity, openness, and acceptance. Fourth, evoking the quality of effectiveness (Dimidjian & Linehan, 2003) or flexibility (Langer & Moldoveanu, 2000). Finally, to cultivate a transcendent or interconnected quality of consciousness (Diekman, 1982 as cited in Bach et al., 2015). Bach et al., (2015, p11) combined all five features together in a definition of mindfulness that 'involves deliberate, non-judgmental, and accepting attention to what is present, so as to foster more conscious, interconnected, flexible, and effective styles of interacting with the internal and external world' (Bach et al., 2015).

What can be seen from these conceptualisations of mindfulness is a teasing out of qualities that make up mindful attention and mindful awareness, which then affects how a person responds to their lived experience and how they cope with life's challenges. The study of mindfulness within Western science is relatively young and will continue to evolve. An expanding research base aims to elucidate the specific active components of mindfulness that link to various psychological and physiological processes underlying clinical benefits of mindfulness. Perspectives from numerous disciplines have emerged in the literature, including cognitive science, neuroscience and clinical psychology. Research has begun to explore the association between mindfulness and functional neural mechanisms (Holzel, Lazar, Gard, & Schuman-Olivier, 2011; Hölzel et al., 2011), cognitive processes such as attention and emotion regulation (Chiesa, Serretti, & Jakobsen, 2013; Moore, 2013; Reese, Zielinski, & Veilleux, 2015; Scott, 2014), and immune function, inflammatory processes and the stress response (Bergin & Pakenham, 2016; Davidson et al., 2003; T. Jacobs et al., 2011).

As discussion of the varied conceptualisations of mindfulness continues to develop in the literature, each discipline applies their unique perspective to mindfulness and offers new insights. When dealing with such multi-layered concepts as conscious awareness and emotion regulation, no doubt the conceptualisations of mindfulness will continue to build and compete with one another. The current research was designed with the aim of providing detailed information on measures of mindfulness and related aspects of mindfulness including emotion reactivity, with the over-arching goal of understanding how

different facets of mindfulness might be cultivated with a brief, self-directed approach to mindfulness training and to explore the active components of mindful attention and awareness.

Cultivating mindfulness

Different conceptualisations of mindfulness reflect the varied approaches to integrating mindfulness within clinical practice. Within a psychological perspective, mindfulness is conceptualised as the mental state of focussing on the present-moment experience without judgement (Chang, Huang, & Lin, 2015). As a whole, mindfulness-based therapies promote the development of greater awareness and acceptance of emotions and thoughts, rather than attempting to change or moderate the internal experience (Corcoran, Farb, Anderson, & Sega, 2010). While mindfulness is conceptualised in different ways, in general, most authors agree that mindfulness practice involves directing attention to the present moment with a general attitude of openness and acceptance, and with an ability to describe or label the experience (Reese et al., 2015).

The capacity for sustained moment to moment awareness, especially when dealing with emotional or physical difficulties, is a difficult skill to acquire (Siegel, Germer, & Olendzki, 2009). Mindfulness is often presented as a set of skills, and like any new skill, requires practice to master. Mindfulness training commonly begins with tasks in concentration, whereby participants learn to restrict their attention to a specific focus (such as the breath) and repeatedly return their attention to this focus if they become distracted (Lykins, Baer, & Gottlob, 2012). After some degree of attentional control is attained, mindfulness training proceeds to receptive practices involving non-judgmental observation of all sensations, thoughts and feelings as they naturally arise (Lykins et al., 2012).

In an attempt to regulate difficult emotions or thoughts, people often engage in maladaptive emotion regulation strategies, such as suppression, avoidance and non-acceptance, which in turn exacerbates the emotion or thought they are trying to avoid (Curtiss, Klemanski, Andrews, Ito, & Hofmann, 2017; Desrosiers, Vine, Klemanski, & Nolen-Hoeksema, 2013). By encouraging observation of thoughts, feelings and sensations as they arise, and noting

any tendency to judge, it is proposed that mindfulness awareness develops greater acceptance of one's internal experience that in turn mediates behaviour (Crescentini, Urgesi, Campanella, Eleopra, & Fabbro, 2014). In this way, it may become easier to interrupt destructive patterns of responding to stressful events. It has been suggested that mindfulness practice promotes positive reappraisal, through which stressful events or difficult internal experiences, may be reframed as beneficial, meaningful or harmless (Chambers, Gullone, & Allen, 2009; Holzel et al., 2011).

The labelling of experience in mindful practice fosters a simple acknowledgement of the experience, rather than getting caught up in elaborative thought processes about one's experience and their implications (Bishop et al., 2004). It is hypothesised that mindfulness practice permits a *decentered* awareness, or spacious quality of attention to thoughts and emotions, that may reduce the tendency to be routinely caught up in or attached to certain cognitions or emotions (Teasdale et al., 2002). Decentering involves learning to observe thoughts and emotions as transient mental events, rather than enduring reflections of the self (Safran & Segal, 1996 as cited in Chittaro & Vianello, 2016). Developing a decentered perspective is defined as an awareness of thoughts and feelings as separate from the self, so that the individual is able to notice thoughts and feelings as they arise and recognise that they can step back from them, or let them go (Baer, 2013). Rather than identifying personally with the negative thoughts and feelings, the individual is able to relate to negative experiences as mental events in a wider context of awareness, which in turn affects behaviour (Teasdale et al., 2002).

Mindfulness-based approaches

Mindfulness can be cultivated through a number of well-established approaches. Validated mindfulness-based approaches include; Mindfulness-Based Stress Reduction (Kabat-Zinn, 1985), Dialectical Behavioural Therapy (DBT; Linehan et al., 1991), Acceptance and Commitment Therapy (ACT; Hayes, Strosahl, & Wilson, 1999) and Mindfulness-Based Cognitive Therapy (MBCT; Segal, Williams, & Teasdale, 2002). Mindfulness interventions aim to promote greater attention to and awareness of the present moment experience of both external and internal stimuli. In mindfulness and acceptance-based approaches

therapists work with clients to shift their relationship to thoughts and feelings in order to foster new ways of responding to difficult internal experiences of external situations. Rather than challenging maladaptive patterns of thoughts, mindfulness approaches develop acceptance of difficult thoughts and emotions, and promote a space between thinking or feeling and then choosing to respond (Siegel et al., 2009).

Stress Reduction

Mindfulness-Based Stress Reduction (MBSR; Kabat-Zinn, 1985) was initially developed to treat chronic pain and has since been employed with a wide range of chronic clinical conditions, as well as with relatively healthy individuals to improve the response to stresses of daily life (Grossman, Niemann, Schmidt, & Walach, 2004; Khoury, Sharma, Rush, & Fournier, 2015). MBSR is an 8-week program where participants learn to foster mindfulness in their lives using a standardised evidenced based protocol. MBSR consists of weekly 2-2.5 hour group-based classes with a qualified teacher, daily audio-guided home practice (approximately 42 min/day), and a day-long mindfulness retreat on the sixth week (Kabat-Zinn, 1990). Formal guided mindful practices include; the body scan, mindfulness of the breath, sounds and thoughts, mindful movement, and mindfulness of everyday activities (Cavanagh, Strauss, Forder, & Jones, 2014). Through formal practice, MBSR aims to shift the relationship to stressful thoughts and events by decreasing emotional reacting and enhancing cognitive appraisal (Khoury et al., 2015). By learning to become aware of automatic patterns of responding, in a non-judgemental manner, participants can develop new ways of coping in response to stressful situations (Gotink, Meijboom, Vernooij, Smits, & Hunink, 2016). Substantial benefits have been reported with MBSR in the literature across a diverse range of clinical and non-clinical populations (Grossman et al., 2004; Kabat-Zinn, 2003b; Kabat-Zinn, Lipworth, & Burney, 1985; Kabat-Zinn et al., 1992; Khoury et al., 2015). Studies have demonstrated reduction in stress, depression, anxiety and distress, as well as changes in the physiological response to stress including reductions in levels of cortisol, heart rate and inflammation (Khoury et al., 2015). Consistent and relatively strong effect sizes across very different populations indicate that MBSR can enhance general features of coping with distress and disability in everyday life, as well as for serious disorders or stress (Grossman et al., 2004).

Mindfulness-Based Cognitive Therapy

The Mindfulness-Based Cognitive Therapy (MBCT; Segal, Williams, & Teasdale, 2002) approach uses both cognitive therapy and mindfulness techniques for the treatment of recurrent major depressive disorder (MDD). MDD is one of the most prevalent and debilitating affective disorders (Kessler et al., 2014). The risk of recurrence in MDD is around 50% and increases with each episode (Kessing, Hansen, Andersen, & Angst, 2004). MBCT is based on a model of cognitive vulnerability to depressive relapse and recurrence (Segal, Williams, & Teasdale, 2013). The systematic training in mindfulness meditation is modelled on the MBSR program. Systematic reviews of MBCT in randomised controlled trials (RCTs) support MBCT as a method for treating depression as well as anxiety (Coelho, Canter, & Ernst, 2013; Fjorback, Arendt, Ornbol, Fink, & Walach, 2011; Galante, Iribarren, & Pearce, 2013; Gu, Strauss, Bond, & Cavanagh, 2015; Metcalf & Dimidjian, 2014; Segal et al., 2013).

Dialectical Behavioural Therapy

Dialectical Behavioural Therapy (DBT; Linehan et al., 1991) is a cognitive behavioural therapy with a focus on mindfulness and acceptance strategies. DBT was created by Dr Linehan to treat chronically suicidal individuals and developed into a comprehensive treatment for Borderline Personality Disorder (BPD) (Linehan, Armstrong, Suarez, Allmon, & Heard, 1991). BPD is a personality disorder characterised by prominent and pervasive dysregulation of emotion, behaviour and cognition. Emotion dysregulation is defined as a lack of skills needed, or using maladaptive strategies to regulate emotional responses (Kring & Sloan, 2010). Central to BPD, emotion dysregulation is considered a transdiagnostic problem due to its relevance to the majority of psychological disorders (Neacsiu, Eberle, Kramer, Wiesmann, & Linehan, 2014).

DBT is a comprehensive treatment program that includes weekly group training, individual therapy sessions and telephone coaching (Kliem, Kroger, & Kosfelder, 2010). The dialectic in DBT signifies the tension between accepting the client as they are in that moment and simultaneously moving towards change and creating a life worth living (Rizvi, Welch, & Dimidijian, 2009). The core mindfulness skills in DBT are designed to help individuals

focus on the present moment, let go of memories of the past, and worries about the future (Rizvi et al., 2009). Skills training includes: developing mindful attention (increasing awareness of thoughts and emotions), emotion regulation (acceptance of emotional distress and decreasing impulsive behaviour in response to emotion), increasing self-validation and promoting interpersonal effectiveness (Kliem et al., 2010; Rizvi et al., 2009). In a recent meta-analysis and systematic review, DBT demonstrated efficacy in stabilising and controlling self-destructive behaviour in BPD clients and improving compliance (Panos, Jackson, Hasan, & Panos, 2014).

Acceptance and Commitment Therapy

Acceptance and Commitment Therapy (ACT) is a trans-diagnostic approach that focuses on increasing psychological flexibility by emphasising mindfulness, acceptance, and values-based committed action (Räsänen, Lappalainen, Muotka, Tolvanen, & Lappalainen, 2016). The psychological flexibility model underlying ACT provides a unified model of behaviour change (Hayes, Pistorello, & Levin, 2012). In ACT, rather than changing or disputing negative thoughts, clients are taught to defuse from them using mindfulness and acceptance techniques that promote the process of disentanglement (Hayes, Strosahl, & Wilson, 2012). Instead of seeking to reduce uncomfortable emotions and sensations, clients are encouraged to mindfully accept these experiences with an emphasis on living in accordance with personal values (Hallis, Cameli, Dionne, & Knäuper, 2016). Support for the ACT model has been shown to have positive outcomes across a broad range of psychological problems (A-Tjak et al., 2015). The American Psychological Association has stated that ACT has modest research support for treating depression (American Psychological Association, 2016; Hallis et al., 2016).

Measuring Mindfulness

How mindfulness is conceptualised and assessed within research and clinical settings has considerable importance for the field. A large body of literature supports mindfulness based treatment for reducing psychological distress and increasing wellbeing (Creswell, 2017; Gotink et al., 2015). However, less research exists about the extent to which participants

acquired mindfulness skills during the interventions, or what specific aspects of mindfulness contribute to the positive treatment effects. In the first meta-analytic review of mindfulness-based interventions (Baer, 2003), none of the twenty-one studies reviewed had included measures of mindfulness. This highlights the lack of validated mindfulness measures that were available to assess changes in mindfulness alongside psychological outcomes. The literature reporting benefits of mindfulness on clinical outcomes continues to lack studies analysing measures of mindfulness. A more recent meta-analysis of Mindfulness Based Therapy (MBT) examined 209 studies and reported less than half (45%) of the studies had analysed measures of mindfulness alongside psychological outcomes, whereas the remaining 55% measured psychological outcomes alone. The lack of studies measuring mindfulness makes it difficult to verify causal pathways responsible for the psychological benefits. As investigations increasingly seek to understand the active components of mindfulness underlying clinical outcomes, the development of reliable and valid measurements of mindfulness is necessary.

The difficulty operationalising the construct of mindfulness, and the overlapping aspects of the construct has made developing validated measures of mindfulness problematic in the literature. As previously introduced, mindfulness is unusually difficult to define and conceptualise given the many aspects it encompasses. Some studies have supported the conceptualisation of mindfulness as distinct and stable facets, whereas others suggest mindfulness is intertwined with connected aspects that cannot be explicated (Baer, Walsh, & Lykins, 2009). Mindfulness has been presented as a dispositional quality that is a universal human capacity to varying degrees (Shapiro & Carlson, 2017). At other times, mindfulness is viewed as an attentional state, which can be acquired through training (Sayers, Creswell, & Taren, 2015).

Several self-report instruments have been developed in recent years to assess mindfulness in daily life (Baer et al., 2008; Baer et al., 2009; Bergomi, Tschacher, & Kupper, 2013a; Walach, Buchheld, Buttenmüller, & Kleinknecht, 2006). Each of the validated measures represents an attempt to operationalise the construct of mindfulness and each scale has both weaknesses and strengths reflecting the relatively recent development of the instruments (Bergomi, Tschacher, et al., 2013a; S. Sauer & Baer, 2010). It is beyond the scope of this

review to critique all of the measures here, for a review see (Baer et al., 2009). The first measure of mindfulness that was developed was the Freiburg Mindfulness Inventory (FMI) (Buchheld, Walach, & Grossman, 2001). Subsequent self-report questionnaires were then developed by independent research teams, each based on a specific conceptualisation of the construct of mindfulness (Baer, 2016). These included the Mindful Attention Awareness Scale (Brown & Ryan, 2003), the Kentucky Inventory of Mindfulness Skills (Baer, Smith, & Allen, 2004), the Cognitive and Affective Mindfulness Scale-Revised (Feldman, Hayes, Kumar, Greeson, & Laurenceau, 2007) and the Southampton Mindfulness Questionnaire (Chadwick et al., 2008).

The Five Factor Mindfulness Questionnaire (FFMQ) (Baer, Smith, Hopkins, Krietemeyer, & Toney, 2006) was developed in an attempt to produce a comprehensive measure that constructs mindfulness multi-dimensionally (Baer et al., 2009). To examine the elements of mindfulness systematically, Baer et al. (2006) combined responses to all five of the above questionnaires into a single data set and conducted an exploratory factor analysis to examine the underlying dimensions (Baer et al., 2009). This analysis allowed items from different instruments to combine to form factors, yielding an empirical integration of these independent attempts to operationalise mindfulness (Baer et al., 2009). The FFMQ differentiates mindfulness across five subscales as identified by factor analysis: (1) *Observing* the immediate experience, (2) *Describing*/labelling the experience in words, (3) *Acting with awareness*, (4) *Non-judgment* of experience, and (5) *Non-Reactivity* to inner experience (Baer et al., 2008).

Baer (2008) suggests that investigating facets of mindfulness is likely to improve our understanding of the specific skills that are cultivated through the practice of mindfulness and how these are related to psychological adjustment (Baer et al., 2008). Using multi-faceted measures of mindfulness presents more opportunity to capture both the attentional and attitudinal aspects of the construct (Keng & Tong, 2016). Several authors have argued that assessment of mindfulness using complex constructs at the facet level is essential for clarifying the relationship of the active components of mindfulness with outcome variables (Schneider, Hough, & Dunnette, 1996; Smith et al., 2007; Smith, Fischer, & Fister, 2003; Smith & McCarthy, 1995). Others recommend that future research should expand the

assessment of mindfulness to include methods other than self-report questionnaires, citing a growing number of laboratory experiments that study the effects mindfulness and assess how participants cope with stressors, or that use experience sampling methods as a means to examine individuals' mindful awareness during daily activities (Brown & Ryan, 2003).

The current research was designed to address the limitations of previous studies assessing mindfulness and clinical outcomes. The literature reporting benefits of mindfulness on clinical outcomes continues to lack studies analysing measures of mindfulness. The lack of studies measuring mindfulness makes it difficult to verify causal pathways responsible for the psychological benefits. The current study addresses this gap in the literature by measuring psychological outcomes with both self-report measures of mindfulness as well as objective laboratory assessments of theoretically relevant processes. By including both self-report and objective measures of mindfulness it was hoped the current study would provide a thorough assessment of the extent to which participants acquired mindfulness skills during the intervention, and which specific aspects of mindfulness contributed to treatment effects.

Given that no single method of psychological assessment can provide a complete picture of the characteristic it is designed to measure, two self-report measures were used in an attempt to explore the complex construct of mindfulness within this research. Understanding how different items in mindfulness questionnaires are interpreted in different sample groups is unresolved in the literature given the relatively recent development of the instruments and the difficulty operationalising the many aspects of mindfulness. Continued testing and development of instruments validated in different sample groups is required. As such, it was considered beneficial to use two measures in the current sample to explore both the attentional and attitudinal aspects of the construct.

The FFMQ was used in this study to provide more detailed information about the different facets of mindfulness that might be responsive to the intervention, and associated with adaptive outcomes. It was selected on the basis that evidence has demonstrated that changes in dispositional mindfulness are sensitive to participation in mindfulness interventions, including MBMA interventions. FFMQ mindfulness was found to mediate the relationship

between formal mindfulness practice and measures of symptom reduction and well-being (Carmody & Baer, 2008). The FFMQ was developed in a large sample of undergraduate students with little or no meditation experience (Baer et al., 2006). The five-facet scales demonstrated adequate to excellent internal consistency. The *Methods* section of this thesis contains further information about properties of the FFMQ.

The FMI was used in the study because it captures several components of mindfulness and is associated with reduced psychological symptoms. (Walach, Buchheld, Buttenmüller, Kleinknecht, & Schmidt, 2006). The 14-item short form is reported as a robust version of the FMI, which is semantically independent from a Buddhist or meditation context. It is recommend for populations without knowledge of the Buddhist background of mindfulness. Validation studies indicated that an increase in mindfulness as measured by the FMI is related to a decrease in psychological symptoms. Higher scores on both the 30-item and 14-item versions of the FMI were related to increased private self-awareness and self-knowledge, decreased dissociation, and lower psychological distress in meditating and general adult samples (Baer et al., 2009). The *Methods* section of this thesis presents a more detailed overview of the psychometric development of the FMI and structural analysis.

1.3 BENEFITS OF MINDFULNESS

Mindfulness and mental health

Mindfulness and acceptance-based approaches have been shown to elicit beneficial effects on a number of psychological and stress-related symptoms and have been incorporated into various therapeutic approaches with positive results (Hayes, Pistorello, et al., 2012; Kabat-Zinn, 2003a; Linehan & Wilks, 2015; Segal, Williams, & Teasdale, 2002). Large amounts of empirical evidence has now accrued to support the efficacy of mindfulness-based treatments for a variety of mental and physical health difficulties (Chiesa, Fazia, Bernardinelli, & Morandi, 2017). A review of empirical studies concluded that mindfulness practice can bring about various positive psychological effects including increased subjective wellbeing, reduced psychological distress, and improved behavioural and emotional regulation (Keng, Smoski, & Robins, 2011).

Engagement in mindfulness-based interventions in various formats is associated with reduction in psychological distress and improvements in anxiety and mood in clinical populations (Hofmann, Sawyer, Witt, & Oh, 2010; J. Miller, Fletcher, & Kabat-Zinn, 1995; Perestelo-Pereza, Barracac, Penated, Rivero-Santana, & Alvarez-Pereze, 2017; Piet & Hougaard, 2011). A meta-analysis of Mindfulness Based Therapy (MBT) concluded that MBT is an effective treatment for a variety of psychological problems and is especially effective for reducing symptoms of anxiety, depression and stress (Khoury et al., 2015). The meta-analysis examined 209 studies with over 12,000 participants and found large and clinically significant effects treating anxiety and depression, and the gains were maintained at follow up. The meta-analysis identified that only 45% of the studies analysed measures of mindfulness, whereas the remaining 55% measured psychological outcomes without assessing mindfulness measures as well. The lack of studies measuring mindfulness makes it difficult to verify causal pathways responsible for the psychological benefits. The results from the studies that did examine changes in self-reported mindfulness showed that participants in MBT were more mindful post-treatment and there was a strong positive correlation between mindfulness levels and clinical outcomes. The authors concluded that

the results provide preliminary support for the role of mindfulness in the effectiveness of MBT but future studies need to explore the causal mechanisms of action for MBT.

Mindfulness interventions have been demonstrated in RCTs to impact a broad range of outcomes (Piet & Hougaard, 2011). It has been argued that methodological limitations within the literature make it difficult to draw strong inferences about the validity and reliability of mindfulness intervention effects on some outcomes (Creswell, 2017). Creswell (2017) cautions that many mindfulness interventions have used small samples and lack high-quality pre-treatment, post-treatment, and follow-up measures. To date, the studies that have provided the most robust evidence for the efficacy of MBTs are MBSR (Kabat-Zinn, 1990) and MBCT (Segal, Williams, & Teasdale, 2002). MBSR and MBCT have demonstrated large and clinically significant effects in a wide range of mental and physical disorders (Gotink et al., 2015; Grossman et al., 2004; Gu et al., 2015; Khoury et al., 2015; Metcalf & Dimidjian, 2014; Piet & Hougaard, 2011; Teasdale et al., 2002). Evidence from 187 reviews supports the use of MBSR and MBCT for the treatment of, anxiety disorders, depression, chronic pain, cardiovascular disease and as an adjunct treatment of cancer (Gotink et al., 2015). The MBCT program has provided some of the strongest evidence, demonstrating significant reduction in risk for relapse for a major depressive episode compared to treatment as usual or placebo controls (Piet & Hougaard, 2011; Teasdale et al., 2000). RCTs have demonstrated that the 8-week MBCT is a cost-effective treatment that significantly reduces depression relapse during long-term follow-up periods ranging from 12 months to 2 years (Creswell, 2017; Teasdale et al., 2000).

Despite methodological limitations within the literature, there is a convergence of findings from correlational studies, and clinical intervention and laboratory studies that suggest mindfulness is positively correlated with psychological health (Keng et al., 2011). However, the explanatory mechanisms responsible for these associations are far less understood (Bice, Ball, & Ramsey, 2014). Authors of a recent citation analysis of the literature about mindfulness observed a general increase in the number of reviews published and concluded that as mindfulness research advances, higher attention should be given to the mechanisms by which mindfulness interventions work in order to provide necessary insights for future research (Chiesa et al., 2017).

Mindfulness and wellbeing

MBTs have been shown to attenuate stress and maladaptive coping, improve mood and increase psychosocial wellbeing across clinical (Hill, McKernan, Wang, & Coronado, 2017), and non-clinical populations (Cousin & Crane, 2016) including university students (Erogul, Singer, McIntyre, & Stefanov, 2014; Zimmaro et al., 2016) and professionals (Manotas, Segura, Eraso, Oggins, & McGovern, 2014). Mindfulness is thought to enhance wellbeing by fostering an ability to disengage from automatic thoughts, habits and maladaptive patterns of behaviour (Brown & Ryan, 2003). The mechanisms by which mindfulness affects wellbeing are not yet clearly resolved in the literature. Studies have shown that mindfulness is positively associated with several facets of wellbeing, including positive affect, life satisfaction, psychological fulfilment, and self-regulation (Brown et al., 2007; Hart, Ivtzan, & Hart, 2013; Shapiro, 2006).

Accumulating evidence indicates that mindfulness is associated with improving emotional wellbeing, measured by an increase in positive affect, self-esteem, and adaptive emotion regulation, and/or a decrease in negative affect and psychopathological symptoms (Bergomi, Ströhle, Michalak, Funke, & Berking, 2013; Brown & Ryan, 2003; Kiken & Shook, 2014; Walach, Buchheld, Buttenmüller, & Kleinknecht, 2006). A recurring finding is that self-report measures of dispositional mindfulness are associated with reduced negative affective states and positively associated with positive affective states and traits (Brown et al., 2007). A meta-analysis that analysed over 2000 participants found that mindfulness was positively correlated with positive affect and negatively correlated with negative affect (Giluk, 2009). In a non-clinical sample of 75 healthy adults, Cousin (2016) reported significant improvements in positive affect compared to a control group, with decreased use of disengagement coping styles (i.e., problem avoidance, self-criticism, social withdrawal) mediating these improvements (Cousin & Crane, 2016).

Some studies have shown that mindfulness is correlated with subjective wellbeing and psychological need fulfilment (Chang et al., 2015). Need fulfilment refers to the individual's desire to fulfil or obtain core human needs that are not present or that one desires to maintain. (Williams, 2009 as cited in Bice et al, 2014). Two studies assessed 475

undergraduate students at university on measures of subjective wellbeing, including positive and negative affect, and life meaning (Chang et al., 2015). The authors found that across both studies, basic psychological needs fulfilment mediated the relationship between mindfulness and wellbeing. They suggested that mindfulness can serve as an alternative pathway for psychological needs fulfilment via a intrapersonal process rather than a interpersonal process (Chang et al., 2015). Another study with 399 university students and employees demonstrated a significant positive relationship between mindfulness and need fulfilment, and these variables were negatively associated with poor mental health outcomes (negative affect and depressive symptoms) (Bice et al., 2014). The authors also found that need fulfilment partially mediated the relationship between mindfulness and mental health outcomes. These studies highlight the positive relationship between mindfulness and wellbeing. However, further research is needed to elucidate the underlying psychological mechanisms relating mindfulness to wellbeing.

Mindfulness and stress

The observed effects of mindfulness on health may be explained in part by the capacity of mindfulness to foster resilience to stress (Creswell et al., 2014). The effects of stress tend to accumulate over time, and can lead to serious health problems. Heightened stress reactivity, or the tendency to respond to stress with higher levels of negative affect, predicts poorer mental health outcomes (Wichers et al., 2009). Changing the way stressful events are perceived can positively impact affective states and ameliorate the adverse physiological and psychological responses to stress (Taylor, 2014a). It has been hypothesised that higher dispositional mindfulness may facilitate the ability to be more accepting and receptive to stressors as they arise, in a way that buffers threat appraisals and improves coping (Kaiseler, Poolton, Backhouse, & Stanger, 2017; Zimmaro et al., 2016). As a result, by responding more receptively and detecting early symptoms of stress, an individual may be better able to implement positive coping strategies in response to stressful situations (Bergin & Pakenham, 2016; Salmon et al., 2004).

The effect of mindfulness practice on the response to stress has been well documented across several different populations (Grossman et al., 2004; Khoury et al., 2015; Pascoe et

al., 2017). Several studies have reported that mindfulness is related to lower perceived stress, and physiological reactivity (Bergin & Pakenham, 2016; Creswell et al., 2014; Hwang et al., 2017; R. Jacobs et al., 2017; Snippe et al., 2017; Suyi, Meredith, & Khan, 2017; Zimmaro et al., 2016). These results demonstrate that mindfulness practice can modulate physiological reactivity to stress. The most recent systematic review and meta-analysis based on 45 RCTs found that meditation practice leads to decreased physiological markers of stress (blood pressure, heart rate, lipids, cortisol activity and inflammatory mediators) in a range of populations (Pascoe et al., 2017). Their findings show that mindfulness interventions can decrease activation of the sympathetic nervous system (SNS), responsible for the fight-flight stress response (Pascoe et al., 2017). While this response is adaptive during times of acute threat, modern life stressors can cause pathological arousal associated with physical and mental ill health (Pascoe et al., 2017).

Studies have examined the effectiveness of mindfulness interventions for stress in university students generating positive results (Creswell et al., 2014; Kerrigan et al., 2017; Zimmaro et al., 2016). A recent qualitative study explored the role of mindfulness training in a highly-ranked North American university setting. The results indicated students are exposed to a high level of constant stress related to study and life demands, and may experience additional pressures such as socially prescribed perfectionism, which contributes to on-going stress and related risk behaviours (Kerrigan et al., 2017). Students responded well to the MBSR intervention generally reporting that the sessions were helpful and describing positive experiences. The authors concluded that MBSR and mindfulness programs may contribute to improved health and wellbeing for students and a more supportive learning environment (Kerrigan et al., 2017). Another study assessed the efficacy of a brief (3-day) mindfulness meditation training intervention in a RCT with 66 university students (Creswell et al., 2014). The results of the study established that the brief mindfulness training reduced self-reported psychological stress reactivity. The study was the first to demonstrate that that a small dose of mindfulness meditation (25-min per day, for 3 days) can reduce stress reactivity (Creswell et al., 2014).

Dispositional mindfulness has been associated with reduced stress in university students (Kaiseler et al., 2017; Soysa & Wilcomb, 2015). Kaiseler et al (2017) assessed measures of

dispositional mindfulness in 202 student-athletes using the 39-item FFMQ. The results of their study showed that *Non-Judge* and *Act-Aware* facets were negative predictors of life stress, and were positively associated with higher coping effectiveness and lower decision rumination. Whereas, the *observe* facet was found to be a positive predictor of stress (Kaiseler et al., 2017). Examining facets of mindfulness among 204 undergraduate students in the USA, Soysa and Wilcomb (2015) also found that the facets *Non-Judge*, *act with awareness*, and *Non-React* were inversely associated with stress. In a more recent study, Zimmaro et al (2016) assessed measures of mindfulness, perceived stress and psychological wellbeing from 84 university undergraduates. These results indicated that students with higher dispositional mindfulness reported significantly less perceived stress and had lower mean diurnal cortisol (as a measure of physiological stress reactivity) and reported increased wellbeing.

These findings suggest that mindfulness practice may assist students to manage life stress and improve self-regulation skills and highlights the importance for researchers and practitioners to consider the facets of mindfulness. Evidence has been presented to demonstrate that mindfulness practice can modulate physiological reactivity to stress and improve wellbeing. The following section explores the mechanisms by which mindfulness may positively impact affective states and ameliorate the adverse physiological and psychological responses to stress.

Mindfulness and emotion regulation

Several authors have begun to investigate the mechanisms of mindfulness within the context of emotion regulation (Chambers et al., 2009; Chiesa et al., 2013; Garland et al., 2010; Guendelman, Medeiros, & Rampes, 2017). It has been suggested that emotional regulation may be a key neural mechanism by which mindfulness practice elicits a clinical benefit (Chiesa et al., 2013). Evidence suggests that mindfulness practice is associated with areas in the brain that establish the processes of enhanced self-regulation (Holzel et al., 2011). Research studies have indicated that mindfulness is conducive to a variety of practical forms of self-regulation, including the regulation of negative emotions and problematic behaviours (Ostafin, Robinson, & Meier, 2015). This section introduces

mechanisms of mindfulness in relation to emotion regulation strategies and highlights relevant research in the area.

Emotion regulation is defined as the process by which individuals modulate their emotional experience and expression (Gross, 1998). Emotion regulation strategies are understood as complex processes, and a detailed description is beyond the scope of this paper, for a review see (Gross, 2013). Two main strategies of emotion regulation are suppression and reappraisal (Corcoran et al., 2010). Suppression involves the deliberate inhibition of emotional expression, whereas reappraisal strategies aim to reinterpret the emotive stimulus in order to modify the emotional impact (Nyklíček, 2011). Emotion dysregulation or using maladaptive strategies to regulate emotion is a component of most psychopathologies (Amstadter, 2008; Kring & Sloan, 2010). Avoidance is a common maladaptive emotion regulation strategy (Corcoran et al., 2010). Strategies of avoidance include distraction, suppression of thoughts and emotions, or avoidance of people and places, and emotional or experiential avoidance (Corcoran et al., 2010). Using substances or engaging in risky behaviour are forms of emotional avoidance (Linehan, 1993). Experiential avoidance is defined as an escape or avoidance of internal experiences (i.e., thoughts, emotions and physical sensations) (Boulanger, Hayes, & Pistorello, 2010). In contrast, over-engagement with emotions is another central emotion regulation strategy that includes rumination, obsessions, worry and compulsions (Corcoran et al., 2010). Repetitive forms of thinking about the past and present (rumination), or about the future (worry) involve cognitive over-engagements in an attempt to control or mitigate unpleasant emotional experiences (Desrosiers et al., 2013).

It has been put forward that mindfulness mediates effects on wellbeing by decreasing rumination and experiential avoidance, and improving self regulation (Baer, 2009). Mindfulness develops greater acceptance of emotions, by encouraging observation of thoughts, feelings and sensations as they arise, noting any tendency to evaluate or appraise, and consciously not engaging in these processes (Chambers et al., 2009). Directing attention on purpose and without judgment is a central component of mindfulness practice. Greater attentional training may result in changes to maladaptive strategies used to deal with negative internal experiences. Through repeated observation of affective states, people

learn that emotions fluctuate and dissipate. In this way, mindfulness develops increased openness to and acceptance of thoughts and feelings, whether they are pleasant or unpleasant, and removes the need to intervene with strategies of avoidance and suppression.

Specific emotion regulation strategies (suppression, avoidance, rumination, worry, non-acceptance, and reappraisal) have been shown to mediate associations between mindfulness and various outcome measures (Baer et al., 2006; Brown & Ryan, 2003; Chambers et al., 2014; Desrosiers et al., 2013; Freudenthaler, Turba, & Tran, 2017; Keng, Tan, Eisenlohr-Moul, & Smoski, 2017). Freudenthaler et al (2017) concluded that mindfulness exerts positive effects on mental health mostly via improving emotion regulation. Their study operationalised emotion regulation with the Difficulties in Emotion Regulation Scale (DERS). Their findings demonstrated that trait mindfulness was associated with greater emotion regulation mediating the symptoms of depression and anxiety (Freudenthaler et al., 2017). Chambers et al (2014) demonstrated that mindfulness was negatively correlated with rumination and with all symptoms of depression and anxiety. The authors support a hypothesis that dispositional mindfulness is a distinct dimension of emotion regulation. They concluded that mindfulness, as a separate emotion regulation strategy, is associated with positive mental health outcomes and better quality of life (Chambers et al., 2014).

Evidence is emerging that suggests mindfulness training may modulate affect and emotion reactivity (Giluk, 2009; Kiken & Shook, 2014). Some evidence has shown that mindfulness may increase attentional stability and decrease reactivity to emotion provocation (Farb, Anderson, Irving, & Segal, 2015). Attentional bias to negative information is understood to make a maladaptive contribution to emotion regulation that elevates emotional vulnerability (MacLeod & Grafton, 2015). It has been reported that mindfulness training can improve a person's ability to control their attention when faced with emotional distractors, such as the Emotion Stroop Task (see *Methods* section for details) (Lykins et al., 2012). Other studies have reported that mindfulness elevates positive affect (Garland, Geschwind, Peeters, & Wichers, 2015; Kiken, Lundberg, & Fredrickson, 2017) and decreases negative affect (Keng et al., 2017). Garland et al (2015) reported significant increases in positive affect associated with mindfulness and Keng et al. (2017) reported that mindfulness is an effective regulation strategy to facilitate reductions in sad mood.

Mindfulness training is thought to develop a metacognitive, or *decentered* awareness, that promotes experiencing thoughts, emotions and physical sensations, as transient mental events (Chambers et al., 2009; Corcoran et al., 2010). Teasdale and colleagues (2002) describe metacognitive awareness as a cognitive process in which negative thoughts and feelings are observed as 'passing events in the mind rather than inherent aspects of the self or reflections of reality' (Teasdale et al., 2002). They examined 100 patients undergoing MBCT and reported that the ability to adopt a decentered perspective may be an important mediator in the effectiveness of the treatment (Teasdale et al., 2002). Decentering has been demonstrated to mediate the effect of mindfulness on the reduction of emotional arousal in meditative states (Shoham, Goldstein, Oren, Spivak, & Bernstein, 2017).

Similarly, Shapiro (2006) describe *reperceiving*, as a meta-mechanism, in which one is able to dis-identify from the 'contents of consciousness (i.e., one's thoughts, emotions, value judgement) and view their moment by moment experience with greater clarity and objectivity (Shapiro, 2006). This dis-identification process is described in relational frame theory as *cognitive defusion*, and is a central process in ACT (Hayes, Pistorello, et al., 2012). The perspective afforded by *decentering*, *reperceiving* or *defusing*, may serve to disrupt habitual ways of interpreting and creating time for reappraisal (Farb et al., 2015; Garland, Gaylord, & Fredrickson, 2011). An increased ability to disengage from self-elaborative rumination or worry creates an opportunity for re-interpreting a difficult or challenging experience. Garland et al. (2011) conducted a prospective observational study of 339 participants undergoing an 8-week MBSR course and reported that the effect of dispositional mindfulness on reducing stress was mediated by increases in positive reappraisal. The authors reported that the ability to mindfully *decenter* from cognitive appraisals and observe present-moment experience without judgement, may promote positive reappraisal coping over time. In this way, mindfulness may cultivate positive reappraisal, or the adaptive process through which stressful events are reframed as beneficial, meaningful, or benign (Holzel et al., 2011).

These findings illustrate how cultivating mindful attention and awareness can facilitate shifts in perspective that allows for alternative interpretations to lived experience and the response to external stressors. Evidence was presented demonstrating how mindfulness

practice can positively impact affective states and result in positive health outcomes. An introduction to the proposed cognitive mechanisms of action was presented in context with conceptualisations of mindfulness in practice. Research that continues to explore the active components of mindfulness will provide a better understanding of the psychological mechanisms underlying the observed benefits of mindfulness interventions and will serve to inform mindfulness-based practice.

1.4 NOVEL APPROACHES TO MINDFULNESS

Self-directed and online mindfulness training

As the literature grows, different approaches to mindfulness training have emerged. Mindfulness and acceptance-based resources are widely available in the public domain. A recent systematic review and meta-analysis of mindfulness-based interventions summarised the empirical evidence regarding the effectiveness of mindfulness-based self-help interventions (Cavanagh et al., 2014). The review reported effects of internet-based interventions, books, and audio recordings designed to promote mindfulness and acceptance. The researchers found no studies regarding singular use of computer or phone apps for mindfulness-based training. The findings of the review indicated that mindfulness-based self-help interventions result in significant increases in dispositional mindfulness and reductions in depression and anxiety compared to controls. Their review concluded that irrespective of intervention approach format, small to medium effect sizes were found (Cavanagh et al., 2014).

The efficacy of an 8-week self-help version of MBCT was tested in a single-blind RCT in a student sample (Taylor, Strauss, Cavanagh, & Jones, 2014b). Participants engaged in home practice for a median of 2-3 times a week. Consistent with findings that students experience high level of stress, it was reported that participants in the study had more severe symptoms of anxiety, depression and stress at baseline than those typically seen in non-clinical samples (Taylor et al., 2014b). The authors reported significant benefits in the self-help group compared to the waitlist control on measures of depression, anxiety and stress symptom severity with small to medium effect sizes. They also reported significant improvements in satisfaction with life, mindfulness and self-compassion with medium to large effect sizes. The authors recommended that future research should include an active control condition and explore mindfulness as the mechanism of change by collecting data at multiple time points (Taylor et al., 2014b).

Studies investigating the efficacy of delivering mindfulness-based treatments online have demonstrated benefits for various health issues including; stress management (Aikens et al.,

2014; Ljotsson et al., 2011; Morledge et al., 2013), and depression (Dimidjian et al., 2014; Thompson et al., 2010). Thompson (2010) evaluated the efficacy of a home-based depression intervention for people with epilepsy based on MBCT. Forty participants were randomly assigned to one of three conditions. The 8-week intervention was designed for group delivery via the internet or telephone and was compared to a waitlist control. Results of the study demonstrated that both online and telephone interventions were significantly more effective in reducing symptoms of depression than the waitlist control (Thompson et al., 2010). Dimidjian (2014) examined a web-based approach to deliver MBCT called *Mindful Mood Balance.* In a quasi-experimental design, 100 depressed individuals were enrolled and received an 8-session open trial with a 6-month follow up. Findings demonstrated a significant reduction in depressive severity, which was sustained over 6 months, and improvement on rumination and mindfulness. Aikens et al (2014) tested the efficacy of a 7-week online workplace program on measures of mindfulness (FFMQ-39) and perceived stress (PSS). Eighty-nine participants were randomised to an online intervention or waitlist control. The mindfulness group demonstrated significant increases in mindfulness and decreases in perceived stress. The authors concluded that the online intervention was both practical and effective in decreasing employee stress and enhanced work engagement and overall wellbeing (Aikens et al., 2014).

Several studies have begun to investigate the effectiveness of ACT-based interventions using self-directed internet-delivered formats reporting positive trends (Lappalainen et al., 2014; Lappalainen, Langrial, Oinas-Kukkonen, Tolvanen, & Lappalainen, 2015; Räsänen et al., 2016). One study tested the effectiveness of an online self-help iACT intervention compared with a face-to-face ACT intervention for depressive symptoms (Lappalainen et al., 2014). Sixty participants were randomised to a 6-week internet program (*The Good Compass*) or individual ACT-based therapy once a week over the same period of time. Both groups demonstrated a significant reduction in depression symptomatology and an increase in general wellbeing after treatment, which was sustained at the 18-month follow-up. There was a tendency for a slightly better recovery in the iACT group. The authors concluded that guided online ACT interventions can be as effective as ACT-based face-to-face treatment for outpatients reporting depressive symptoms. The authors suggested that the self-directed online program may offer some advantages over a face-to-face

intervention. Participants in the iACT group reported having taken responsibility for their own wellbeing and becoming independent from the therapist. In addition, the internet program allowed access anytime to the site to conduct exercises and rehearse the content if they had not understood it the first time and needed more time to reflect on it. Given the study design did not include a control group, no definitive conclusions can be drawn.

Brief mindfulness interventions

Brief mindfulness-based interventions have been developed and preliminary evidence is gathering to support the efficacy of brief training programs ranging from days to weeks (Creswell et al., 2014; Demarzo et al., 2017; Harnett et al., 2010; Hwang et al., 2017; Montero-Marin et al., 2017; Ruscio, Muench, Brede, MacIntyre, & Waters, 2016). Demarzo et al (2017) tested the efficacy of a 4-week abbreviated MBI protocol and a standard 8-week protocol, compared to a no-treatment control in a sample of 150 undergraduate students. The quasi-experimental design was conducted with pre-post measures and a 6-month follow up. Results from the study demonstrated an improvement in mindfulness levels, anxiety, depression and positive affect in both treatment groups. The authors concluded that the efficacy of abbreviated mindfulness programs may be similar to that of standard MBI programs making them potentially more accessible for a larger number of students (Demarzo et al., 2017). Manotas et al (2014) also demonstrated that a brief (4-week) mindfulness training elicited similar effects as the longer training approaches on measures of perceived stress, mindfulness, anxiety, depression, and somatisation (Manotas et al., 2014). Cavanagh (2013) explored whether a brief online MBI could increase mindfulness and reduce perceived stress and anxiety/depression symptoms within a student population. University students (n104) were randomly assigned to a 2-week mindfulness protocol or a waitlist control. Their analysis identified significant time by group interactions demonstrating improvements in perceived stress, anxiety and depression in the mindfulness group, whereas no changes were observed in the control group (Cavanagh et al., 2013). Another study assessed the efficacy of a brief (3-day) mindfulness meditation training intervention in a RCT with 66 university students (Creswell et al., 2014). The results of the study demonstrated that the brief mindfulness training reduced self-reported psychological stress reactivity. The study was the first to

demonstrate that a small dose of mindfulness meditation (25-min per day, for 3 days) can reduce stress reactivity (Creswell et al., 2014).

These findings provide preliminary support for the feasibility and effectiveness of shorter, self-guided mindfulness-based interventions that are delivered online or via computer. However, many of the studies presented have methodological limitations, with quasi-experimental designs and low power. Future studies that address these limitations are needed to provide support for the use of brief, self-directed or online mindfulness training protocols.

1.5 MOBILE HEALTH & PSYCHOLOGY

What is mobile health?

Mobile health has been broadly defined as 'healthcare to anyone, anytime, and anywhere that removes locational and temporal constraints while increasing both the coverage and the quality of healthcare' (Varshney, 2014 p20). Mobile health applications (apps) refer to programs on smart devices (phones, tablets, computers) for targeted delivery of interventions aimed at improving psychological or physical wellbeing (Jones & Moffitt, 2016). Mobile phones have become an appealing target for the delivery of health interventions because they are widespread, people tend to have them on their person at most times, and they have advancing technical capabilities that can facilitate different personalised functions (Klasnja & Pratt, 2012).

Mobile phone health apps are currently being developed and made available direct to consumers to download. Health-related apps are among the fastest growing app categories (Kortum & Sorber, 2015). The availability of smart phone apps related to psychological health is rapidly growing. It was estimated that there are more than 13,600 health apps intended for use in Apple's App Store (Donker et al., 2013). Of the estimated health apps currently available, approximately 6% are targeted mental health outcomes, while 18% focussed on related health issues; 11% to stress management, 4% to sleep and 2%, to smoking cessation (Donker et al., 2013; Morris & Aguilera, 2012). In a year long study of smartphone users, people spent on average 30 hours a month using apps, which amounted to 2,000 app launches per month and 142 apps downloaded per year (Kortum & Sorber, 2015).

The future of smartphone psychology

It is predicted that the future of psychological practice will be linked with smartphone use to enhance psychological services (Miller, 2012). With increasing user dependency, mobile phones have the potential to influence psychological practice and research. Several authors suggest that smartphones will challenge existing methodologies and transform the delivery

of psychological interventions (Howells, Ivtzan, & Eiroa-Orosa, 2016; Miller, 2012). Their affordability and near ubiquity makes them a cost-effective means of targeting interventions to wide audiences and to complement the practice of psychological assessment and treatment. In a survey among the Australian general public, 76% of those surveyed indicated they would be interested in using mobile phones for the monitoring and self-management of depression, anxiety, and stress as long as privacy and security are assured, the program is intuitive and easy to use, and the feedback is clear (Proudfoot et al.,., 2010).

Global sales of smartphones have more than tripled since 2009 (Plaza, Demarzo, Herrera-Mercadal, & Garcia-Campayo, 2013), and by the end of 2016 it was estimated that 2 billion smartphones were in use (Kortum & Sorber, 2015). By 2025, a projected 8 billion people worldwide will use smartphones (Miller, 2012). With advancing technologies, the smartphones of the future will have far greater capabilities, including better connectivity, sensor options and computing power offering a vast array of functionality. Currently, smartphones have already replaced a large number of other devices creating an unprecedented user dependency.

Technology is adopted when it has a high-perceived usefulness and is also viewed as being easy to use (Kortum & Sorber, 2015). Elements of portability, ubiquity, low cost, and the availability of large numbers of specialised apps make smartphone technology attractive to the user. Mobiles phones have taken on greater emotional and practical significance in people's lives (Morris & Aguilera, 2012). The integration of social networking, wearable and embedded sensors, photography, and other diverse applications, have transformed the mobile phone into a platform for self-expression, social learning, and role exploration. The emotional bond people experience with their smartphones has been described in popular culture and research (Morris & Aguilera, 2012). Some authors have reported that at the neuronal level, people respond to the iPhone sound as they do to a loved one, and that the phone may be experienced as an extension of the self (Morris & Aguilera, 2012). For many, the mobile phone has become an inescapable requirement of modern life. Leaving home without one can cause stress and a sense of social isolation. The strong attachment many users feel towards their mobile phones is evidenced by the numerous checks per day a

person makes on their phone. It is estimated that on average people check their phones every 6.5 minutes, or 150 times per day (Howells et al., 2016).

Given the high user dependency, perceived usefulness and technological capabilities, mobile phones have the potential to enhance psychological practice. Clinicians can make use of mobile technologies in a variety of ways including; psycho-education prior to treatment, guided practice and acquisition of skills learned in therapy, as well individualised tracking of mood and outcome ratings, homework and feedback. Approaches that utilise mobile health apps to deliver psychological services may become increasingly necessary as the demand for services becomes increasingly difficult to meet via the traditional model of individual level therapy (Kazdin & Blase, 2011).

Interventions in this format are considerably less costly than traditional psychological interventions and therefore may be made available to more mental health consumers (Howells et al., 2016). Delivery of psychological services via smartphone apps may reduce the stigma associated with mental health care and lower barriers to seeking treatment (Morris & Aguilera, 2012). Smartphones are portable, so content can be accessed in any geographical location or situational context (Chittaro & Vianello, 2016). In addition, using a phone does not attract attention, so users can engage in the content without fear of judgement or stigma (Ly et al., 2014).

Mobile health apps could be utilised in numerous ways to enhance psychological practice and client learning. Daily tracking systems enable users to input and keep track of subjective mood and outcome ratings. An app can keep track of hours of sleep, anxiety levels, and medication use and can generate reports that could be sent to a family member, or a clinician. In the context of therapy, these assessments can be shared with the treating clinician, tracked over time, and presented in a useful visual display to characterise treatment outcome. Clinicians may provide therapeutic skills training, such as mindfulness techniques, for continued practice of skills outside session. Interactive or adaptive virtual training tools using audio or visual instruction could coach skill rehearsal to ensure successful skill acquisition. It is also possible for physiological variables to be monitored

by an app that incorporates reinforcement for increased relaxation or behavioural activation.

Mobile apps for mindfulness training

Mobile apps represent a potential opportunity to deliver cost-effective mindfulness-based training to a large number of mental health consumers. This medium of delivery may be particularly relevant for at risk youth or young adults who may be unable or unwilling to seek treatment. Mobile phone apps are regularly used by the student demographic and provide an accessible, non-threatening mode of therapeutic delivery. Klasnja and Pratt (2012) suggest that mobile phones are becoming an increasingly important platform for the delivery of health interventions. They suggest that mobile phones are appealing for delivery of health initiatives because they are widespread, people tend to have them on their person at most times, and they have advancing technical capabilities that can facilitate different functions and personalised tracking features (Klasnja & Pratt, 2012).

A mobile mindfulness app has numerous benefits as a therapeutic vehicle; it is cost-effective and can be administered easily to a large number of students. A mindfulness app may be an appropriate and helpful aid for university students dealing with the psychological demands of life and study. Mobile phone apps may provide the necessary assistance for a novice meditator to begin to cultivate formal home based practice.

1.6 MINDFULNESS APP REVIEW

Introduction

The usability and ubiquity of mobile devices makes them a promising target in the delivery of health interventions (Plaza et al., 2013). Mobile phone apps represent a potential opportunity to deliver cost-effective health interventions to a wide audience. Evidence supporting the use of mindfulness-based interventions in a variety of formats has prompted the development of mindfulness-based smartphone interventions. Mobile apps for mindfulness training may support the need for regular practice and have the potential to provide individualised support for ongoing skills acquisition. These approaches present mindfulness techniques in accessible, interactive and novel ways, that may be particularly attractive to a younger demographic or those new to mindfulness practice. Despite widespread availability of mindfulness apps, few studies have assessed their effectiveness. This section provides an overview of research investigating mindfulness app interventions.

Mindfulness app studies

Whilst research in the area is limited, preliminary evidence is beginning to emerge examining the viability of mindfulness-based mobile apps (MBMAs) with mixed results. Numerous MBMAs have been developed and are available direct to the public via the App Store. In a review of MBMAs, Plaza et al. (2013) found that 203 mindfulness-based apps were available on the market, and this number is rapidly increasing. Their review found that while there was a wide selection of MBMAs available, there was a complete lack of evidence supporting the usefulness of those applications. At the time of their review, they found no RCTs evaluating the impact of the various apps on mindfulness training or health indicators. Since then, only three RCTs have been published that include control conditions (Carissoli, Villani, & Riva, 2015; Howells et al., 2016; van Emmerik, Berings, & Lancee, 2017). With two other parallel RCTs comparing two treatment groups (Ly et al., 2014; Morrison Wylde, Mahrer, Meyer, & Gold, 2017). Table 1 presents an overview of the studies investigating mindfulness app interventions.

In the first RCT, Howells et al (2016) investigated the viability of delivering a smartphone based mindfulness application to self-selecting 'happiness seekers'. Participants (n121) were randomly assigned to use either the mindfulness-based app, *Headspace*, or a control condition that used a task list app, *Catchnotes*, for 10 minutes a day for 10 days (Howells et al., 2016). The *Headspace* app provides the user with simple guided mindfulness meditations each day to progress mindfulness practice and animated introductions to mindfulness theory and practice. Screen shots from the *Headspace* app are presented in Figure 1 below.

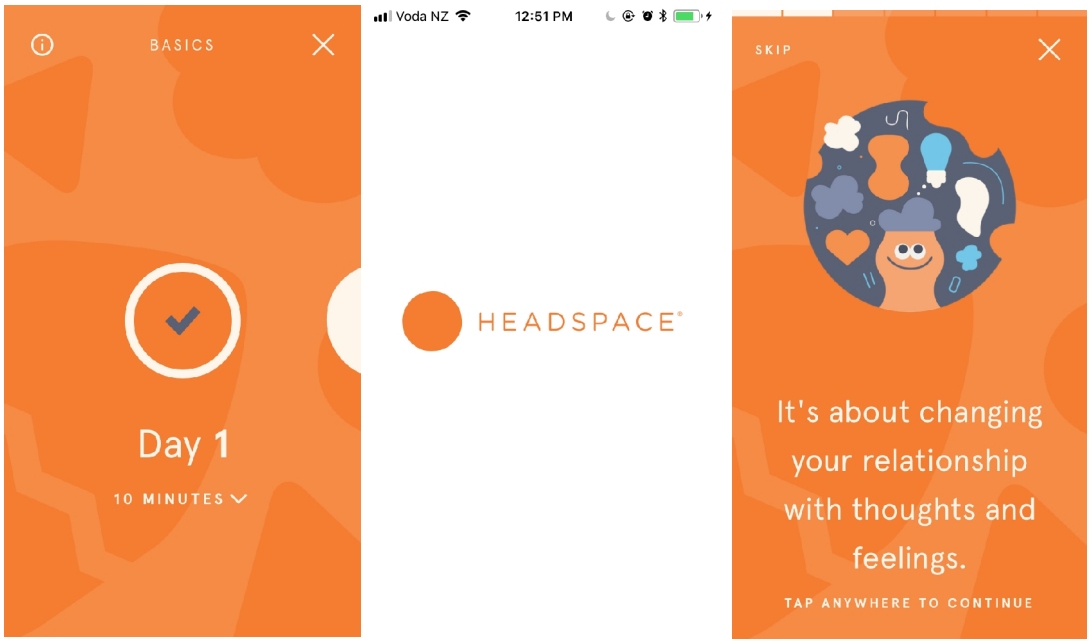

Figure 1. Screen shots of the mindfulness app *Headspace* (Headspace, 2016).

The authors hypothesised that engaging with an empirically based mindfulness app would enhance wellbeing, and that there would be a positive correlation between task enjoyment and wellbeing. The results from the study found that participants in the mindfulness group had significant improvements in positive affect with a medium effect size, and significant decreases in depressive symptoms, with a small effect size (See Table 1 for measures). On both measures there were no significant differences over time for the control group. The

authors detected no significant effects on negative affect, satisfaction with life, or flourishing. They concluded that their findings support the viability of a smartphone-based mindfulness intervention to significantly enhance elements of wellbeing. The authors emphasised the importance of the empirically based app content for beneficial outcomes.

In a parallel RCT, Morrison Wylde et al. (2017) compared the effects of a 'traditionally delivered mindfulness' intervention to the *Headspace* app in a population of (n95) paediatric nurses with no mindfulness experience. The study was part of a larger study investigating stress exposure, compassion fatigue, and burnout and job satisfaction (Morrison Wylde et al., 2017). The traditional mindfulness condition undertook a brief mindfulness training (1 session per week for 4-weeks), in a group format led by a trained Buddhist Priest. The protocol for the intervention was derived from Mackenzie et al (2006), a 4-week abbreviated version of Kabat Zinn's traditional 8-week model. The smartphone delivered mindfulness condition used the *Headspace* app for the same allotted time, once a week for 4-weeks. The smartphone group showed a significantly greater increase on the facet of mindfulness *acting with awareness* and marginally significant on *Non-React* compared to the traditionally delivered mindfulness group. The app condition showed additional benefits on the Compassion Fatigue Test, specifically an increase in *compassion satisfaction* and decrease in *burnout* compared to traditional mindfulness group. The authors concluded that their findings indicate that smartphone interventions may provide more benefits for novice nurses than traditional mindfulness interventions.

A recent pilot study used a quasi-experimental design (without a control group) investigating the feasibility of the *Headspace* app as a method of self-guided mindfulness practice to improve resident physician wellbeing (Wen, Sweeney, Welton, Trockel, & Katznelson, 2017). Participants (n43) used the app on a self-guided basis for 4-weeks and pre-post measures were assessed for stress, wellbeing and mindfulness. Results of the study demonstrated a significant increase in mindfulness measured by FMI and a trend toward increases in the positive affect score, with no difference in the negative affect score. The study demonstrated that increased use of the app was significantly associated with increased frequency of self-reported mindfulness episodes outside the app.

Chittaro and Vianello (2016) investigated the efficacy of a MBMA to teach the mindfulness technique, *decentering*. Participants (n136), 120 new to mindfulness and 16 experienced meditators were enrolled in the study by downloading the app, *Aeon*. Participants agreed to engage with the mindfulness-based app for 4-weeks and complete a series of self-report measures at various stages. The app *Aeon* was designed to evoke the sensation that each thought is impermanent to help users achieve decentering. The interactive thought distancing app, allowed participants to type in a thought and watch it disappear. The authors reported that, after 2-weeks using the app, participants reported significantly higher decentering scores compared to baseline. After 4-weeks, scores had increased significantly yet again. Qualitative feedback provided by participants indicated that the app was positively perceived as beautiful and its usage elicited positive affect for most participants. Screenshots of the *Aeon* app are shown in Figure 2. A control group was not used in the study, so no causal connections can be drawn about the effect of the intervention per se.

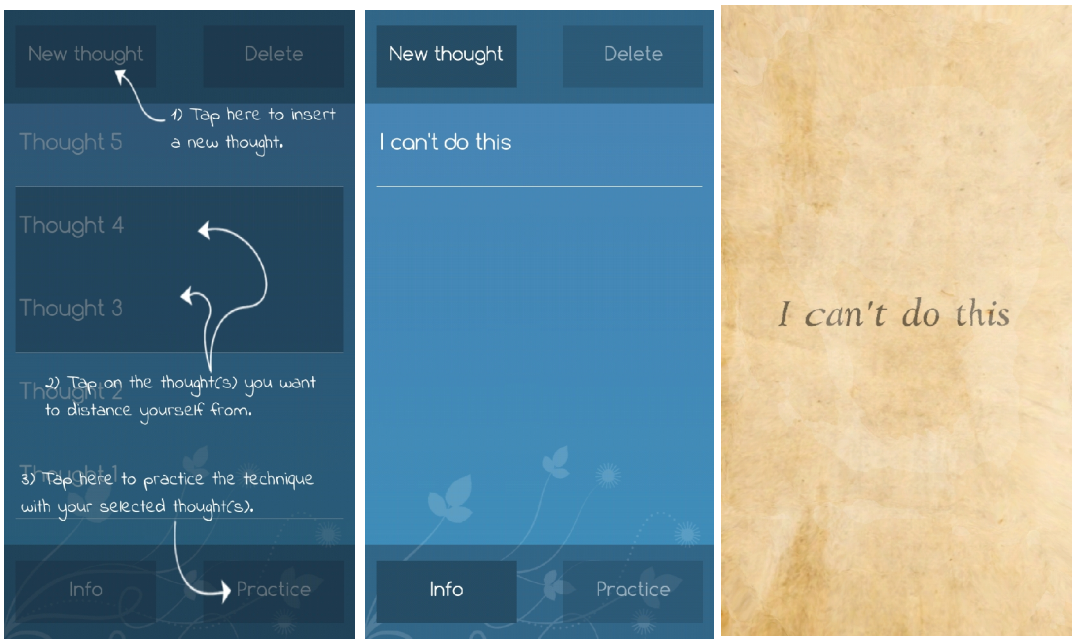

Figure 2. Screen shots of the mindfulness app *Aeon* (Chittaro & Vianello, 2016*)*.

Table 1 Overview of mindfulness app studies

Study	*Method*	*Intervention*	*Hypotheses*	*Outcome measures*	*Results*
Carissoli (2015)	RCT n56 Italian workers Pre-Post 3-weeks	Mindfulness condition: *It's time to relax* mindfulness smartphone app 2x 15 mins per day listening to guided mindfulness exercises Active control: listened to music 2x 15 mins per day Waitlist control	Test the effectiveness of a brief self-help mindfulness intervention supported by a smartphone app in real life routine practice conditions as suggested by the pragmatic trial approach	Main outcomes: Perceived stress Measures: Italian validated version of the Mesure du Stress Psychologique (MSP), Heart rate (BPM) measured manually by each participant before and after exercise	No significant differences were found between groups Both mindfulness and music groups demonstrated a moderate but significant reduction in perceived stress Music and mindfulness groups reported a significant decrease in heart rate
Chittaro & Vianello (2016)	Quasi-experimental research in the large n136 enrolled in the study by down-loading the app, *Aeon* n120 naïve meditators n16 experienced Pre-Post: 4-weeks	All participants engaged with the mindfulness based app *Aeon* for 4-weeks: Interactive thought distancing app Aims to evoke the sensation that each thought is impermanent to help users achieve decentering	Building from their laboratory study the authors predicted that prolonged use (4-weeks) of the app would help cultivate a mindful state and improve it over time	Main outcomes: Decentering and experience of app use Measures:11-item Decentering Subscale of the Experience Questionnaire (DEQ), Qualitative questionnaire Taken at entry, 2-weeks and 4-weeks.	Significant increase in mindfulness for naïve users. App was positively perceived and usage promoted positive feelings No waitlist control
Howells, Ivtzan, & Eiroa-Orosa (2016)	RCT n121 Self-selecting 'Happiness seekers' Pre-Post 10-days	Mindfulness condition: n57 *Headspace* mindfulness app 10 days, 10 mins per day Guided mindfulness exercises and instructional animations Control condition: n64 *Catchnotes* list app 10-days, 10 mins per day Recall and write checklist of activities completed on the same day the week before	Test viability of smartphone to deliver positive interventions: predicted that 'happiness seekers' engaging in an empirically based mindfulness app would enhance wellbeing. Test role of person-activity fit: a positive correlation was expected between task enjoyment and wellbeing	Main outcomes: life satisfaction, positive & negative affect, depression, task enjoyment Measures: Satisfaction with life scale (SWLS), Flourishing scale, Positive and Negative Affect Scale (PANAS), Center for Epidemiologic Studies of Depression Scale (CES-D),	Significant increase in positive affect with medium effect size Significant decrease in depressive symptoms with small effect size. Positive correlation between task enjoyment and wellbeing No significant change on satisfaction with life, flourishing or negative effect

Table 1 Overview of mindfulness app studies continued.

Study	*Method*	*Intervention*	*Hypotheses*	*Outcome measures*	*Results*
Morrison Wylde, Mahrer, Meyer & Gold (2017)	Parallel RCT n95 nurse trainees Pre-Post 4-weeks	Traditionally derived mindfulness: 1x group session per week Smartphone delivered mindfulness app *Headspace*	Part of a larger study examining nurses' stress exposure, compassion fatigue, burnout and job satisfaction	Main outcomes: Mindfulness and burnout Measures: Compassion Fatigue Self Test (CFST), Life Events Checklist (LEC), Posttraumatic stress disorder checklist (PCL-C), Five Facet Mindfulness Questionnaire (FFMQ)	Significant increase in *acting with awareness*, and marginal increase in *Non-React* compared to traditional mindfulness Reduced risk of compassion fatigue in nurses without posttraumatic stress No waitlist control
Ly, Dahl, Carlbring & Andersson (2012)	Quasi-experimental exploratory study n11 Swedish iPhone users Pre-Post: 8-weeks	ACT based smartphone app *Viary* & web-based psycho-education as a self-help intervention for living consistently with one's values *Viary*: assists user to remember and register behaviours in line with values	Assess effect of ACT based smartphone app on valued actions, psychological flexibility and life satisfaction as well as depression, anxiety and stress	Main outcomes: valued actions, psychological flexibility, life satisfaction, depression, anxiety & stress Measures: Bull's Eye Value Survey (BEVS), Acceptance and Action Questionnaire (AAQ-II), Satisfaction with Life Scale (SWLS), Depression, Anxiety, Stress Scale (DASS)	Significant increase in valued action & psychological flexibility General positive experience of intervention No waitlist control
Ly, Trüshel, Jarl, Magnusson, Windahl, Johansson, Carlbring, Andersson (2014)	Parallel RCT n81 community sample with diagnosed major depressive disorder (MDD) Pre-Post: 8-weeks 6-month follow up	Mindfulness condition: n41 Mindfulness smartphone app included guided and unguided mindfulness exercises and theory Behavioural activation: n40 Smartphone app to remember and record behaviours to increase behaviour activation Minimal therapist contact (maximum 20 mins per week)	Evaluate and compare effects of two smartphone-delivered treatments for mild to moderate major depression	Main outcomes: depression Measures: Beck Depression Inventory (BDI-II), Patient Health Questionnaire Depression Scale (PHQ-9). Beck Anxiety Inventory (BAI), Quality of Life Inventory (QOLI), Acceptance and Action Questionnaire (AAQ-II)	Large reductions in depression after both interventions for at least 6 months No waitlist control

Table 1 Overview of mindfulness app studies continued.

Study	*Method*	*Intervention*	*Hypotheses*	*Outcome measures*	*Results*
Wen, Sweeny, Welton, Trokel, Katznelson (2017)	Quasi-experimental single arm pilot study n43 Resident physicians Pre-Post 4-weeks	All participants used the app *Headspace* on a self guided basis	Assess whether a mindfulness practice supported by a self-guided smartphone mindfulness app can improve resident wellness	Outcome: stress, wellbeing and mindfulness Measures: Freiburg Mindfulness Inventory (FMI), PANAS Taken at entry, 2 and 4-weeks	Significant increase in FMI scores Trend toward increase in positive affect No change in negative affect
van Emmerik, Berings & Lancee (2017)	RCT n377 recruited via Facebook ad with Dutch fluency Pre-Post 8-weeks 20-wk follow up	*VGZ mindfulness coach*: 5 week program: 25 preselected audio exercises as well as background information on meditation and mindfulness Participants received a standard weekly email reminder to promote use of the app Waitlist control	Test immediate and long-term efficacy of mindfulness based intervention app compared to a waitlist control without any form of therapeutic guidance in addition to self-help	Outcome: mindfulness primary out come variable Measures: FFMQ, World Health Organization Quality of Life (WHOQOL-BREF), General Health Questionnaire-12 (GHQ-12), Short Index of Self-Actualization (SISA), General satisfaction with app (usability, quality of voice-over, and clarity and usefulness of content, frequency of use)	Significant increases in FFMQ overall and individual facets *Observe, Describe*, *Act with awareness, Nonjudging*, and *Non-React* Large decrease in general psychiatric symptoms Moderate increase in psychological, social and environmental quality of life

In an exploratory study, Ly et al. (2012) compared the effectiveness of an ACT-based smartphone app. The intervention employed a combination of an ACT-based smartphone-application and web-based psychoeducation as a self-help intervention for living consistently with one's values (Ly, Dahl, Carlbring, & Anderson, 2012). The *Viary* app is shown in Figure 3. *Viary* allows users to track valued action in various life domains. The study used a quasi-experimental pre and post-test design without a control group. Eleven participants were enrolled in the study and randomly assigned to use either the mindfulness-based app or the behavioural activation app for 8-weeks. The group analyses showed that the participants in the mindfulness-based intervention increased their valued action and psychological flexibility significantly. The qualitative questionnaire showed a general positive experience of the intervention. Due to the quasi-experimental design of the study, no conclusions can be drawn, but the positive trend indicates the intervention may have a therapeutic benefit.

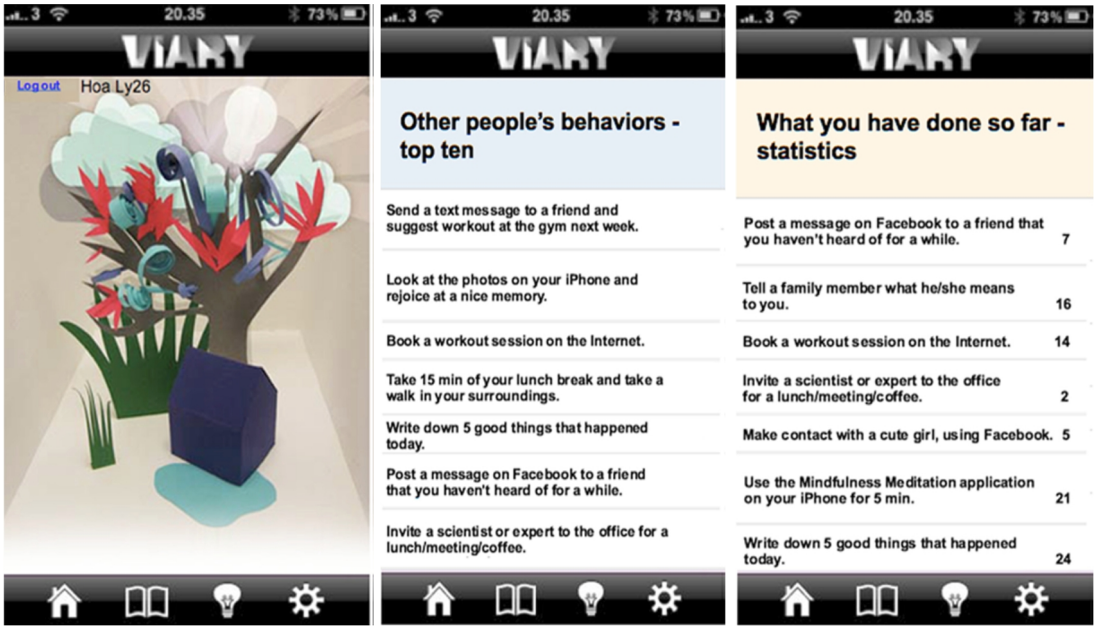

Figure 3. Screen shots of the mindfulness app *Viary* (Ly et al., 2012).

In a later study, Ly et al., (2014) evaluated and compared the effectiveness of two smartphone delivered treatments for mild to moderate depression. Participants (n81) were randomly assigned to use either a mindfulness-based app (n41) or a behavioural activation based app (n40) for a period of 8-weeks with minimal therapist contact

(maximum of 20 min per week, per participant). The mindfulness intervention consisted of a short web-based psychoeducation, and a step-by-step mindfulness practice programme, administered via a smartphone application. The mindfulness-based app included guided and unguided mindfulness exercises, and mindfulness theory. The behavioural activation app was used to record behaviours to increase behaviour activation. Figure 4 presents a screenshot of the application.

The authors reported the two smartphone interventions did not differ significantly (Ly et al., 2014). Large reductions in depression after both interventions were reported, that continued at 6 months follow up. When the sample was analysed according to depression severity, the behavioural analysis based app was more effective in reducing depression ratings for participants with more severe depression, whereas, for participants with less severe depression, the mindfulness-based app was more effective in reducing scores. The study was underpowered and did not have a waitlisted control group. Despite the limitations, the authors concluded that the results of their study might indicate that the smartphone format used in this study could work well for a depressed population and may be effective in helping those with mild psychological problems. They cautioned the need for more studies investigating the smartphone format are necessary before any conclusions can be drawn.

Figure 4. Screenshot of mindfulness app (the native version) (Ly et al., 2014).

Carissoli et al. (2015) conducted a RCT to evaluate the feasibility of an 18-day MBMA intervention to improve the response to stress in a non-clinical adult sample (Carissoli et al., 2015). Using a pragmatic trial approach the intervention tested the effectiveness of a brief self-help intervention under real life routine conditions. The final sample included 55 non-clinical participants randomised to three conditions: 1) an experimental condition that engaged in the mindfulness-based smartphone app; 2) an active control group that listened to music; 3) a waitlisted control group. Stress was measured by a questionnaire and with a psychophysiological measure: heartbeats per minute (BPM). The mindfulness-based app *It's Time to Relax* was used twice a day to listen to 15-minute guided mindfulness exercises. Figure 5 shows screenshots from the app. Both thought distancing and mindful breathing exercises were included in the app. The results did not show any significant differences between groups, but both self-help intervention groups demonstrated an improvement in coping with stress and decrease in average heartbeats per minute after each session. The authors cited the small sample size and short duration of the intervention as limitations to their study. The authors suggested that future research should include psychophysiological sensors integrated within applications to verify the efficacy of mindfulness-based mobile protocols, as well as testing the long-term effects.

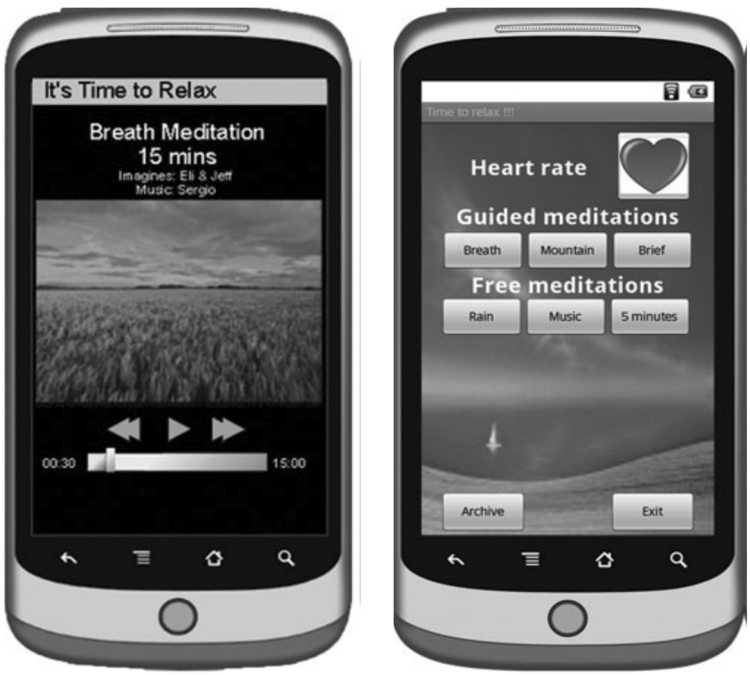

Figure 5. Screenshots of the app *It's Time to Relax* (Carissoli et al., 2015).

Most recently van Emmerik et al. (2017) conducted a RCT testing the immediate and long-term effects of an MBMA. Participants were recruited through a Facebook advertisement targeted at people who were known to have an interest in mindfulness. Participants (n377) over the age of 18 years, with Dutch fluency, that gave written informed consent were randomised to either the *VGZ mindfulness coach* or a waitlist control for a 5-week program. The *VGZ mindfulness coach* is a self-help intervention without any form of automated or therapist-provided guidance or feedback. The app includes 40 audio exercises, including breathing and attention, body scan, guided meditation, visualization, mantra and yoga exercises. Participants in the experimental condition received standardised weekly email reminders to encourage use of the app. Results of the study demonstrated large significant increases on the FFMQ overall after 8-weeks, and small-to-medium effects on all five individual facets. The self-help MBMA was associated with large significant improvements in general psychiatric symptoms and moderate increases in quality of life, and the improvements were maintained at the 3-month follow up.

The convenience, portability, and ubiquity of mobile phones make them an accessible resource for engagement with mindfulness-based app interventions that utilise evidenced based protocols and demonstrate good face validity and perceived usefulness. Studies investigating the effectiveness of these apps in improving various health outcomes are sparse, have several methodological limitations and have yielded mixed results. Some preliminary results suggest benefits after participant engagement in mindfulness-based smartphone apps. They have highlighted increases in mindfulness skills (Chittaro & Vianello, 2016; Ly et al., 2012; Morrison Wylde et al., 2017; Wen et al., 2017), positive affect (Howells et al., 2016; Wen et al., 2017) and quality of life (van Emmerik et al., 2017), and reductions in stress (Carissoli et al., 2015), and depressive symptoms (Howells et al., 2016; Ly et al., 2014) and general psychiatric symptoms (van Emmerik et al., 2017). However, the scarcity of randomised controlled designs testing the efficacy of MBMAs means the feasibility and potential of this format of intervention delivery remains largely unknown.

There is a need for future research to address the methodological limitations reported in previous MBMA studies. Research that examines the efficacy of mindfulness-based smartphone apps, utilising a randomised controlled design should incorporate both

mindfulness measures as well as psychological outcomes. The current study was designed to address this need. To date most measurement in studies assessing MBMA's is self-report, whereas the current study uses self-report in conjunction with objective assessments of theoretically relevant processes to capture both implicit and explicit measures of mindfulness and emotion regulation. In addition the current study attempts to address the issue of validity by comparing the effects of a mindfulness intervention with an active control. Previous studies noted methodological issues such as quasi-experimental protocols without control conditions making it difficult to draw conclusions from the findings of these studies. Considering that few MBMA studies to date have used control groups, it is possible that some of the positive outcomes reported in earlier studies are not true effects. Without a control condition there is no verification that the effects were due to the intervention alone, and not some other factor. The current study addresses this gap by using a randomised controlled design comparing the mindfulness condition with an active waitlist control condition in order to compare treatment effects across conditions.

1.7 CONCLUSION & RATIONALE

Stress is a significant predictor of adverse affects on psychological and physiological health in the university student population. Tertiary students experience a high degree of psychological stress due to assignment and examination deadlines, financial concerns and demographic factors. There is a need to develop cost-effective, efficacious psychological health supports that reach large groups of New Zealand students. It is proposed that a brief self-directed mindfulness training approach, using mobile app technology could deliver psychological support to students dealing with the demands of life and study.

Mindfulness meditation has been reported to elicit beneficial effects on a number of psychological and stress-related symptoms and has been incorporated into numerous therapeutic interventions with positive results. Developing mindful attention of the present moment experience in an attitude of non-judgmental acceptance, is thought to enable individuals to engage in more adaptive coping behaviours in response to demands of modern life. This may be particularly relevant to a university student demographic due to high prevalence of maladaptive coping in response to stressors, including alcohol and other drug use, and other behaviours that can adversely affect health.

Several approaches to mindfulness training have been developed. Preliminary findings suggest the use of brief, self-directed approaches to mindfulness using online methods of delivery may be effective. A mobile phone app has numerous benefits as a therapeutic vehicle for mindfulness training; it is cost-effective, can be easily provided to a large number of students, and offers unique functionality to support the naïve meditator to develop their own meditative practice.

At the time of conceptualisation, the current study was the first of it's kind to assess self-directed mindfulness training using mobile phone app technology. It was considered that a mindfulness app might be an appropriate and helpful aid for university students dealing with stress and the demands of life and study. Mindfulness training with a mobile app has the potential to ameliorate the response to stress, positively influence emotion regulation, and moderate maladaptive health behaviours. By including both self-report and objective measures of mindfulness and emotion

regulation, one of the aims of the current study was to provide information on the mechanisms underlying the therapeutic benefit of mindfulness training. Previous research investigating MBMA's have methodological issues such as quasi-experimental protocols without control conditions making it difficult to draw conclusions from the findings of these studies. The current study addressed this gap by using a randomised controlled design comparing the mindfulness condition with an active waitlist control condition in order to compare treatment effects across conditions.

METHODS

2.1 STUDY DESIGN

The current study is a non-blind RCT that was conducted during 2015 at Massey University Albany Campus. In a between subjects experimental design n=54 tertiary students were randomly allocated to either a mindfulness training group (n28) or an active control group (n26). A schematic of the study design is shown in Figure 6. The mindfulness group were instructed to use a mobile phone application (app) to listen to guided mindfulness meditations for a minimum of 20 minutes a day, for seven days. The active control group were instructed to engage in a memory task using a mobile phone list app for 10 minutes a day. Participants were assessed using both physiological and psychological measures at baseline and post-intervention to investigate changes in perceived stress, mindfulness, wellbeing and emotion reactivity. Each participant was required to attend two laboratory sessions spaced seven days apart.

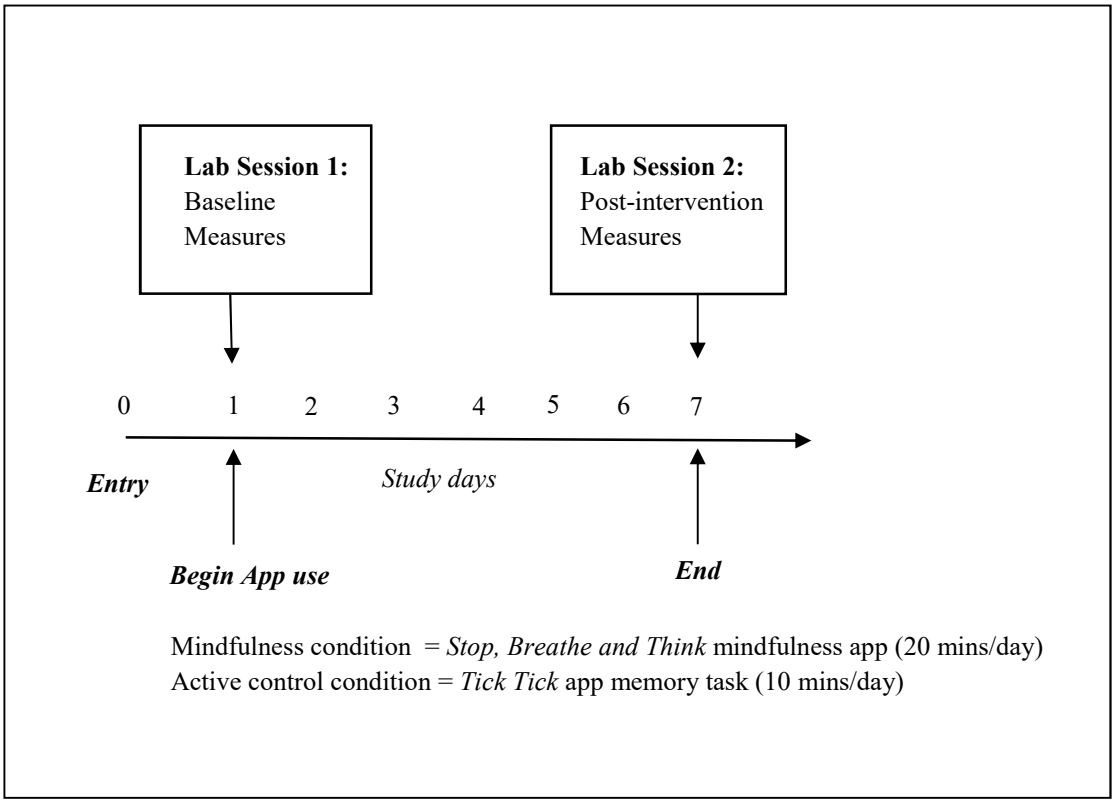

Figure 6. Illustrates the overall study design.

2.2 AIMS & OBJECTIVES

The aim of the current study was to test the efficacy of brief self-directed mindfulness training using a freely available mobile phone app on measures of mindfulness, perceived stress, wellbeing and emotion reactivity in a university student sample, with the overall aim of improving the response to stress and reducing adverse health outcomes in this population.

Specific aims of this research are:

- Provide preliminary evidence for the use of a mobile mindfulness app to ameliorate stress in a student population
- Contribute to the understanding of mechanisms of mindfulness underlying health outcomes

The study addresses the following research questions:

- Can brief self-directed mindfulness training with a smartphone app
    - Help students manage stress
    - Teach mindfulness skills, or the ability to respond mindfully to the experience of daily life

It is hypothesised that the mindfulness training condition will show:

- Reduced perceived stress as measured by the Perceived Stress Scale (PSS)
- Increased self-reported mindfulness as measured by Freiburg Mindfulness Inventory (FMI) and Five Facet Mindfulness Questionnaire (FFMQ)
- Increased positive affect and decreased negative affect as measured by the Positive and Negative Affect Scale (PANAS)
- Reduced interference by emotionally salient words, shorter completion times and fewer mistakes in colour-naming emotion words as measured by the Emotion Stroop Task
- Reduced emotional reactivity when presented with emotion-inducing stories
    - Subjective Affective Manikin (explicit measure)
    - Facial Electromyography (implicit measure)
    - Electrocardiogram (implicit measure)

2.3 RECRUITMENT

Participants were recruited from Universities in Auckland from February through September 2015. Potential participants were notified of the opportunity via posters (Appendix A) and flyers (Appendix B). A4 sized posters, were displayed on notice boards at Massey University, Auckland University, and Auckland University of Technology, as well as supermarkets and community boards. Flyers were distributed around student buildings and passed out by hand at each campus to provide students with an opportunity to ask questions about the study. A short introduction was given to students attending student lectures at Massey University. An email version of the flyer was sent to the Massey graduate student email list. A $20 reimbursement was offered to compensate for time taken to attend the laboratory and transport costs.

2.4 PARTICIPANTS

All participants were adults (aged 18 years or over) who gave informed consent (Appendix C). Students wishing to participate in the study were assessed for the inclusion criteria (over 18 years, full or part-time students for the duration of the semester), and exclusion criteria (current active mindfulness meditation). Participants in the study were 54 university students attending universities in the Auckland region of New Zealand. Of the 54 participants, 31 were studying at undergraduate level (57.4%), 18 were studying at postgraduate level (33.3%) and five did not specify their level of study (9.3%). The age range of participants was 18 to 51 years (M = 27.4, SD = 8.6), with 44 females (81.5%) and 10 males (18.5%). Of the 54 participants, 51.0% identified as *NZ European or Pākehā*, 30.6% identified as *Asian*, 14.3% identified as *Other*, 4.1% identified as *Māori*, 4.1% identified as *Non-New Zealand European* and 2% identified as *Pacific Peoples*. Sixty-three participants enrolled in the study, 28 completed in the mindfulness group and 26 completed in the control group. Five participants did not attend the first laboratory (two had been allocated to the mindfulness group and three to the control) and four participants did not attend the second laboratory (two from each group).

2.5 ETHICS

A Low Risk Notification was used to record the research on the Low Risk Database, which is reported in the Massey University Human Ethics Committee Annual Report. A low risk research project is one in which the nature of the harm is minimal and no more than is normally encountered in daily life. Research considered low risk does not receive approval from a Human Ethics Committee. All considerations of the code of ethical conduct have been considered with regard to this research. Written informed consent was required for all participants before enrolling in the study. Participants were briefed in full before signing the consent form, and retained the right to withdraw at any point during the study.

There were no guaranteed benefits to the participants. It was hypothesised that those randomised to the brief mindfulness training condition might experience improved ability to cope with stress and an increase in mindfulness and wellbeing. The risk of harm associated with the intervention and measures used in this study was minimal. No adverse outcomes were expected. No interim analyses were conducted. Each participant was briefed on the protocols before attending the lab so they were fully informed of the procedures involved. Participants were free to leave at any point during the session and this was made explicit during the lab. To safe guard against any potential harm occurring, several checks were made throughout the protocol. At certain time points (having electrodes applied, and after listening to fear and anger stories) experimenters checked if the participants wished to continue. At the conclusion of the experimental procedure, the participant was offered a brief guided relaxation exercise before departure. No participants reported any distress or adverse effects from the study.

While not specifically aimed at Maori, this study has relevance to the on-going quest to improve Maori health status and education. Article 2 of Te Tiriti O Waitangi guarantees Maori continuance of possession of Taonga, good health and education included. It was hoped that a successful outcome for this study might lead to improved physiological and psychological health status for students, including Maori students. In consultation with the Massey Kaumātua Nephi Skipwith, the Psychology Lab was blessed and named Pakiri. Pakiri means ‘to smile and show teeth’ and pā kiri translates to ‘to touch the skin’.

Strict confidentiality of all data collected from participants was adhered to. Results from the data is used for the current study only unless with written consent is obtained participants. No data collected has been used for undisclosed purposes. Data is stored electronically and password protected. Individuals are not identifiable from their stored data. Personally identifiable information from the study consent forms is not linked to the study.

2.7 STUDY PROTOCOL

At entry into the study participants were sent a demographic questionnaire (Appendix D) via email. Participants who met the inclusion criteria (18 years or over, full or part-time student), and exclusion criteria (current active mindfulness meditation) were enrolled in the study. Written informed consent was required for all participants before enrolling (Appendix C). Participants were briefed in full before signing the consent form and were aware they could withdraw at any point during the study. At enrolment participants were be randomly allocated (using sealed envelopes) to two groups; a mindfulness training group or an active control group.

Participants attended two laboratory sessions spaced seven days apart. Lab sessions were held from June through to September 2018, which was a mix of end semester, semester break and beginning of semester, with both undergraduate and post-graduate students. The workload questionnaire (Appendix I) was an attempt to capture whether university workloads were equalised across groups. Each laboratory study session lasted 60 to 90 minutes. Figure 7 outlines the overall protocol for each laboratory session. The session details are shown in Table 2. Both session one and two followed the same protocols outlined below with the exception of the different experimental condition briefings. Each participant attended individual sessions with the experimenter at the Pakiri Psychology Lab at the Massey Albany Campus. The lab is quiet and set up to optimise the quality of EMG recordings (Fridlund & Cacioppo, 1986). Each session began with the psychophysiology set up for FEMG and ECG recordings. Once the electrodes were placed the participant was positioned at a cubicle. After five minutes of baseline psychophysiological recordings the participant was instructed to complete the self-report questionnaires. The participant notified the experimenter when the questionnaires were completed and the computer program was initiated. Participants

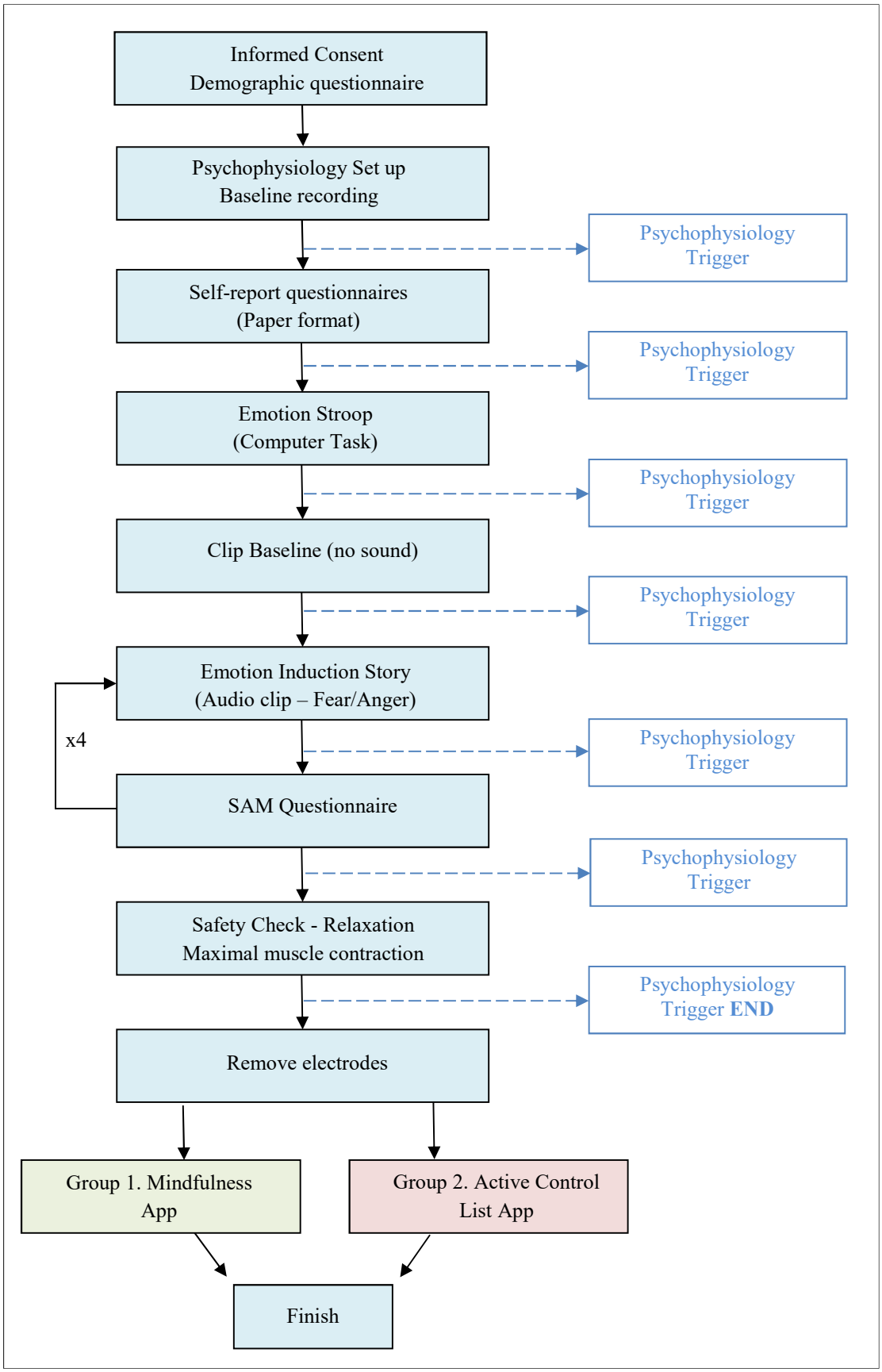

Figure 7. Overview of laboratory protocols

Table 2. Laboratory protocols

Written Informed Consent
Participants were briefed in full before signing the consent form (Appendix C). Participants were made aware that the study was voluntary and they had the right to withdraw at any point during the study.

Facial electromyography set up
Sensor electrodes were placed on the face to detect the electrical activity from muscle activation. The participant was informed about placing EMG electrodes on their face and asked if they felt comfortable with this protocol before proceeding. The participant was then directed to the bathroom to cleanse their face. A small area of skin is wiped with alcohol to achieve the optimal level of electrode to skin adhesion. The electrodes are 4mm in diameter and attach to the skin with small double-sided sticky pads. A small amount of gel is used on the skin under the electrode for conductance. Seven electrodes were placed on the face: on the cheek (Zygomaticus major), the brow (Corrugator supercilii) and on the forehead (Frontalis). The specific protocols for electrode placement can been viewed in Appendix E.

Electrocardiography set up
Sensors were placed under the clavicle and on the abdomen to record heart rate variability. The participant was informed about ECG electrode placement, and was shown by the experimenter where they would be placed. The participant was asked if they were comfortable with this protocol before proceeding. The participant was asked if they would prefer to place the stickers and electrodes on themselves. Specific protocols for electrode placement can be viewed in Appendix E.

Self-Report Questionnaires
Participants were asked to complete six self-report questionnaires to assess perceived stress (PSS, Appendix H), mindfulness (FMI, Appendix F and FFMQ, Appendix G), current workload (WQ, Appendix I), emotional complexity (RDEES, Appendix J) and positive and negative affect (PANAS, Appendix K).

Emotion Stroop Task
While at the computer, participants were presented with 192 words in one of four colours (black, red, blue or green). The words were a combination of negative emotion words, positive emotion words and neutral words. Participants were required to indicate the colour of the words as quickly as possible using the keyboard. This task lasted approximately 20 minutes.

Emotion induction exercise
Participants completed another PANAS questionnaire for current mood (Appendix L). Four audio clips were then played that were designed to induce mild fear or mild anger. Immediately after listening to each audio clip, the participants recorded their subjective emotional responses using a non-verbal response scale (SAM, Appendix M). Instructions for SAM are presented in Appendix N. After listening to all four audio clips the participant completed a second PANAS to assess change in mood. Appendices O and P include the full story scripts. Participants were randomised to either listen to set A at lab 1 then set B at lab 2 or set B at lab 1 and set A at lab 2. As a safety check, the participant was then asked if they were experiencing any distress and whether they wished to listen to a guided imagery relaxation exercise.

Conclusion
Before the electrodes were removed, the participant was asked to give exaggerated facial expressions (smile, frown and fear) to record maximal muscle contractions. The electrodes were then carefully removed and the participant was briefed according to the experimental protocol.

first performed the Emotion Stroop Task on the computer, which lasted approximately 20 minutes. Next, the participant completed an additional PANAS questionnaire to assess current mood. They then listened to 4 storiesdesigned to induce mild fear or mild anger. After listening to each audio clip the participant was directed to record their subjective emotional responses using the non-verbal response scale SAM. Once all of the stories had finished and each SAM sheet was completed the participant answered a second PANAS questionnaire to assess change in mood. The electrodes were removed and the participant was briefed according to the experimental protocol.

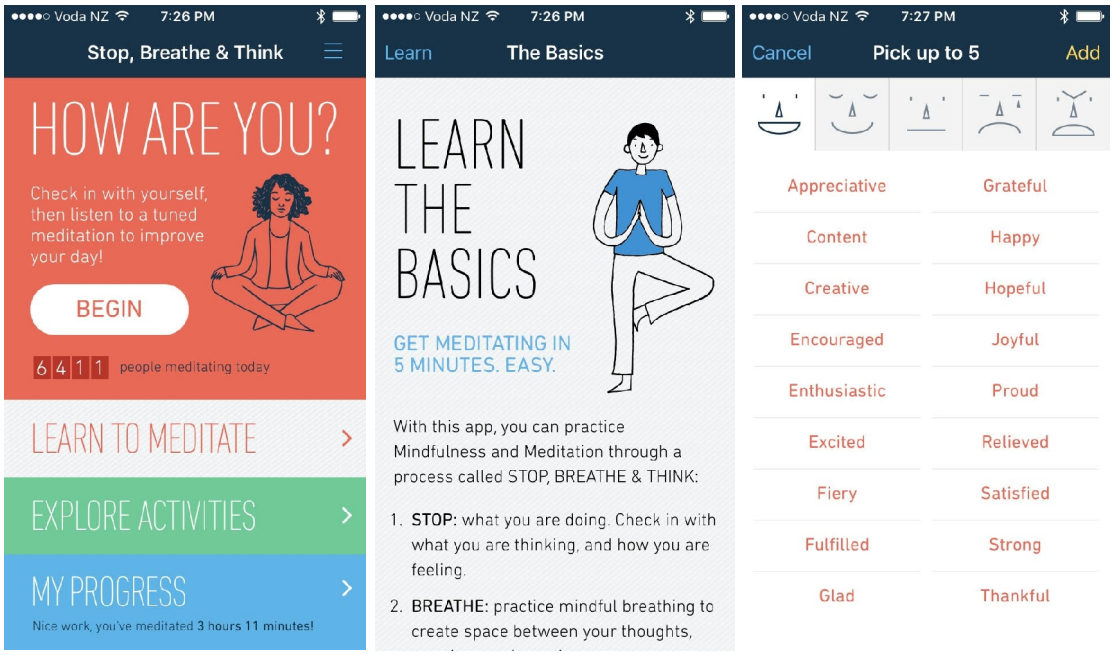

Figure 8. Screenshots of the mindfulness app *Stop, Breathe and Think* Version 2.0 (Tools for Peace, 2014).

Mindfulness Condition

At the conclusion of the first laboratory session, participants in the mindfulness condition were shown how to download and use the freely available mindfulness app; *Stop, Breathe and Think* Version 2.0 (Figure 8). The participants were instructed according to the protocol explained below and given a checklist to record time spent using the app (Appendix Q). The checklist was collected at the second laboratory session seven days later and checked against the tracking function of the App (Table 3). At the beginning of the second lab participants were given a mindfulness debrief

questionnaire that asked about their enjoyment and level of engagement with the app (Appendix S).

Table 3. Functions available in the mindfulness app *Stop, Breathe and Think* version 2.0.

Main menu functions	*Tracking features*

- Learn the basics
- List of meditations
- Track progress
- Check-in
  • Identify emotional state
  • Identify physical state
	- Total time meditating
	- Top meditation
	- Mental and physical check-in record
	- Novelty stickers based on meditation milestones

Mindfulness meditations	
- Mindful breathing	- Gratitude
- Body scan	- Commonality of suffering
- Be present	- Cause & effect
- Mindful walk	- Kindness
- Engaging your senses	- Relax, ground and clear

Mindfulness protocol

Participants were instructed to use the mindfulness app *Stop, Breathe and Think* for a minimum of 20 minutes per day. The time could be broken up into two or more separate meditations from the menu options (Table 3). Participants were given a brief introduction to mindfulness and had an opportunity to ask any questions. On the first day participants were instructed to read *The basics, How it works,* and *Practice*. This is a brief introduction to mindfulness which reinforces that developing mindful attention is a skill that we build upon, and the more you practice, the more you develop the skills. Participants were instructed to complete the mindfulness exercises *Mindful Breathing* and *Body Scan* on the first day. They were then free to pick and choose the exercises for the other six days.

App selection and function

Freely available mindfulness mobile phone apps were searched using the Apple App Store. 20 free mindfulness apps were tested for relevance and usability. The *Stop, Breathe and Think* app was chosen for functionality, relevance to evidence based protocols, accessibility, ease of use and appeal to younger adults and naïve meditators. *Stop, Breathe and Think* offers a series of guided audio meditations, physical and emotion rating check-in, and tracks daily progress. It provides an introduction to mindfulness and therapeutic benefits. An outline of the functions included in the mindfulness app is presented in Table 3. The guided meditations are in line with evidence-based protocols for beginners mindfulness training that focus on directing attention with an attitude of non-judgemental acceptance (Baer, 2003; Erogul et al., 2014; Kabat-Zinn, 2003b). The app also has a physical and emotional *Check-in* function which assists the user to identify and differentiate their present moment experience of physical sensations and emotions.

Active Control Condition

At the conclusion of the first laboratory session participants in the active control condition were shown how to download and use the freely available task list app; *Tick Tick* (Figure 9). The participants were instructed according to the protocol explained below and given a checklist to record time spent using the app (Appendix R). The checklist was collected at the second laboratory session. At the beginning of the second lab, participants in the control condition were given a debrief questionnaire that asked about their enjoyment and level of engagement with the app (Appendix T). At the conclusion of the second lab session the active control group were shown how to download and use the mindfulness app *Stop, Breathe and Think* and were given the same protocol as the mindfulness condition.

Active control protocol

Participants were instructed to use a list making app *Tick Tick* for a minimum of ten minutes a day. The instructions were to use the app to make a memory checklist. Participants were asked to use the app to make a list each day of what they did on the same day the week prior. Aside from the 10-minute task, participants were told to use the app as often or as little as they wished. The protocol for the active control was used

in accordance with a previous study looking at the effects of a mindfulness mobile app (Howells et al., 2016). This experimental condition was described as a task that can hone one's mental recall and organisation skills. To equalise the placebo effect across groups and increase compliance a cover story that all participants (including controls) may increase their ability to cope with study stress was employed. These instructions were given in accordance with procedures of standard placebo controlled designs in which all participants are informed the 'treatment' that is being tested has a reasonable chance of working.

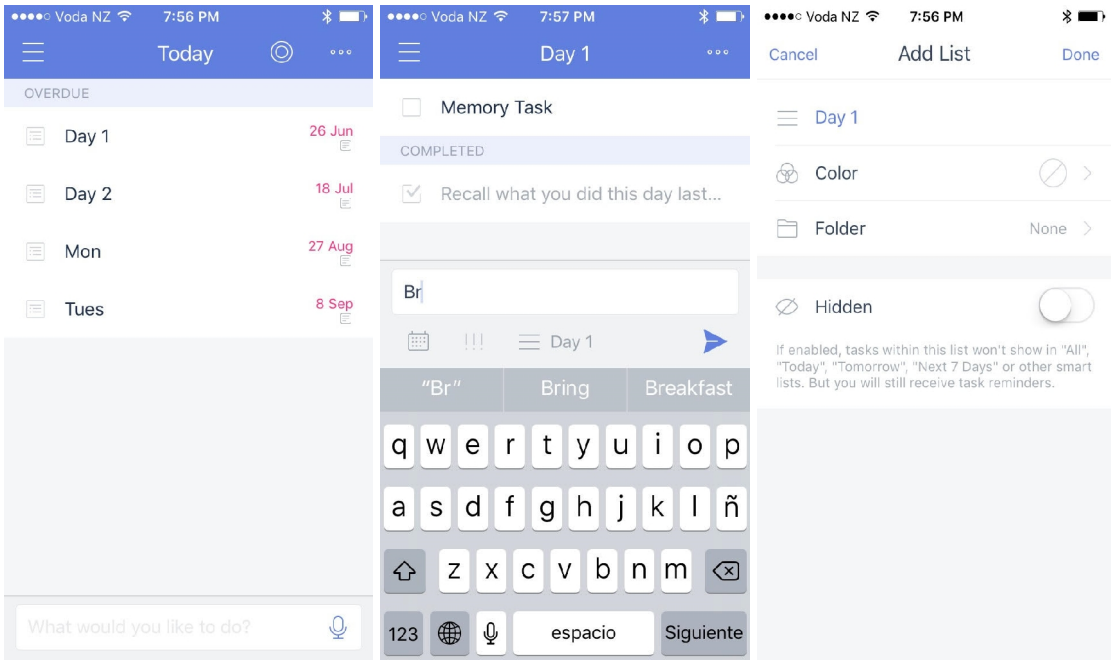

Figure 9. Screenshots of the task list app *Tick Tick*.

App selection and active control

It has been argued in the literature that much of the research that investigates the health effects of mindfulness interventions is problematic due to the lack of validated active controls (MacCoon et al., 2012). This research attempted to address this by including an active control condition to control for potential non-specific effects of intervention engagement (Josefsson, Lindwall, & Broberg, 2014). The active control condition is structurally equivalent to the delivery of the self-directed mindfulness training (mobile app based, includes tracking and check-in and requires active engagement for seven

days). The protocol for the active control was based on a previous study looking at the effects of a mindfulness mobile app (Howells et al., 2016).

Table 4. Functions available in the list-making app *Tick Tick*.

Main Menu - Today - Inbox - Calendar - Add List	*Today* - Lists - Create tasks in list - Check off tasks - Add photos, notes, comments
Inbox - Current lists - Completed lists	*Calendar* - Current day - Month - Week

Freely available list making apps were searched using the Apple App Store. Five free list apps were tested for relevance and usability. The *Tick Tick* app was chosen for its simplicity and ease of use. The *Tick Tick* app is a simple list-making app with limited functionality. An outline of the functions included in the *Tick Tick* app is presented in Table 4.

Standardisation of protocols

Two experimenters undertook all laboratory protocols and instructed the participants according to each experimental condition. The experimenters underwent training together in the Parkiri psychology lab at Massey University with Dr Peter Cannon who is experienced using the psychophysiological measures. Both experimenters followed stepwise instructions in order to standardise the procedures. Appendix E outlines the protocols for the lab sessions.

2.6 MEASURES

At entry to the study, participants completed a demographic questionnaire (Appendix D) and returned it via email. Participants attended two laboratory sessions spaced seven days apart. At each lab session participants completed eight self-report measures and two computer tasks. During the lab participants had electrodes applied to record facial muscle contraction and heart rate variability (Appendix E). At the conclusion of the second lab, participants completed a debrief questionnaire about app engagement.

Mindfulness questionnaires

Self-report measures of mindfulness were used to assess whether participation in brief, self-directed mindfulness training with a mobile phone can cultivate mindfulness skills, or the ability to respond mindfully to the experience of daily life. Two self-report measures of mindfulness were used at entry and post-intervention to test this hypothesis and differentiate specific aspects of mindfulness. It was predicted that the brief mindfulness intervention would demonstrate an increase in mindfulness as measured by the following self-report questionnaires.

Freiburg Mindfulness Inventory

All participants completed the short form of the FMI which is a 14-item scale that assesses openness to and non-judgemental observation of the present moment (Walach, Buchheld, Buttenmüller, Kleinknecht, et al., 2006). Items are rated on a 4-point Likert scale ranging from 1 (*Rarely*) to 4 (*Almost always*) (Appendix F).

The FMI was developed with experienced meditators participating in mindfulness retreats (Buchheld et al., 2001; Walach, Buchheld, Buttenmüller, Kleinknecht, et al., 2006). The 30-item self report questionnaire was designed to measure non-judgmental present moment observation and openness to negative experience (Baer et al., 2009). The development of the FMI involved a pre-post measurement of 115 participants attending Buddhist meditation retreats consisting of a minimum of eight hours of meditation in silence per day (Walach, Buchheld, Buttenmüller, Kleinknecht, et al., 2006). Psychometric analysis demonstrated high internal consistency at both measurements (Cronbach's alpha (α) = .93/.94)(Walach, Buchheld, Buttenmüller, Kleinknecht, et al., 2006).

The short form FMI (Walach, Buchheld, Buttenmüller, Kleinknecht, et al., 2006)(Appendix F) was developed for use in a non-meditating sample, and has shown adequate to good internal consistency in several samples (Baer et al., 2009). The authors validated the 14-item questionnaire in a study with 85 participants from the general population, 117 participants from clinical populations, and 85 participants from retreats. The reduced scale was shown to be psychometrically stable (α = .86) and had good construct validity correlating well with the long 30-item version (r = .95) (Walach, Buchheld, Buttenmüller, Kleinknecht, et al., 2006).

Factor analysis demonstrated that the FMI captures several components of mindfulness, but the factor structure was not stable across administrations and the authors recommend a uni-dimensional interpretation (Baer et al., 2009). A Principal Component Analysis across all 30-items with 156 participants in retreats demonstrated a four factor version with 51.2% explanation of variance after Varimax Rotation (Walach, Buchheld, Buttenmüller, Kleinknecht, et al., 2006). The factors were tentatively identified as *Mindful Presence*, *Non-Judgemental Acceptance*, *Openness to Experiences*, and *Insight*. The authors concluded that the Principal Component Analysis supports one common factor due to the high inter-correlations of the factors and high secondary loadings, especially for the short version. The authors do not recommend splitting the construct into distinct components. They suggested that the analysis of dimensionality shows that mindfulness is a general construct with some interrelated facets (Walach, Buchheld, Buttenmüller, Kleinknecht, et al., 2006).

Walach et al., 2006 advised that the 14-item short form is a robust version of the FMI, which is semantically independent from a Buddhist or meditation context. The authors recommend using the 30-item version in samples familiar with Buddhist and mindfulness meditation and the 14-item version for populations without knowledge of the Buddhist background of mindfulness. The data from their validation study indicates that an increase in mindfulness is related to a decrease in psychological symptoms (Walach, Buchheld, Buttenmüller, Kleinknecht, et al., 2006). Higher scores on both the 30-item and 14-item versions of the FMI were related to increased private self-awareness and self-knowledge, decreased dissociation, and lower psychological distress in meditating and general adult samples (Baer et al., 2009).

It has been demonstrated that mindfulness can be measured validly and reliably with the FMI (Baer et al., 2006; Kohls, Sauer, & Walach, 2009; Leigh, Bowen, & Marlatt, 2005; Walach, Buchheld, Buttenmüller, Kleinknecht, et al., 2006). However, the factor structure remains unclear and dimensionality of the construct has been questioned (Kohls et al., 2009; Walach, Buchheld, Buttenmüller, Kleinknecht, et al., 2006). While a uni-dimensional approach has been demonstrated to be statistically valid (Kohls et al., 2009; Walach, Buchheld, Buttenmüller, Kleinknecht, et al., 2006), some authors have suggested a two- or three- factor solution (Kohls et al., 2009; Leigh et al., 2005; Sebastian Sauer, Ziegler, Danay, Ives, & Kohls, 2013).

A study by Leigh, Bowen, and Marlatt (2005) tested the reliability and validity of FMI in a sample of undergraduate students and found that it was internally consistent (α = .80). A Principal Components factor analysis extracted three factors: (1) *Acceptance and Openness to Self and Experiences* (α =.76), (2) *Mind/Body Awareness* (α =.73 and (3) *Non-Attachment to Thoughts* α =.63 (Leigh et al., 2005). The authors concluded that analysis of the FMI scale provided support for use in a university sample with good reliability ratings for the three subscales, but cautioned the need for further analysis to determine if it is a valid and reliable measure of mindfulness (Leigh et al., 2005). Interestingly, the authors reported higher scores on the FMI were associated with increased smoking and binge drinking. That in one study highlights the difficulties developing a validated measure that assesses the mindfulness construct. The FMI contains several items that represent awareness of the body as well as accepting unpleasant experiences. The authors of that study suggest that it might be the result of an increased tendency to notice bodily sensations in those who use these substances. Another possibility is that the act of smoking a cigarette has some similarities with the construct of mindfulness, such as the focus on the breath (Leigh et al., 2005).

Kohls et al. (2009) tested the 14-item FMI in an online sample of 244 individuals. Their confirmatory analysis of the factor structure found that both the one-dimensional and the two factor solution of the FMI-14 show acceptable, but suboptimal fit indices. For the one-dimensional solution the internal consistency was acceptable to good: α = .83 for the full sample (n = 239), α = .83 for those with meditation training (n = 75) and = .78 for those with no meditation training (Kohls et al., 2009). The two factor solution

was *Acceptance,* α = .77 and *Presence* = .69 for the full sample, α = .80/.74 for the meditation group and = .74/.64 for the non-meditating group. The authors concluded that mindfulness can be measured validly and reliably with the FMI but argued that distinguishing the components *Presence* and *Acceptance* in a two-dimensional measure is more conceptually stringent and has heuristic value besides good fit indices, as it helps to explain how change can be mediated in mindfulness. While they acknowledged that a one-dimensional approach is more practical for most purposes assessing mindfulness as a global moderator, when the focus is on a potential causal mechanism then a distinction of mindfulness would be more elucidating. In their analysis they concluded that the negative relationship between mindfulness and depression was completely due to the *Acceptance* factor of mindfulness (Kohls et al., 2009).

Sauer et al., 2013 analysed the psychometric properties of the FMI-14 by performing a Rasch model analysis. The FMI-14 was administered to a non-clinical sample of 1,452 German adults. Their data demonstrated the uni-dimensional solution of FMI-14 did not fit well to the Rasch model. A re-analysis of the model excluding one item (number 13, *I get impatient with myself and others*) yielded an acceptable fit for the one factor solution. The authors concluded that a two factor solution with the sub-facets *Presence* and *Acceptanc*e (as presented in Kohls et al. 2009) excluding item 13, provided a better overall fit than the solution. They concluded that the FMI in its current form is a promising instrument in need of further research and improvement. They cautioned that measurement of mindfulness is a relatively recent development, especially understanding different item functioning between different sample groups (with and without mindfulness training).

The development of robust mindfulness measures continues to evolve, and further testing and evaluation is necessary in order to advance understanding. The short form FMI was deemed suitable for the current study because it was developed for use in a non-meditating sample, and has shown adequate to good internal consistency in several samples including university populations and those new to mindfulness. Analysis of the factor structure in the current sample revealed good internal consistency (α =.80 to .86).

Confirmatory factor analysis and internal consistency

The original study that validated the Freiburg Mindfulness Inventory (FMI) 30-item reported Cronbach's alpha (α) = .93. The reduced 14-item scale was shown to be psychometrically stable (α = .86) and had good construct validity correlating well with the 30-item version (r = 0.95) (Walach, Buchheld, Buttenmüller, & Kleinknecht, 2006). The current study used the 14-item FMI before and after the mindfulness intervention. The internal consistency was α = .80 at session one, and .86 at session two. This analysis suggests that using the FMI with this sample was appropriate and the measure is reliable. Following the factor analysis method by Walach et al (2006) a Principal Component Analysis was calculated with a resulting four factor version after Varimax rotation with 59.2% explanation of variance (eigenvalues: 4.2, 1.6, 1.4, 1.0). The original authors extracted a four factor version with 51.2% explanation of variance (eigenvalues: 9.4, 2.3, 2.2, 1.5). They argued in favour of one general factor and concluded that the construct was likely uni-dimensional due to high inter-correlations of the factors and high secondary loadings. The current study supports this finding. Factors showed high inter-correlations and secondary loadings across the four factors.

The two factor version from Kohls et al. (2009) was also analysed in this sample and a Principal Component Analysis after Varimax rotation demonstrated 41.5% of variance (eigenvalues of 4.2, 1.6). The two factor version showed moderate internal consistency: (1) *Presence* (items 1, 2, 3, 5, 7, and 10) α =.71 at session one and .73 at session two, (2) *Acceptance* (items 4, 6, 8, 9, 11, 12, 13r and 14) α =.71 at session one and .78 at session two.

In conclusion, analysis of the FMI-14 scale in the current study provides support for its reliability, and confirmatory factor analysis supported a uni-dimensional scale, with good reliability ratings. It was concluded that the uni-dimensional scale would be utilised for hypothesis testing.

The Five Facet Mindfulness Questionnaire

All participants completed the short form of the FFMQ (Baer et al., 2006) which is a 24-item scale that assesses five facets of a general tendency to be mindful in daily life (Appendix G). Items are rated on a 5-point Likert scale ranging from 1 (Never or very

rarely true) to 5 (Very often or always true). The five-facets are: *observing* one's inner experiences and responses to stimuli, *describing* one's thoughts and feelings, *acting with awareness*, *non-judging* and acceptance to one's inner state rather than judging thoughts and emotions as good or bad, and *Non-Reactivity* to inner experiences, or the tendency to allow provocative stimuli to come and go without necessarily reacting (Baer et al., 2008).

The FFMQ was originally developed in an attempt to provide a comprehensive measure that constructs mindfulness multi-dimensionally (Baer et al., 2009). The 39-item scale and its facets resulted from an exploratory factor analysis of the combined pool of 112 items collected from five different mindfulness questionnaires in a sample of 615 undergraduate students with little or no meditation experience (Baer et al., 2006). The five mindfulness questionnaires examined were: the Mindful Attention Awareness Scale (MAAS) (Brown & Ryan, 2003), the Kentucky Inventory of Mindfulness Skills (KIMS) (Baer et al., 2004), the Cognitive and Affective Mindfulness Scale-Revised (CAMS) (Feldman et al., 2007) and the Mindfulness Questionnaire (MQ) (Chadwick et al., 2008). All questionnaires showed good internal consistency and were significantly positively correlated with each other, and to a large extent correlated in expected directions with variables related to mindfulness (meditation experience, openness to experience, emotional intelligence, psychological symptoms, thought suppression and experimental avoidance) (Baer et al., 2006). However, the variation in the correlations between mindfulness and other constructs suggested that the questionnaires may be measuring somewhat different aspects of the mindfulness construct (Baer et al., 2006).

The combined responses were analysed using a Principal Axis Factoring with Oblique Rotation to allow for correlations among the factors. The analysis yielded a five factor solution accounting for 33% of the variance after factor extraction. The five-facet scales demonstrated adequate to excellent internal consistency with the following alpha values: *Non-Reactivity* α = .75, *Observing* = .83, *Acting with awareness* = .87, *Describing* =.91, and *Non-judging* = .87 (Baer et al., 2006). The authors used a hierarchical confirmatory factor analysis to test whether the five facets were indicators of an overall mindfulness construct or are better understood as five separate constructs (Baer et al., 2006). Their findings support a hierarchical structure to mindfulness, in which *Describe, Act-Aware, Non-Judge* and *Non-React* can be considered facets of a

broad mindfulness construct. However, the *Observe* facet loaded non-significantly on the overall mindfulness factor (Baer et al., 2006). The lack of fit was unexpected because observing is widely described as a central feature of mindfulness. Further analysis comparing samples with and without meditation experience suggested that the *Observe* facet is likely sensitive to changes with meditation experience that alter its relationships with other mindfulness facets.

Baer et al. (2006) also found that the *Observing* facet demonstrated a modest positive correlation with several maladaptive constructs, including psychological symptoms and thought suppression. The authors suggested that this may relate to the literature on self-focussed attention which can be maladaptive and is associated with negative emotion and psychological disorder (Baer et al., 2008). They noted that close observation of internal experience may be maladaptive in the general population but adaptive when it is done mindfully. Mindfulness training includes close observation of internal stimuli, but teaches the ability to observe with an attitude of acceptance, non-judgment and non-reactivity, even if the internal experience is unpleasant. However, learning to observe internal stimuli with mindful acceptance and non-judgment takes practice and requires more meditation experience. A follow up confirmatory analysis supported the finding that the *Observing* facet may function differently in individuals with meditating experience (Baer et al., 2008). Most correlations between mindfulness facets and psychological symptoms were negative, however for the *Observing* facet this was true only in the meditating sample. In addition, when correlating mindfulness facets with wellbeing, the *Observing* facet was only significant in the meditating sample. The authors reported that the tendency to notice internal and external stimuli is strongly related to wellbeing in meditators but not in others (Baer et al., 2008).

The short version of the FFMQ (FFMQ-24) (Bohlmeijer, ten Klooster, Fledderus, Veehof, & Baer, 2011) was developed from a sample of 376 adults with clinically relevant symptoms of depression and anxiety. All facets of the FFMQ demonstrated adequate to excellent internal consistency, with alpha coefficients: *Non-Reactivity* = .73, *Observing* = .78, *Acting with awareness* = .86, *Describing* = .91, and *Non-Judging* = .86 (Bohlmeijer et al., 2011). Total facet scores were highly correlated with the original version with: *Observing* r = .89 (r_c = .77), *Describing* r = .98 (r_c = .89), *Acting with awareness* r = .92 (r_c = .81), *Non-Judging* r = .96 (r_c = .84), and *Non-React* r = .95 (r_c =

.74). Both the inter-correlations among the facets and their correlations with the other constructs were comparable to those of the full FFMQ. As with the full FFMQs, a uni-dimensional model of the FFMQ-24 showed poor fit to the data. Confirmatory factor analysis showed good model fit for a correlated five factor model which performed slightly better than the hierarchical five factor model (Bohlmeijer et al., 2011).

In summary, the FFMQ was used to provide more detailed information about the different facets of mindfulness that might be responsive to the intervention, and associated with adaptive outcomes. It has been argued in the literature that the multi-faceted approach to the assessment of mindfulness is important for MBI research as it may help to clarify how psychological outcomes are mediated by mindfulness and to explore how mindfulness training may affect different sample populations. The FFMQ was selected for this study because evidence has demonstrated that changes in dispositional mindfulness are sensitive to participation in mindfulness interventions, including MBMA interventions. The FFMQ represents an attempt to explore and operationalise common dimensions from five mindfulness questionnaires developed within a few years by independent research teams. Factor analysis in the current sample demonstrated moderate to good internal consistency that ranged from α = .74 to .90 for FFMQ-24 facets (More details are available in the *Results* section).

Confirmatory factor analysis and internal consistency

The internal consistency of the FFMQ-24 as a whole was α =.84 at session one, and .88 at session two. Alpha coefficients for each of the five factors were; (1) *Observe* α =.69 session one, and .81 at session two, (2) *Describe* α =.90 at session one and .86 at session two, (3) *Non-React* α =.74 at session one and .82 session at two, (4) *Act-Aware* α =.80 at session one and .89 at session two, (5) *Non-Judge* α =.80 at session one and .83 at session two. Thus, all five-facet scales showed adequate to excellent internal consistency and demonstrate that the FFMQ-24 is suitable for the current study's participant group. Based on the exploratory factor analysis used by Baer et al. (2006) a Principal Axis Factoring with Oblique rotation specifying five factors was done to test whether the current study supported the five factor structure of the FFMQ. The results support the five factor structure, yielding a five factor solution that accounted for 64.7% of the variance after factor extraction (eigenvalues 5.4, 3.8, 2.7, 1.9, 1.6).

Perceived stress and workload measures

Perceived Stress Scale

The PSS (Cohen, Kamarck, & Mermelstein, 1983) (Appendix H) was used to assess psychological stress over the seven days prior to the baseline and post-intervention lab sessions. Participants answered 10 questions on a 4-point Likert scale: 1 (*Never)* and 4 (*Very often*). Higher scores are indicative that stressors negatively impact an individual. The PSS-10 was used to test the hypothesis that brief mindfulness training with a mobile phone could improve a student's response to stress. It was predicted that the mindfulness intervention would reduce student stress as measured by the PSS.

The PSS is a widely used self-report questionnaire that measures the variation by which individuals appraise stressful life situations (Cohen, Kamarck, & Mermelstein, 1983). The PSS was developed using Lazarus's transactional stress model of an individuals ability to cope with life events, that characterizes stress as the interaction between the appraisal of the stressor (i.e., the severity) and the individual's perceived ability to cope (Ergol, Singer, McIntyre, & Stefanov, 2014; Taylor, 2014a). It does not assess the context of specific stressful life events such as moving house or a death in the family, but it gauges the individual's patterns of reacting to events, and how unpredictable, uncontrollable, and overloading respondents find their lives (Cohen & Janiki-Deverts, 2012; Ergol et al., 2014).

The original 14-item PSS (PSS-14) was validated with two samples of college students (n = 456) and another community sample of people in a smoking cessation program (n = 64) (Cohen et al., 1983). The PSS-14 exhibited good internal consistency across all three samples (α = .84, .85, .86) with moderate predictive and concurrent validity correlating in the expected manner with a range of self-report and behavioural criteria (Cohen et al., 1983). A subsequent exploratory factor analysis revealed inadequately performing items, which were dropped to create the 10-item PSS (PSS-10) (Cohen, 1988 as cited in Taylor 2014a). There is some debate in the literature about the dimensionality of the scale (Cohen & Williamson, 1988; Taylor, 2014a). In a study with 1,236 adults, Taylor (2014a) compared the original uni-dimensional factor structure hypothesised by Cohen and Williamson (1988). Findings from an Ordinal Confirmatory Factor Analysis suggest the relationship among the items is best described by an

Oblique two factor model (*Perceived helplessness* and *Perceived self-efficacy*). The authors concluded that inferences made using PSS-10 scores are valid, however the multi-dimensionality of the scale needs to be considered. They cautioned that reliable measurement of perceived stress becomes untenable as the degree of perceived helplessness becomes increasingly low and the degree of perceived self-efficacy becomes increasingly high (Taylor, 2014a).

The PSS-10 has consistently shown good reliability and convergent validity across studies. A recent psychometric analysis of the PSS-10 confirmed that the PSS-10 is a psychometrically valid instrument for the measurement of psychological stress (Taylor, 2014a). A recent study with a sample of 557 undergraduate students in North America tested the validity of the PSS-10 (Smith, Rosenberg, & Haight, 2014). The authors concluded that their findings provide compelling evidence in the support of the PSS-10 as a stress assessment measure for business students in general and accounting students in particular (Smith et al., 2014).

The PSS-10 was considered appropriate for this study as it has demonstrated good psychometric properties with adequate convergent and concurrent validity, and has been validated in samples of university students. The internal consistency was measured at pre and post intervention and was found to be appropriate for this sample (alpha = .86, for details see the Results section).

Confirmatory factor analysis and internal consistency

The PSS-10 exhibited good internal consistency at session one $\alpha = .86$ and session two .86. This analysis suggests that using the PSS with this sample was appropriate. A Principal Components Factor Analysis tested the factor structure and yielded one factor accounting for 45.4% total variance with an eigenvalue of 4.5.

Workload questionnaire

The Workload Questionnaire (WQ) (Appendix I) was made for the study by the author to assess participant workload over the seven days prior to the baseline and post intervention lab sessions. The self-report questionnaire assessed university, home life, and employment related workload. Participants answered three questions on a 5-point

Likert scale 1 (*None)* and 5 (*Highest ever*) then checked boxes that applied to them for current work and study status. Data were collected from June through to September 2018, which was a mix of end semester, semester break and beginning of semester, with both undergrad and post-grad students. The workload questionnaire was an attempt to capture whether university workloads were equalised across groups and whether students were studying for exams or assignments, or on semester break. Data from this questionnaire was used as a check to confirm workload was evenly spread across groups.

Affect and emotion measures

The Range and Differentiation of Emotional Experience Scale

Participants completed the Range and Differentiation of Emotional Experience Scale (RDEES) (Appendix J) at entry and after mindfulness training to assess differences in emotional complexity (Kang & Shaver, 2004). The 14-item scale assessed perceptions about the range of emotions experienced. Participants answered questions on a 5-point Likert scale: 1 (*Does not describe me very well)* and 5 (*Describes me very well*). Firstly, this measure was used as a baseline check to test whether groups differ on measures of emotional complexity at entry. Comparing changes in RDEES over time with condition tested the prediction that mindfulness training increases observation of emotional experience, therefore potentially increasing the ability to identify and differentiate a broader range of emotions.

The RDEES was developed with three samples of students (n=1129) to explore the psychological significance of individual differences in emotional complexity, which was conceptualised as having two correlated aspects: (1) a broad range of emotional experiences and (2) a propensity to make subtle distinctions within emotion categories (Kang & Shaver, 2004). Under this conceptualisation, the authors presented that emotional complexity is a product of cognitive complexity, personality dispositions, and life experiences, and that emotional complexity leads to empathic understanding of others' feelings and greater interpersonal adaptability (Kang & Shaver, 2004). Across two studies, the authors explored the association between emotional complexity and other related constructs including openness to experience, emotional intelligence, emotional expressiveness, empathy and social adjustment.

The development and refinement of the RDEES was done through correlations with related constructs and exploratory factor analyses. A Principal Axis Factor Analysis with Oblique Rotation extracted two factors accounting for 41% of the total variance. The alpha coefficient of the 14-item RDEES was .85. The correlations between the two subscales *Range* and *Differentiation,* ranged from r = .30 to .47. The RDEES was positively correlated with several relevant emotion scales (Kang & Shaver, 2004). Three separate Principal Axis Factor Analyses were conducted on all the emotion variables and demonstrated positive loadings on the first un-rotated variable. The authors

interpreted from this, that there was one general emotion factor. However, based on the scree plot, two factors were extracted. The first factor includes expressivity, intensity, attention, range, differentiation, and externally oriented thinking, and the second factor encompasses clarity of feelings, describing feelings, identifying feelings, and mood repair (Kang & Shaver, 2004).

Across their two studies evidence was presented for the RDEES's construct validity. Their results were robust across three different samples and demonstrated that RDEES was positively correlated with openness to experience, private self-consciousness (awareness of- and attention to- internal aspects of self), empathy and social adaptability (Kang & Shaver, 2004). The authors concluded that individuals with varied and well-differentiated emotional experience were more attentive to their inner feelings and thoughts, open to experience, cognitively complex, showed empathic concern and were more adaptable in interpersonal interactions (Kang & Shaver, 2004).

The RDEES was chosen for inclusion in this study initially as a baseline check to test whether groups differ on measures of emotional complexity. The RDEES was used as an additional measure of mindfulness and to test whether the intervention would increase participant's ability to identify and differentiate their emotional experience.

Confirmatory factor analysis and internal consistency

The RDEES demonstrated excellent internal consistency as a whole scale in session one $\alpha = .91$ and session two .93. The *Range* and *Differentiation* subscales exhibited good reliability ranging from $\alpha = .84$ to .89. This analysis suggests that using the RDEES scale was appropriate for this population sample. The original paper reported a Principal Axis Factor Analysis with Oblique rotation that extracted two factors accounting for 41% of the total variance with correlations between $r = .30$ to .47. The current study used a Principal Axis Factor Analysis with Oblique rotation and yielded two factors accounting for 59.0% of total variance (eigenvalues 6.8, 1.4). The correlations between the two subscales *Range* and *Differentiation,* ranged from $r = .25$ to .61. The results of the current study support the two factor structure.

The Positive and Negative Affect Scale

The PANAS (Watson, Clark, & Tellegen, 1988) (Appendix K) was employed as a measure of both psychological distress and pleasurable experience. The PANAS consists of two 10-item mood scales and was developed to provide brief measures of positive and negative affect. Participants were asked to rate the extent to which they have experienced each particular emotion within a specified time period, with reference to a 5-point scale: 1 (*Very slightly* or *Not at all*) to 5 (*Very much*). Half of the items are words that described negative affect, such as *Nervous* and *Irritable*, and the other half of the items were words that described positive affect, such as *Interested* and *Enthusiastic*.

A number of different time frames have been used with the PANAS, and in this study, two separate time frames were adopted. Participants first completed the PANAS *Over the last 7 days* at the beginning of each lab session (Appendix K). As a measure of psychological distress, it was hypothesised that the mindfulness condition would show a reduction in the *Negative affect* scale and an increase in the *Positive affect* scale across the pre to post-test time frame. Participants also completed the PANAS *Right now* measure immediately before and directly after the *Emotion Induction Task* to explore whether the stories affected participants' mood states (Appendix L). This tested the prediction that those in the mindfulness condition would be less reactive to the stressful stories and therefore demonstrate less negative affect in response to the story.

The items from the PANAS were derived using a Principal Components Analysis with a large sample of emotion descriptors from Zevon and Tellegen's (1982) mood checklist. The authors accepted terms with loadings of .40 or greater on the relevant factors. The final scale resulted in 10 *Positive affect* terms and 10 *Negative affect* terms. The PANAS scale inter-correlations and internal consistency reliabilities were all acceptably high, ranging from α = .86 to .90 for *Positive affect* and from .84 to .87 for *Negative affect* (Watson et al., 1988).

The terms *Positive affect* and *Negative affect* were demonstrated to be highly distinctive dimensions. The correlation between the *Negative affect* and *Positive affect* scales was reported as ranging from -.12 to -.23, in so that the two scales share only 1% to 5% of their variance (Watson et al., 1988). *Positive affect* is described as the extent to which a person feels enthusiastic, active, and alert (Watson et al., 1988). High *Positive affect*

was characterised as a state of high energy, full concentration, and pleasurable engagement. Whereas, low *Positive affect* was defined as sadness and lethargy (Watson et al., 1988). In contrast, high *Negative affect* was characterised as a general dimension of subjective distress that includes a variety of aversive mood states, including anger, contempt, disgust, guilt, fear, and nervousness. Whereas low *Negative affect* was described as a state of calmness and serenity (Watson et al., 1988).

The authors examined correlations with measures of distress and psychopathology and suggested that the PANAS *Negative affect* scale may be a shorter, simpler and conceptually more straightforward measure of general psychological distress (when compared against larger measures of clinical symptomology). Depressive symptomatology for example is affectively complex, and involves both the lack of pleasurable experiences (low *Positive affect*) as well as anger, guilt, and general psychological distress (high *Negative affect)*. The PANAS however, provides a reliable and independent measure of two affective components (Watson et al., 1988).

The PANAS was used in this study because it has demonstrated strong psychometric properties and has been used in numerous MBIs investigating the effect of mindfulness on stress and wellbeing. The PANAS provides a reliable and independent measure of two affective components as a means to assess changes in wellbeing during the intervention.

Confirmatory factor analysis and internal consistency

Each scale of the PANAS exhibited good to excellent internal consistency. The *Positive affect* scale was $\alpha = .90$ at session one and .91 at session two. The *Negative affect* scale was $\alpha = .87$ at session one and .89 at session two. This analysis suggests that using the PANAS with this sample was appropriate. A Principal Components Factor Analysis for the *Positive affect* scale resulted in one factor accounting for 52.2% total variance (eigenvalue 5.2). The *Negative affect* scale Principal Components Analysis yielded one factor accounting for 47.2% of variance (eigenvalue 4.7).

Emotion Stroop Task

The Emotion Stroop Task (e.g., McKenna, 1986; Williams, Mathews, & MacLeod, 1996) has been widely used to assess the association between selective attention responding to negative information or emotional vulnerability (Kappes & Bermeitinger, 2016; MacLeod & Grafton, 2015). The Emotion Stroop Task in this study was used as an implicit measure of emotion responding. It has been reported that mindfulness training can improve a person's ability to control their attention when faced with emotional distractors (Lykins et al., 2012). The Emotion Stroop tests the prediction that mindfulness practice may increase a persons ability to control their attention when faced with emotionally valanced distracters (Lee & Orsillo, 2014). It was hypothesised that the mindfulness group will have shorter completion times, make fewer mistakes in colour-naming emotional words and a have a smaller interference score, than those in the active control.

The original Stroop Colour-Word Test was developed almost a century ago (Jensen & Rohwer, 1966; Stroop 1935) to study attentional processes. The original Stroop test presents participants with a series of colour words in different colour text. The stoop test produces an interference situation in which the participant must name the colour of the text and ignore the meaning of the colour word, when they are incongruous (Jensen & Rohwer, 1966). For example, the name of the word may be *Blue*, whereas the colour of the text is red.

The Emotion Stroop Task is an adaptation of the original Stroop task whereby the colour words are replaced with emotional and neutral words (Lykins et al., 2012). Participants were asked to name the colour of the emotion words, while ignoring their semantic content. Negative emotional words, such as afraid, depressed, and panic, were used with neutral words that are matched for length and frequency of use. The conditions are randomised together so as to avoid practice effects. The dependent variable for each condition is the average reaction time for correct responses from the 192 presented words and total number of errors. The Stroop test is considered a 'gold standard' in attention research as it yields a large and statistically significant effect when administered (MacLeod, 1992).

The degree to which colour naming is disproportionality slow on negative words compared to neutral words is taken as a measure of attentional bias to negative information (emotional distracters), i.e., difficulty ignoring the negative emotion content of these words. The assumption is that the differential attentional responding to negative information relates to individual differences in capacity to regulate emotion (MacLeod & Grafton, 2015). Subjects are asked to identify the ink colour of a word, while the word's meaning is either neutral or emotional/threatening. Typically, subjects take longer to identify the colour of an emotional word than a neutral word. This difference in response time defines the Emotional Stroop Effect (ESE) (Kappes & Bermeitinger, 2016; Lykins et al., 2012). An emotional interference score was computed by subtracting the average reaction time for the neutral condition from the average reaction time of the emotion condition (Lykins et al., 2012).

The Emotion Stroop Task was included in this study as an implicit measure of emotion responding. By measuring attentional responding to negative information, the results can test for changes in emotion reactivity post mindfulness intervention. It has been suggested that there is a need for more studies investigating changes in mindfulness using experimental protocols as assessment tools (Brown & Ryan, 2003). It was anticipated that the use of both experimental measures and self-report data might provide information to further the understanding of how mindfulness practice mediates positive outcomes.

Subjective Affective Manikin (SAM)

Each participant listened to 4 stories developed to induce mild fear or mild anger. After listening to each audio clip, the participant was asked to record their subjective emotional responses using a non-verbal response scale: Subjective Affective Manikin (SAM). The SAM scale measures emotion responses using three items: *Valence* (the positivity or negativity of emotion), *Intensity* (how much the emotion affects the individual's body state), and *Dominance* (how much the individual feels controlled by the emotion). This protocol is a modified version of the Emoter study (2014) developed by Wright, K., Colombetti, G., and Cannon, P., in collaboration with the University of Exeter, UK and Massey University. The SAM response scale is presented in Appendix M, instructions for SAM in Appendix N, and full story scripts can be viewed in Appendices O and P.

This data tested the hypothesis that mindfulness training can impact the way a person responds to difficult emotions. Previous experimental research has demonstrated that mindfulness is associated with reduced emotion reactivity (Sayers et al., 2015). In this study, the prediction was that participants in the mindfulness condition would demonstrate the ability to be less emotionally reactive in an emotion induction experiment. It was hypothesised that in response to the fear and anger stories post-intervention, the participants in the mindfulness group would experience less negative emotion (*Valence*), subjective physiological arousal (*Intensity)* and feel less overwhelmed by emotion (*Dominance)* compared to the control condition. Mindfulness training promotes the ability to identify and differentiate emotions as they arise, both positive and negative. By allowing and accepting the experience of difficult emotions with an attitude of non-judgement, it is hypothesised that the strength of the negative emotion is diffused and the individual learns not to fear or battle with difficult emotions. This in turn reduces the reactivity or sensitivity to negative emotions as they arise. In this study it was hypothesised that participants may identify a negative emotion in response to the stories, but respond to the negative emotion less reactively compared to the control.

SAM was included in this study to provide subjective information about emotion responding to negative emotional experiences, such as listening to fear and anger stories. By combining both self-report and implicit experimental measures, it was hoped to provide a more detailed picture of emotion responding in the context of mindfulness training.

Psychophysiological measures

During testing sensor electrodes recorded facial muscle contraction and heart rate variability as a measure of implicit emotion activation while the participant listened to the fear and anger stories.

Facial muscle tone recorded by electromyography (EMG)

Implicit affective responses to the fear and anger stories were measured using electromyography (EMG) to record facial muscle activation. This data was used to test the hypothesis that mindfulness training would be associated with less emotional reactivity in response to negative emotion stories. In this case, the prediction was that participants in the mindfulness condition would demonstrate reduced facial muscle activation post-intervention, equating to less emotional reactivity to the fear and anger stories. In addition, differences between fear and anger responding were analysed assess differences in emotional responding.

The psychophysiological measure of muscle activity using EMG is a standard technique and its use in this project was within established peer reviewed ethical guidelines (Fridlund & Cacioppo, 1986). Facial EMG (FEMG) as a tool for inferring implicit affective states has been validated in previous research (Cannon, Schnall, & White, 2011). The experimenters were trained by Dr Cannon, who has extensive experience working with this technique and understands the methods for optimising FEMG data (Cannon, 2009; Cannon, Hayes, & Tipper, 2010; Cannon & Schnall, 2012; Cannon et al., 2011). Muscle activity relating to fear (Frontalis), anger (Corrugator Supercilii), and positive affect (Zygomaticus major) were recorded while participants listened to fear and anger stories (Cannon et al., 2011). Appendix E outlines the basic procedures.

Baseline amplitudes and affective EMG response magnitudes vary between individuals due to differences in affective processes as well as anatomical and biophysical differences (van Boxel, 2010). In order to standardise the method, maximal voluntary contractions for each muscle were recorded at the end of each laboratory session (van Boxel, 2010). This leads to a better compatibility between different subjects (van Boxel, 2010).

FEMG data was rectified to convert negative values and calculate a total change value score. Trial baselines were recorded for 1.5 seconds before the story and muscle activation change scores were calculated from the trial baseline. The resulting value was calculated as a percentage of maximum contraction and the change in mean value was used for analysis. A negative value represents muscle relaxation as a percentage of maximum muscle contraction. A positive value represents the level of muscle activation as a percentage of the recorded maximum muscle contraction.

Data was processed using *R* to exclude unstable and irrelevant data such as wires and cell phone interference. A high pass filter allowed over 20htz and blocked out below 20 Hz. This removed extraneous signals from a variety of sources including cables, wires and electrode movement. A low pass filter was set to 500htz, allowing anything below 500htz, excluding interference from cell phones etcetera. A notch filter was set to 50htz and removes interference from mains supply frequency in the lab (lights etcetera).

FEMG was included in this study to gather further information on emotion responding to support self-report and other implicit measures of emotion reactivity. By combining the results from both self-report and implicit experimental measures it is hoped to provide detailed information about any changes in emotion responding after mindfulness training.

Heart rate variability measured by electrocardiogram

Physiological stress was measured using an electrocardiogram (ECG) with a Biopac MP150 device. Heart rate variability was recorded while the participant listened to the fear and anger stories to assess any changes between baseline and the post-test lab session. Change in heart rate variability was measured to assess the level of emotional activation during the emotion induction task and time it took to settle once activated. As with the other psychophysiological measures, this data was used to test the hypothesis that mindfulness training can be associated with less emotional reactivity in response to an stress induction exercise. The prediction being that those in the mindfulness condition would demonstrate less sympathetic activation and faster time to calm.

Raw heart rate data was converted into frequency of heart rate episodes. Heart rate variability is calculated from the ratio of high frequency to low frequency episodes. A

higher ratio of high frequency to low frequency indicates more parasympathetic activation. Whereas, low frequency represents the slow build up of the sympathetic stress response. ECG data was processed to exclude signal noise from a variety of sources including baseline drift and electrode wire movement. A high pass filter was set to 1Hz removing irrelevant data below 1Hz and allowing signals over 1Hz. This removed extraneous signals from cables, wires, electrode movement, cell phones and mains supply. A visual scan of the data checked for artefacts and data was corrected where peaks were missing. Cycles of QRS peaks were summarised for analysis.

Heart rate variability was used in this study as a physiological measure of arousal in response to fear and anger stories to compliment the self-report and experimental measures of emotion responding after mindfulness training.

RESULTS

3.1 DISTRIBUTION

Descriptive statistics assessed distributional assumptions and found evidence of normality in each group. Data was explored to examine the level of skew and kurtosis, with results greater than two standard errors being considered significantly not normal. The Kolmogorov-Smirnov test statistic was used to compare scores in the sample to a normally distributed set of scores with the same mean and standard deviations. Q-Q plots were reviewed for all data showing acceptable fit to a linear model. Data exploration demonstrated that dependent measures were normally distributed within acceptable limits.

3.2 DATA ANALYSIS

Normally distributed data was analysed using independent measures *t*-tests, paired *t*-tests and mixed repeated measures analysis of variance (ANOVA). Independent sample *t*-tests were run to compare sample pre-test means between conditions. Levene's test was conducted to test whether the assumption of homogeneity of variance was not violated and the variances within groups were roughly equal. Randomisation checks are presented in Table 5 with independent samples *t*-tests and descriptive statistics for mean age, workload (WQ), perceived stress (PSS), mindfulness (FMI and FFMQ), range and differentiation of emotion (RDEES) and affect (PANAS) self-report questionnaire results. There were no statistically significant differences between groups at baseline for self-report questionnaires.

Repeated measures ANOVAs were run to identify changes in dependent variables from pre-test to post-test, including changes in scores for the whole group (time effects) and for the experimental versus the control group (group by time effects). Mixed repeated ANOVAs compared the effects of group and time on measures of mindfulness, perceived stress, and emotion reactivity. Where Mauchly's test indicated that the assumption of sphericity had been violated, Greenhouse-Geisser corrected tests are reported. Partial eta squared (η^2_p) was calculated to assess effect sizes.

Table 5. Baseline means, standard deviations, and independent-samples *t*-tests for self-report measures.

	Mindfulness (n = 28)	Control (n = 26)	95% CI for Mean Difference			
Measure	M (SD)	M (SD)	Lower	Upper	t	p
Age	26.42 (8.73)	28.65 (8.50)	-2.87	7.31	-0.88	0.38
WQ	8.70 (2.18)	8.76 (2.37)	-1.21	1.32	-0.09	0.93
PSS-10	23.86 (5.82)	23.42 (5.21)	-3.46	2.59	-0.29	0.77
FMI-14	32.64 (6.90)	33.58 (6.55)	-2.75	4.61	-0.51	0.61
FFMQ-24	73.88 (12.60)	71.50 (11.00)	-8.97	4.20	-0.73	0.47
Observe	13.48 (2.90)	14.58 (3.55)	-0.57	2.92	1.23	0.22
Describe	17.52 (4.09)	15.85 (5.24)	-4.26	0.91	-1.30	0.20
Non-React	13.63 (3.70)	13.12 (3.43)	-2.48	1.46	-0.52	0.60
Act-Aware	14.74 (3.92)	14.46 (2.94)	-2.19	1.63	-0.29	0.77
Non-Judge	14.27 (4.57)	13.50 (3.95)	-3.15	1.61	-0.65	0.52
RDEES	49.70 (11.62)	50.19 (10.52)	-5.63	6.61	0.16	0.87
PANAS-PA	30.52 (7.83)	32.96 (8.03)	-2.07	6.95	-1.09	0.28
PANAS-NA	25.08 (9.05)	26.04 (7.56)	-3.78	5.70	-0.41	0.69
PANAS-Ch PA	-2.37 (7.13)	-0.56 (4.15)	-1.47	5.09	1.11	0.27
PANAS-Ch NA	3.42 (6.54)	2.60 (4.27)	-3.94	2.30	-0.53	0.60

Abbreviations: WQ, Workload Questionnaire; PSS-10, Perceived Stress Scale 10-item; FMI-14, Freiburg Mindfulness Inventory 14-item; FFMQ-24, Five Facet Mindfulness Questionnaire 24-item; RDEES. Range and Differentiation of Emotional Experience Scale; PANAS, Positive and Negative Affect Scale 10-items; PA, Positive Affect; NA, Negative Affect; Ch, Change score.

The risk of Type 1 error was considered and all analyses were planned based on the initial hypothesis. Given the number of comparisons that were run in this study, care has been taken not to over-interpret the findings.

The sample size originally chosen for this study was expected to be adequate to detect a significant effect of the mindfulness training on perceived stress, mindfulness and emotion regulation from published work. At project conceptualisation a sample size calculation determined that n26 participants per group would be required to detect a large effect size with a power of 80% at significance level of 0.05 (Cohen, 1992). However, follow up analysis suggests the current study is underpowered with only 54 participants. It is important to note here that due to the small sample size and low power of the study, it is possible that any significant changes found in individual groups are due to chance alone.

3.3 SELF-REPORT QUESTIONNAIRES

Freiburg Mindfulness Inventory

The FMI tested the hypothesis that participation in a brief, self-directed mindfulness training with a mobile phone app could cultivate mindfulness skills, or the ability to respond mindfully to the experience of daily life. It was predicted that the brief-mindfulness intervention would elicit an increase in mindfulness skills as measured by the FMI, compared to the control condition. Repeated measures ANOVA for FMI did not detect a statistically significant difference in group behaviour over time, demonstrating a statistically parallel time profile for the two groups $F(1, 52) = 1.30$, $p = .26$, $\eta^2_p = .02$. The main effect for group was not significant, $F(1, 52) = .00$, $p = .99$, $\eta^2_p = .00$, on mindfulness measured by FMI. Table 6 lists the results from the repeated measures ANOVA. Figure 10 presents the group FMI means for each group from baseline to post-intervention.

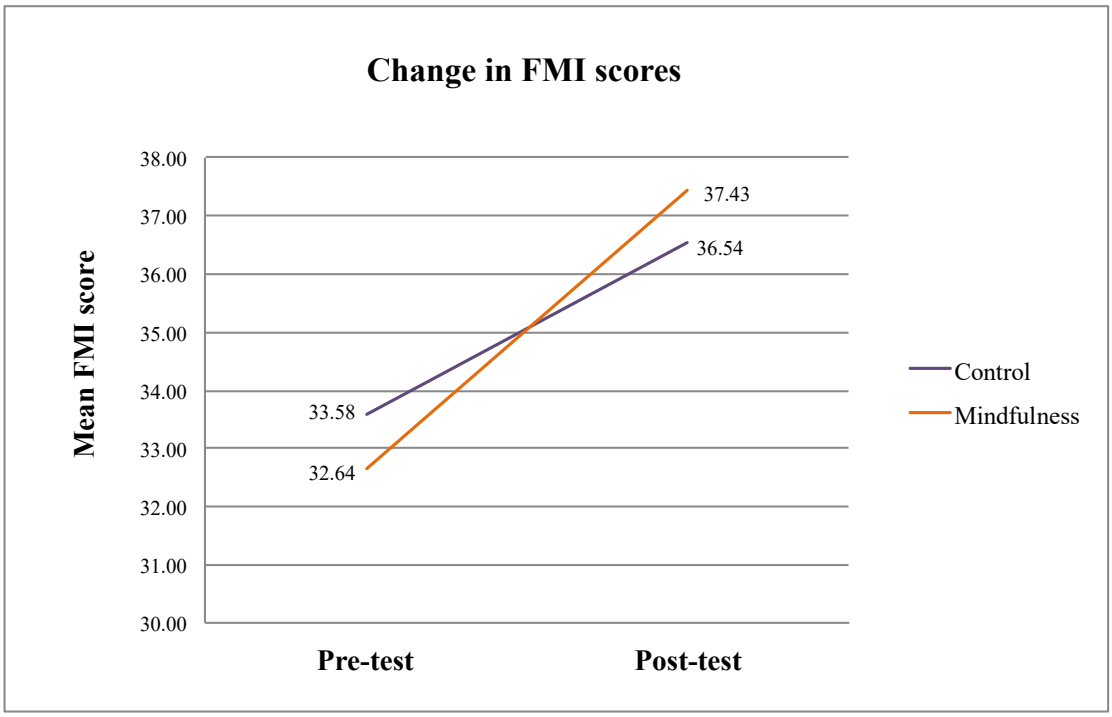

Figure 10. Mean Freiburg Mindfulness Inventory (FMI) scores for both experimental conditions over time. ANOVA results show a significant parallel increase in FMI scores for both groups from baseline (Pre-test) to post-intervention (Post-test) $F(1, 52) = 23.51$, $p < .00$, $\eta^2_p = .31$.

A significant main effect of time was detected demonstrating a positive trend in FMI mindfulness scores for both groups over time accounting for 31% of variability, $F(1, 52) = 23.51$, $p < .00$, $\eta^2_p = .31$. Paired *t*-tests indicated that scores were significantly higher in the mindfulness group post-test than they were at pre-test ($M = 4.79$, $SD = 6.91$), $t = 2.11$, $p < .00$. A significant increase in mindfulness was also observed in the control group from baseline to post-intervention ($M = 2.96$, $SD = 4.47$), $t = 1.16$, $p < .00$.

In summary, the results of this analysis did not confirm the prediction that the mindfulness training would increase measures of mindfulness compared to the control condition. No statistically significant differences in group behaviour over time were detected demonstrating a statistically parallel time profile for the two groups. A significant increase in FMI mindfulness scores for both groups from pre to post-intervention was detected with a large effect size. Given that the control group also increased in FMI scores, the mindfulness intervention cannot be credited with the observed increase in mindfulness skills and there may be other factors contributing to the effect. Possible reasons for this are explored in the discussion.

Five Facet Mindfulness Questionnaire

The FFMQ tested the hypothesis that participation in brief, self-directed mindfulness training could cultivate mindfulness skills or the ability to respond mindfully to the experience of daily life. It was predicted that the brief-mindfulness intervention would elicit an increase in mindfulness skills on multiple facets of the FFMQ compared to the control group. Results from repeated measures ANOVA for FFMQ are illustrated in Table 6. Figures 11 and 12 depict the facet score means from pre to post-test for each group separately. Repeated measures ANOVA for FFMQ as a whole scale did not detect a statistically significant difference in group behaviour over time, demonstrating a statistically parallel time profile for the two groups $F(1, 52) = 1.97$, $p = .17$, $\eta^2_p = .04$. There was no main effect of group $F(1, 52) = 2.55$, $p = .12$, $\eta^2_p = .05$. As a uni-dimensional scale, there was a main effect of time on FFMQ-24 scores, $F(1, 52) = 20.58$, $p < .00$, $\eta^2_p = .30$ indicating an increase in mindfulness scores for both groups.

According to the five factor model, facets of mindfulness on the FFMQ were analysed as five separate factors. Repeated measures ANOVA for FFMQ facets did not detect any statistically significant differences in group behaviour over time for four out of five facets; *Observe*, $F(1, 52) = .11$, $p < .74$, $\eta^2_p = .00$; *Describe*, $F(1, 52) = 1.08$, $p < .30$, $\eta^2_p = .21$; *Non-React*, $F(1, 52) = 1.07$, $p < .30$, $\eta^2_p = .21$; *Non-Judge*, $F(1, 52) = .21$, $p < .65$, $\eta^2_p = .00$. A significant interaction between time and group was detected for the *Act-Aware* factor accounting for 1% of variance, $F(1, 52) = 5.52$, $p < .02$, $\eta^2_p = .01$. No significant main effects for group were detected for any of the facets: *Observe*, $F(1, 52) = .11$, $p < .74$, $\eta^2_p = .00$; *Describe*, $F(1, 52) = 1.08$, $p < .30$, $\eta^2_p = .21$); *Non-React*, $F(1, 52) = 1.07$, $p < .30$, $\eta^2_p = .21$; *Act-Aware*, $F(1, 52) = 1.93$, $p < .17$, $\eta^2_p = .37$; *Non-Judge,* $F(1, 52) = .21$, $p < .65$, $\eta^2_p = .00$.

Parallel increases in three FFMQ facets from pre to post-test were observed for both groups. A significant main effect of time was observed for *Non-React* accounting for 28% of variance, $F(1, 52) = 19.32$, $p < .00$, $\eta^2_p = .28$ and for *Act-Aware* accounting for 15% of variance, $F(1, 52) = 9.01$, $p < .00$, $\eta^2_p = .15$. A time effect for *Non-Judge* was approaching significance accounting for 6% of variability, $F(1, 52) = 3.16$, $p < .08$, $\eta^2_p = .06$. No significant main effects of time were detected for *Observe*, $F(1, 52) = 3.44$, $p < .70$, $\eta^2_p = .63$, or *Describe*, $F(1, 52) = 2.76$, $p < .10$, $\eta^2_p = .5$.

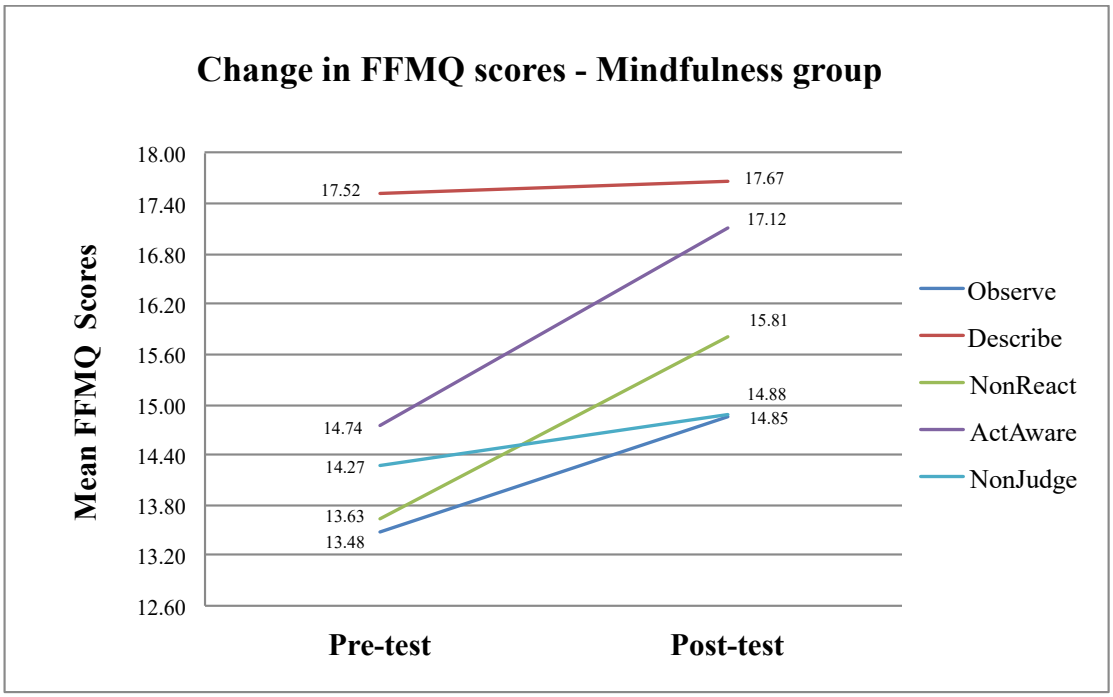

Figure 11. Mean Five Facet Mindfulness Questionnaire (FFMQ) scores for the mindfulness group from baseline (Pre-test) to post-intervention (Post-test). Results indicate a significant increase in *Act-Aware* and *Non-React* facet scores.

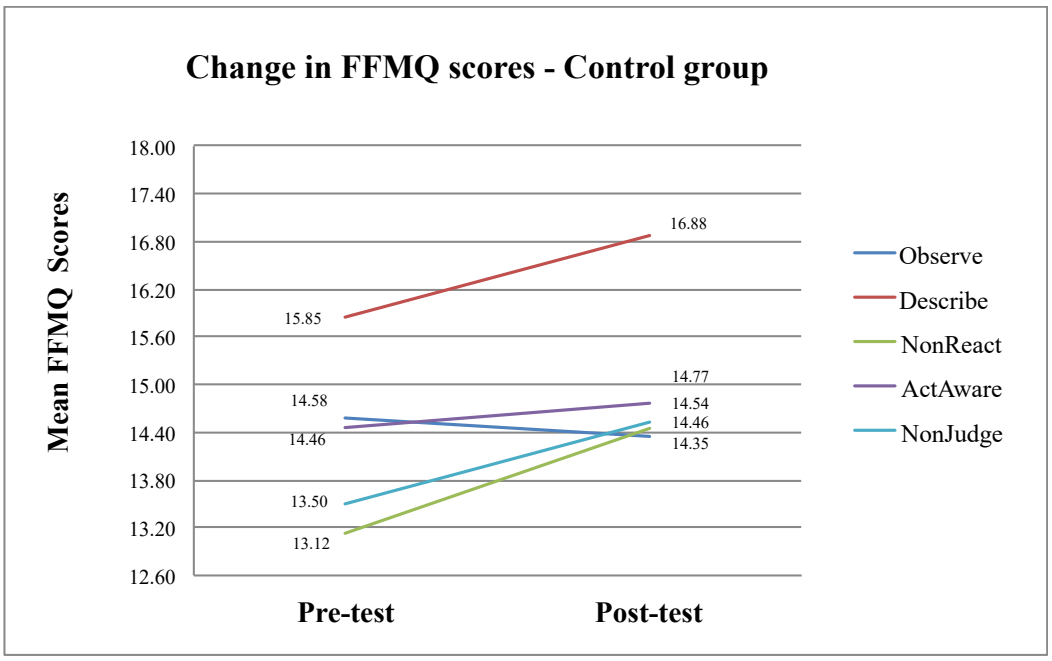

Figure 12. Mean Five Facet Mindfulness Questionnaire (FFMQ) scores for the control group from baseline (Pre-test) to post-intervention (Post-test). Results indicate a significant increase in *Non-React* facet scores.

To investigate the apparent increase in mindfulness on the *Non-React*, *Act-Aware* and *Non-Judge* facets, paired-samples *t*-tests were conducted. *Non-React* scores were significantly higher in both the mindfulness group from pre-test to post-test ($M = 2.19$, $SD = 3.01$), $t = 3.77$, $p < .00$, and in the control group ($M = 1.35$, $SD = 2.83$), $t = 2.43$, $p < .02$. *Act-Aware* scores were significantly higher in the mindfulness group at post-test than for pre-test ($M = 2.50$, $SD = 3.01$), $t = 3.77$, $p < .00$. However, no significant increase in *Act-Aware* scores was detected in the control group from pre-test to post-test ($M = .31$, $SD = 3.22$), $t = .49$, $p < .63$. No significant differences from pre to post-test were detected in the *Non-Judge* facet.

In summary, when analysed as a five-factor scale, the results from the FFMQ analysis partially support the hypothesis that a brief mindfulness intervention with a mobile mindfulness app can increase mindfulness skills compared to a control condition. ANOVA results for the FFMQ failed to detect a difference in group behaviour over time for the *Observe, Describe, Non-React* and *Non-Judge* facets. A significant group by time effect was detected for the *Act-Aware* facet with a small effect size. *Act-Aware* scores increased significantly in the mindfulness group, whereas they remained unchanged in the control group. Results from ANOVA indicated a significant time effect in the *Non-React* facet with a large effect size, indicating a parallel increase in mindfulness for both groups.

The results suggest that participation in brief, self-directed mindfulness training with a mobile app may cultivate the ability to *act with awareness.* Given that the both the mindfulness and the control group increased in *Non-React* scores it is not known whether the mindfulness condition increased the ability to respond *Non-Reactively* or whether other variables contributed to this effect. Possible reasons for this are explored in the discussion section.

Table 6. Repeated Measures ANOVAs for mindfulness variables by mindfulness intervention and active control group.

	Mindfulness (n = 28)		Active Control (n = 26)						
Measure	Pre M (SD)	Post M (SD)	Pre M (SD)	Post M (SD)	Source	df	F	p	η^2_p
FMI-14	32.64 (6.90)	37.43 (7.93)	33.58 (6.55)	36.54 (5.54)	Group	1	0.00	0.99	0.00
					Time (T)	1	23.51	0.00	0.31
					Group × T	1	1.30	0.26	0.02
FFMQ-24	73.76 (12.85)	80.40 (14.05)	71.50 (11.00)	75.00 (11.25)	Group	1	2.55	0.12	0.05
					Time (T)	1	20.58	0.00	0.30
					Group × T	1	1.97	0.17	0.04
- Observe	13.48 (2.90)	14.85 (3.30)	14.58 (3.55)	14.35 (3.81)	Group	1	0.11	0.74	0.00
					Time (T)	1	3.44	0.70	0.63
					Group × T	1	6.79	0.12	0.12
- Describe	17.52 (4.09)	17.67 (3.99)	15.85 (5.24)	16.88 (4.57)	Group	1	1.08	0.30	0.21
					Time (T)	1	2.76	0.10	0.51
					Group × T	1	1.56	0.22	0.03
- Non-React	13.63 (3.70)	15.81 (4.11)	13.12 (3.43)	14.46 (2.97)	Group	1	1.07	0.30	0.21
					Time (T)	1	19.32	0.00	0.28
					Group × T	1	1.09	0.30	0.02
- Act-Aware	14.74 (3.92)	17.12 (3.83)	14.46 (2.94)	14.77 (3.81)	Group	1	1.93	0.17	0.37
					Time (T)	1	9.01	0.00	0.15
					Group × T	1	5.52	0.02	0.01
- Non-Judge	14.27 (4.57)	14.88 (4.50)	13.50 (3.95)	14.54 (4.10)	Group	1	0.21	0.65	0.00
					Time (T)	1	3.16	0.08	0.06
					Group × T	1	0.10	0.75	0.00

Note. FMI-14, Freiburg Mindfulness Inventory; FFMQ-24, Five Facet Mindfulness Questionnaire.

Perceived Stress Scale

The PSS was used to test the hypothesis that brief mindfulness training with a mobile app could improve response to stress in a student population. It was predicted that the mindfulness intervention would reduce student stress as measured by the PSS. Results from repeated measures ANOVA for the PSS are illustrated in Table 7. Figure 13 presents the changes in group means from pre to post-test. The analysis did not detect any significant difference in group behaviour over time suggesting a parallel time profile for both groups, $F(1, 52) = .05$, $p = .82$, $\eta^2_p = .00$. No significant main effect of group was detected $F(1, 52) = .19$, $p = .66$, $\eta^2_p = .00$. There was an apparent decrease in perceived stress in both groups that failed to reach significance $F(1, 52) = 2.55$, $p = .12$, $\eta^2_p = .05$.

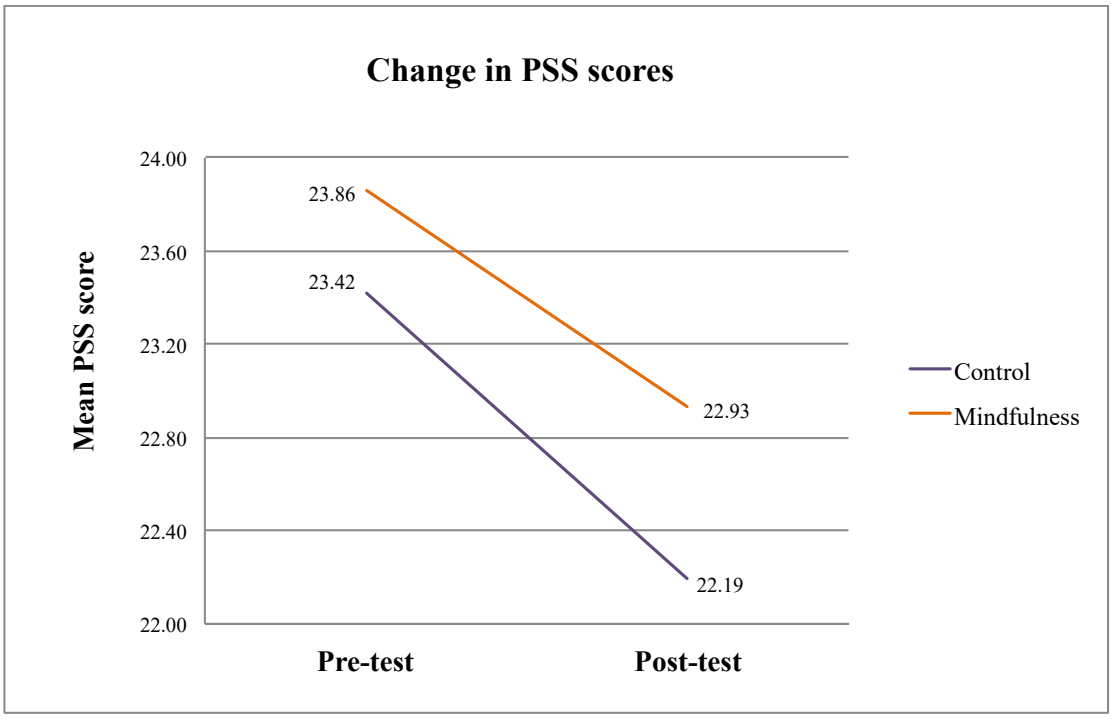

Figure 13. Mean Perceived Stress Scale (PSS) scores for the experimental groups at baseline (Pre-test) and post-intervention (Post-test). ANOVA results show a non-significant reduction in perceived stress for both groups over time $F(1, 52) = 2.55$, $p = .12$, $\eta^2_p = .05$.

In summary, results from this analysis do not support the hypothesis that a brief mindfulness intervention with a mobile app would improve the response to stress compared with a control group. A non-significant trend was observed with a reduction in perceived stress for both groups over time. Possible reasons for the failure of the mobile app intervention to elicit significant changes perceived stress are explored in the discussion section.

Range and Differentiation of Emotional Experience Scale

Analysis of group changes over time tested the prediction that mindfulness training would increase the ability to identify (*Range*) and differentiate (*Differentiation*) a broader range of emotions compared to a control group. Results from repeated measures ANOVA for RDEES are illustrated in Table 7. Figure 14 and 15 present the group means from pre to post-test for *Range* and *Differentiation* respectively.

Contrary to the hypothesis no significant interaction effects of time by condition were detected for emotional *Range*, $F(1, 52) = 2.35$, $p = .13$, $\eta^2_p = .04$. No main effects of group, $F(1, 52) = .07$, $p = .79$, $\eta^2_p = .00$, or time were found, $F(1, 52) = 2.15$, $p = .15$, $\eta^2_p = .04$. Similarly, no significant changes in group scores overtime were detected for emotional *Differentiation,* $F(1, 52) = .97$, $p = .33$, $\eta^2_p = .02$. No significant effect of time was found, $F(1, 52) = 0.30$, $p = .59$, $\eta^2_p = .01$, A significant main effect of group, $F(1, 52) = .79$, $p = .00$, $\eta^2_p = .07$ indicated a difference in group responses, with the mindfulness group rating lower than the active control ($M = 23.81$, $SD = 5.37$ versus $C = 24.65$, $SD = 6.04$, $p = .00$).

In summary, the results from this analysis do not confirm the hypothesis that a brief mindfulness intervention with a mobile app would improve the ability to identify and differentiate a range of emotions compared to a control condition.

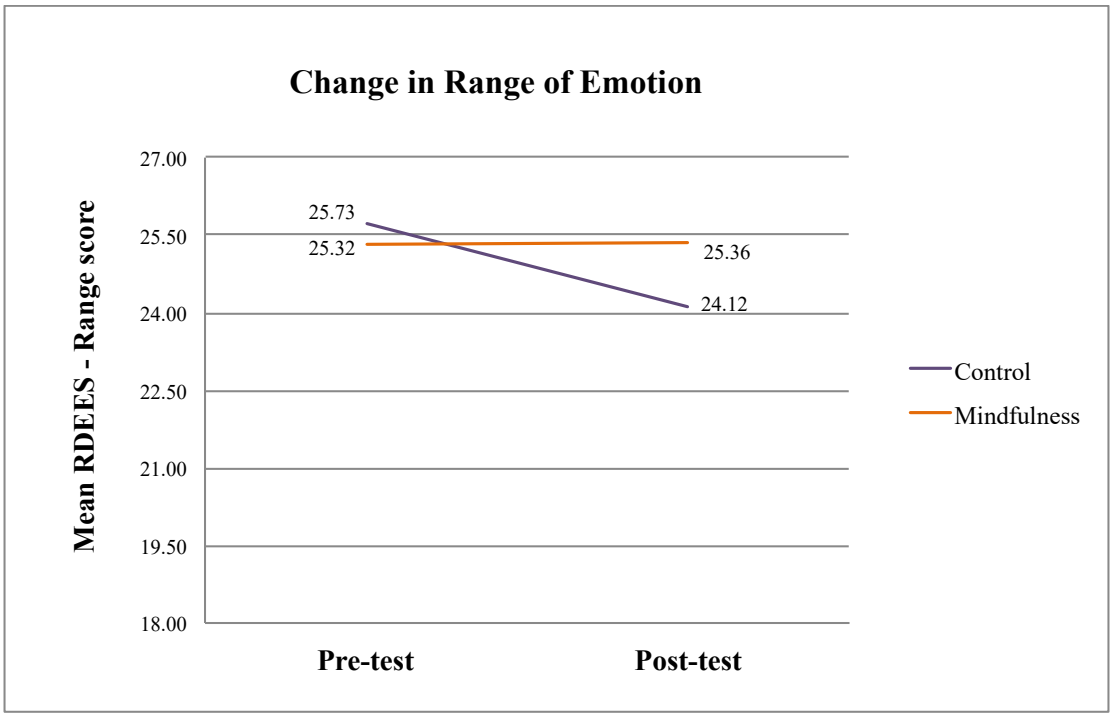

Figure 14. Mean *Range* of emotional experience (Range and Differentiation of Emotional Experience, RDEES) scores for the experimental groups at baseline (Pre-test) and post-intervention (Post-test). No significant effects were detected.

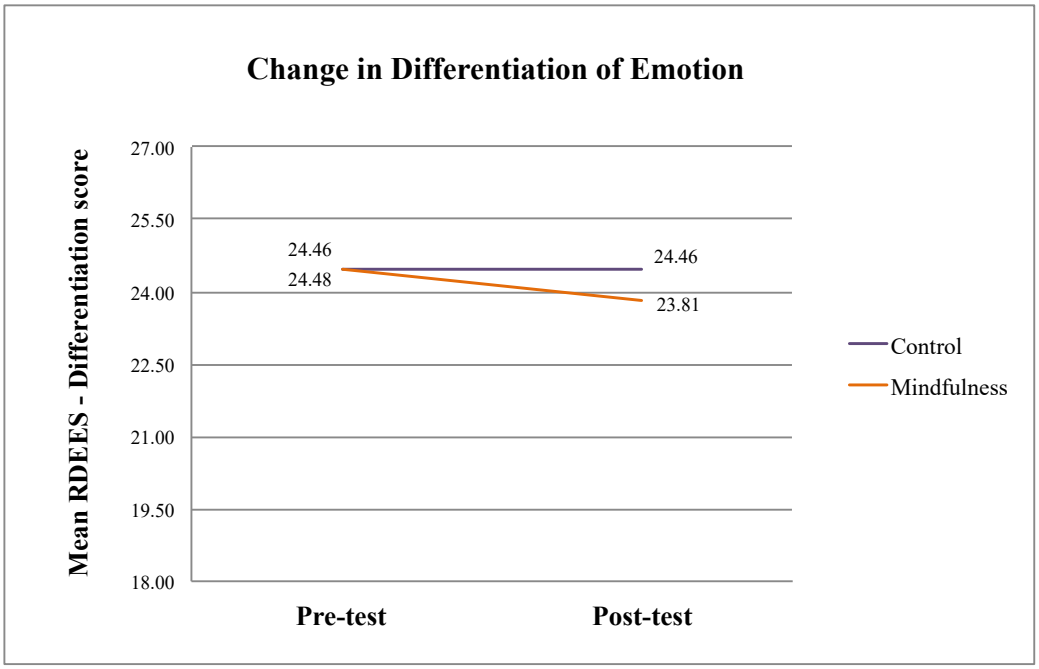

Figure 15. Mean *Differentiation* of emotional experience (Range and Differentiation of Emotional Experience, RDEES) scores for the experimental groups at baseline (Pre-test) and post-intervention (Post-test). No significant effects were detected.

Positive and Negative Affect Scale

PANAS - 7 days

The PANAS scale measures positive and negative affect. As a measure of psychological wellbeing, it was hypothesised that the mindfulness group would demonstrate a reduction in the *Negative affect* scale and an increase in the *Positive affect* scale across the pre to post-test time frame. Results from repeated measures ANOVA for PANAS *7 days* are illustrated in Table 7. Figures 16 and 17 illustrate the group means from pre to post-test for negative and positive affect correspondingly. For the *Positive affect* scale, no group differences over time were detected, $F(1, 52) = 1.74$, $p = .19$, $\eta^2_p = .04$. No significant main effects of group, $F(1, 52) = .23$, $p = .63$, $\eta^2_p = .00$, or time, $F(1, 52) = .77$, $p = .38$, $\eta^2_p = .02$, were found. A non-significant trend was observed for positive affect, whereby the mindfulness group demonstrated a slight increase in positive affect, whereas in the control group there was a trend of reduced positive affect from pre to post-test.

Analysis of the *Negative affect* scale failed to detect a difference between groups over time $F(1, 52) = 1.24$, $p = .27$, $\eta^2_p = .03$. The main effect for group was not significant, $F(1, 52) = .03$, $p = .86$, $\eta^2_p = .00$. A main effect of time was observed, $F(1, 52) = 23.58$, $p < .00$, $\eta^2_p = .33$, indicating that both groups experienced a parallel reduction in negative affect from pre-test to post-test accounting for 33% of variance. Paired-samples *t*-tests confirmed a significant decrease in negative affect in both the mindfulness group from pre to post-test ($M = -3.84$, $SD = 7.45$, $t = -2.58$, $p < .02$), and the control group ($M = -6.13$, $SD = 4.37$, $t = -4.35$, $p < .00$).

In summary, the results of this analysis failed to confirm the hypothesis that the mindfulness condition would increase positive affect and decrease in negative affect compared to the control group. No significant group by time interactions were detected on either the positive or negative affect scales. A parallel reduction in negative affect for both groups was detected with a large effect size. Given that the control group also decreased in negative affect, the observed effect cannot be attributed to the mindfulness intervention. Possible explanations for these findings are addressed in the discussion.

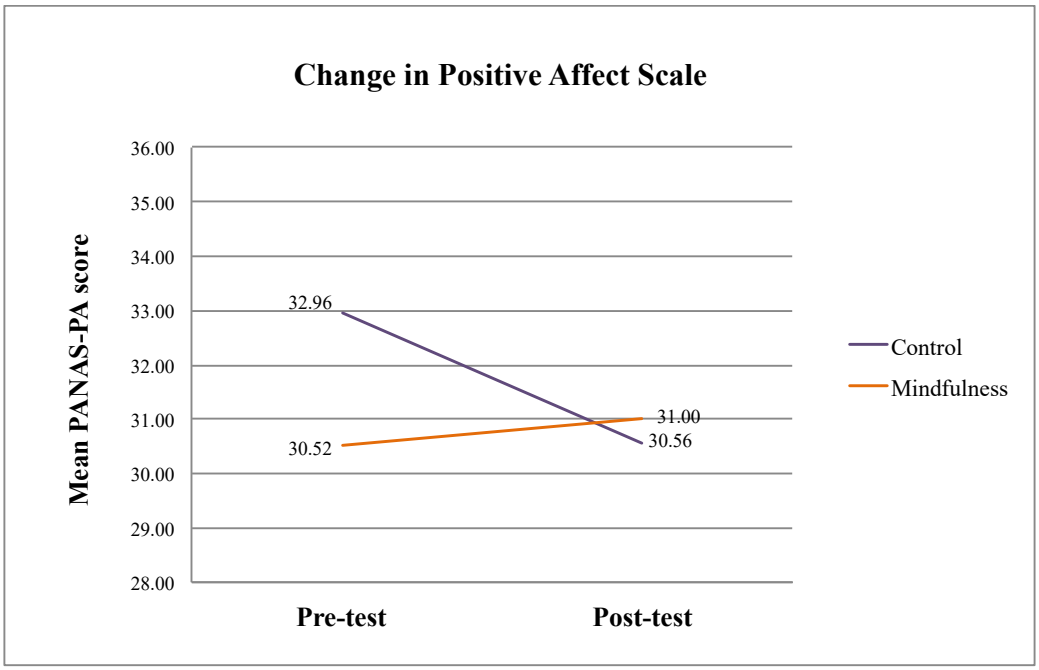

Figure 16. Mean *Positive affect* scale (Positive and Negative Affect Scale, PANAS) scores for the experimental groups at baseline (Pre-test) and post-intervention (Post-test). No significant effects were detected.

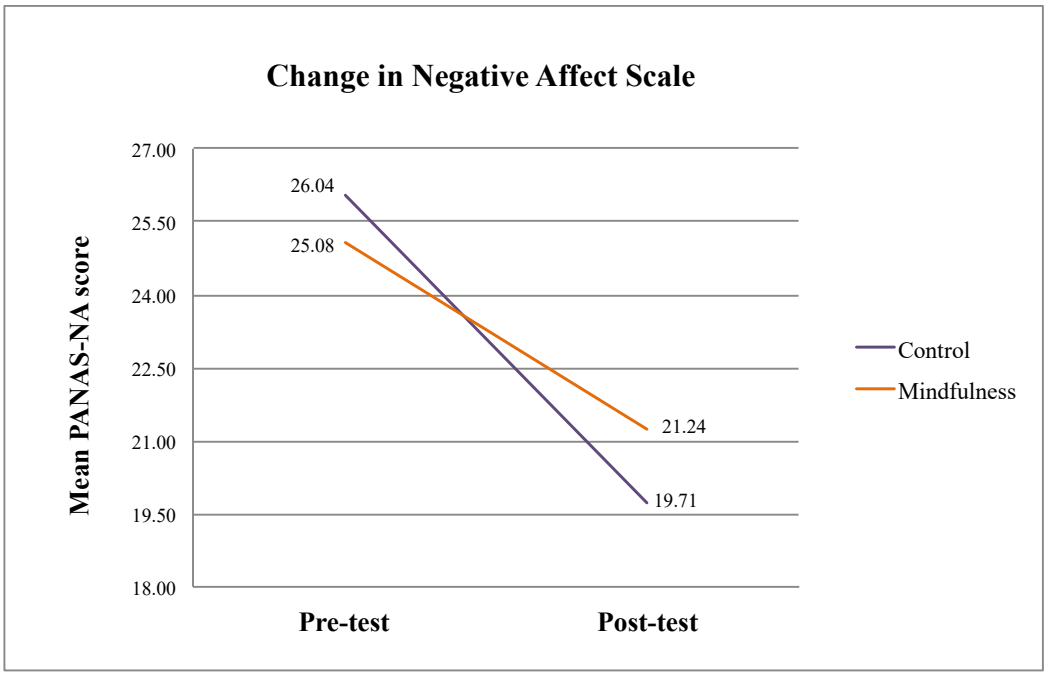

Figure 17. Mean *Negative affect* scale (Positive and Negative Affect Scale, PANAS) scores for the experimental groups at baseline (Pre-test) and post-intervention (Post-test). ANOVA results indicate a significant parallel reduction in negative affect from pre to post-test for both groups $F(1, 52) = 23.58$, $p < .00$, $\eta^2_p = .33$.

PANAS – Before & after stories

The PANAS was used again as a measure of current mood before and after listening to fear and anger stories. As a measure of emotion regulation, it was hypothesised that the mindfulness condition would be less reactive to the fear and anger stories. It was predicted that after listening to the fear and anger stories the mindfulness group would express less change in mood as measured by *Negative affect* and *Positive affect* scales, compared to the control group. A negative change score indicates a decrease in positive affect after listening to the fear and anger stories, whereas a positive change score demonstrates an increase in positive affect after listening to the stories. It was predicted that the mindfulness group would be less affected by the stories compared to the control evidenced by higher positive mood scores and lower negative mood scores than the control post-test.

Contrary to the hypothesis no significant differences in group responding over time were detected for either scale, *Positive affect* $F(1, 50) = .05$, $p = .83$, $\eta^2_p = .00$, *Negative affect* $F(1, 50) = 1.65$, $p = .21$, $\eta^2_p = .03$. Table 7 lists the results from the repeated measures ANOVA. Figures 18 and 19 illustrate the group means from pre to post-test. For the *Negative affect* scale there were no significant differences detected between groups, $F(1, 50) = .01$, $p = .91$, $\eta^2_p = .00$, or over time, $F(1, 50) = .42$, $p = .52$, $\eta^2_p = .01$. A non-significant trend was observed whereby, the mindfulness group experienced lesss negative affect from pre to post-test and the control experienced more negative affect from pre to post-test.

For the Positive affect scale, there were no significant differences detected between the groups $F(1, 50) = 1.62$, $p = .21$, $\eta^2_p = .03$. A significant effect of time was observed, $F(1, 50) = 6.30$, $p = .02$, $\eta^2_p = .12$ accounting for 12% of variance, indicating a parallel increase in both groups over time for positive affect. Both groups experienced a reduction in positive affect at baseline after listening to the stories, whereas both groups demonstrated an increase in positive affect after listening to the fear and anger stories at post-test. Contrary to the prediction, no significant differences were detected for group responding over time for either scale. A significant effect of time was observed in the positive affect scale indicating that both groups increased in positive affect after listening to the fear and anger stories at post-test. The results did not confirm that mindfulness training can modulate the level of emotion reactivity in response to fear and anger stories compared to a control group.

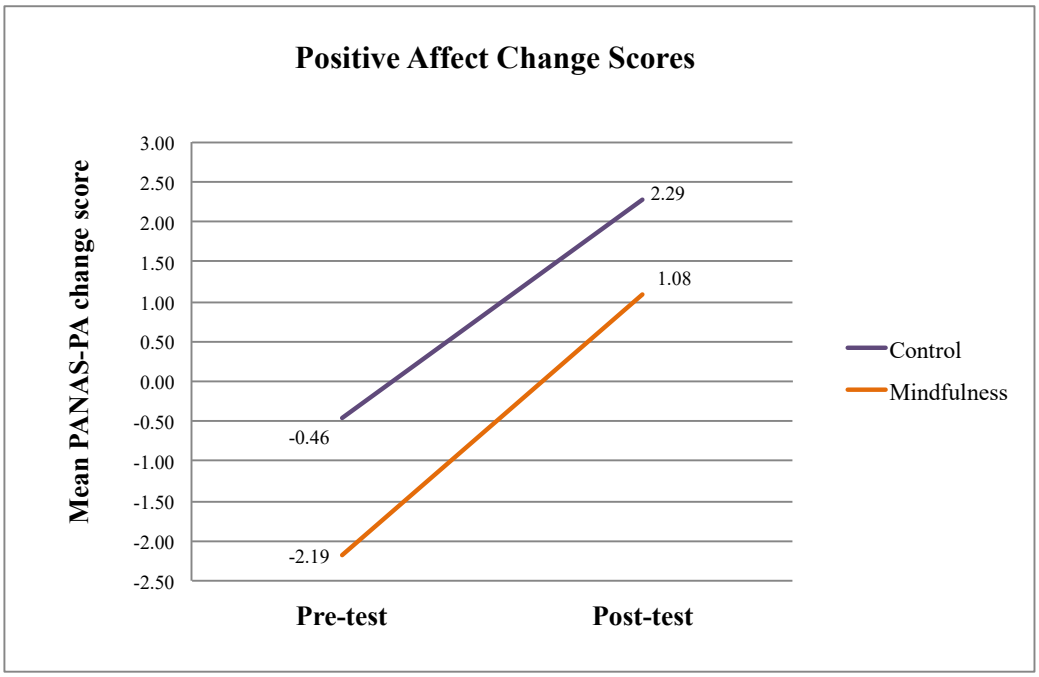

Figure 18. Mean PANAS change scores for the *Positive affect* scale at baseline (Pre-test) and post-intervention (Post-test) by experimental condition. A negative change score indicates a reduction in affect after listening to fear and anger stories, whereas a positive change score indicates an increase in affect. A significant increase in positive affect in both groups over time was detected.

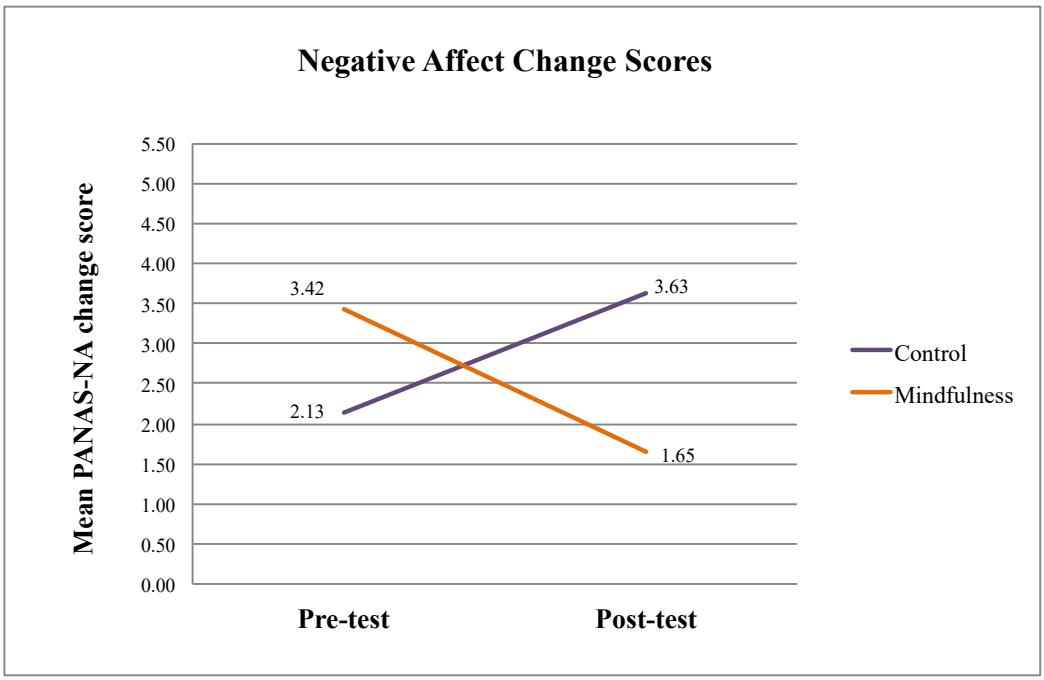

Figure 19. Mean PANAS change scores for the *Negative affect* scale at baseline (Pre-test) and post-intervention (Post-test) by experimental condition. A negative change score indicates a reduction in affect after listening to fear and anger stories, whereas a positive change score indicates an increase in affect. No significant effects were detected

Table 7. Repeated Measures ANOVAs for stress and emotion variables by mindfulness intervention and active control group.

	Mindfulness (n = 28)		Active Control (n = 26)						
Measure	Pre M (SD)	Post M (SD)	Pre M (SD)	Post M (SD)	Source	df	F	p	η^2_p
PSS-10	23.86 (5.82)	22.93 (5.82)	23.42 (5.21)	22.19 (5.10)	Group	1	0.19	0.66	0.00
					Time (T)	1	2.55	0.12	0.05
					Group × T	1	0.05	0.82	0.00
RDEES-14									
- Range	25.36 (5.56)	25.32 (6.19)	25.73 (5.50)	24.12 (6.54)	Group	1	0.07	0.79	0.00
					Time (T)	1	2.15	0.15	0.04
					Group × T	1	2.35	0.13	0.04
- Differentiation	24.46 (5.74)	23.81 (5.37)	24.46 (5.74)	24.65 (6.04)	Group	1	0.79	0.00	0.07
					Time (T)	1	0.30	0.59	0.01
					Group × T	1	0.97	0.33	0.02
PANAS-7days									
- Positive affect	30.52 (7.83)	31.00 (8.49)	32.96 (8.03)	30.56 (8.67)	Group	1	0.23	0.63	0.00
					Time (T)	1	0.77	0.38	0.02
					Group × T	1	1.74	0.19	0.04
- Negative affect	25.08 (9.05)	21.24 (9.74)	26.04 (7.56)	19.71 (6.36)	Group	1	0.03	0.86	0.00
					Time (T)	1	23.58	0.00	0.33
					Group × T	1	1.24	0.27	0.03
PANAS2-Change									
- Positive affect	-2.19 (7.21)	1.08 (5.02)	-0.46 (4.21)	2.29 (6.57)	Group	1	1.62	0.21	0.03
					Time (T)	1	6.30	0.02	0.12
					Group × T	1	0.05	0.83	0.00
- Negative affect	3.42 (6.54)	1.65 (2.94)	2.13 (3.63)	2.71 (5.54)	Group	1	0.01	0.91	0.00
					Time (T)	1	0.42	0.52	0.10
					Group × T	1	1.65	0.21	0.03

3.4 PSYCHOPHYSIOLOGICAL VARIABLES

Subjective Affective Manikin

Data from SAM tested the hypothesis that mindfulness training would moderate the emotional response to negative experiences (fear and anger stories) compared to the control condition. It was hypothesised that in response to the fear and anger stories, participants in the mindfulness group would demonstrate reduced emotional reactivity compared to the control condition. In this study it was hypothesised that when presented with the fear and anger stories post-test, participants in the mindfulness condition would experience less negative affect (*Valence*), less perceived physiological arousal (*Arousal*) and feel less overcome by their emotion (*Dominance*) compared to the control group.

Data was analysed using a 2x2x2 mixed-design ANOVA with the within-subjects factors of time (pre-test, post-test) and emotion (anger, fear), and a between-subject factor of group (mindfulness, control). Results of these repeated measures ANOVA for responses to SAM are illustrated in Table 8. Decreased emotional reactivity can be measured by the difference between fear and anger responding for each measure. Whereas, a large difference between fear and anger responding signifies a higher level of emotion reactivity. To explore the pattern of responses to fear and anger stories between groups, separate ANOVAs with the within-subjects factor of emotion (anger, fear), and between-subject factor of group (mindfulness, control) were conducted separately at baseline and post-intervention. Results of these repeated measures ANOVA for SAM responses are illustrated in Table 9. Where Mauchley's tests indicated that the assumption of sphericity had been violated, Greenhouse-Geisser estimates are reported.

Immersion

Immersion confirmed that both groups were equally engaged with the stories. There were no significant differences between groups across time for engagement with the fear and anger stories (Table 8). No significant effects were observed for group, $F(1, 43) = .00$, $p = .97$, $\eta^2_p = .00$, time $F(1, 43) = 2.29$, $p = .14$, $\eta^2_p = .06$, or emotion $F(1, 43) = .89$, $p = .35$, $\eta^2_p = .02$. No significant interaction effects were found for time by group, $F(1, 43) = 0.06$, $p = .80$, $\eta^2_p = .00$, emotion by group, $F(1, 43) = .01$, $p = .91$, $\eta^2_p = .00$,

time by emotion, $F(1, 43) = .00$, $p = .97$, $\eta^2_p = .00$, or time by emotion by group, $F(1, 43) = 2.52$, $p = .12$, $\eta^2_p = .06$.

Valence

Valence measured affect and the extent to which participants felt *happy*, *pleased, satisfied, contented or hopeful* (1) or *unhappy annoyed, unsatisfied, melancholic or bored* (9) after they listened to the fear or anger clip. There were no significant differences in the pattern of responding to either fear or anger stories (emotion). Figures 20 and 21 illustrate the mean *Valence* scores in response to both anger and fear stories for each group at baseline and post-intervention. Fear versus anger responses at baseline and post-intervention show little deviation for each group (Table 9). No main effects were found for emotion, $F(1, 43) = .65$, $p = .42$, $\eta^2_p = .02$, emotion by group, $F(1, 43) = 2.63$, $p = .11$, $\eta^2_p = .06$, time by emotion, $F(1, 43) = .50$, $p = .49$, $\eta^2_p = .01$, or time by emotion by group, $F(1, 43) = .70$, $p = .41$, $\eta^2_p = .02$ (Table 8).

A significant interaction effect of time by group was observed with 14% of variance explained by *Valence* $F(1, 43) = 6.81$, $p = .01$, $\eta^2_p = .14$ (Table 8), suggesting a difference in group behaviour over time in response to both fear and anger stories combined. To investigate the group by time effect, emotion stories were analysed separately. No significant differences were detected for fear stories for either the mindfulness or control condition. A significant group by time effect was found for anger stories $F(1, 43) = 6.61$, $p = .01$, $\eta^2_p = .13$ with a medium effect size. The mindfulness group decreased in negative affect, and the control group increased in negative affect from pre to post-test. A significant difference between groups at baseline was detected in the response to anger stories; the mindfulness group rated significantly more *Valence* at baseline ($M = 7.22$, $SD = 1.57$) than the control group ($M = 6.23$, $SD = 1.65$), $t = -1.99$, $p < .05$. From pre to post-test, paired *t*-tests detected a significant reduction in negative affect in response to anger stories for the mindfulness group ($M = -1.07$, $SD = 1.72$), $t = -2.97$, $p < .01$ with no significant change in the control group ($M = 0.30$, $SD = -1.83$), $t = .76$, $p < .46$.

In summary, results from this analysis partially support the hypothesis that the mindfulness condition would be associated with reduced emotional reactivity post-test compared to a control. A significant difference in group behaviour over time was detected for *Valence* in response to anger stories with a medium effect size. The

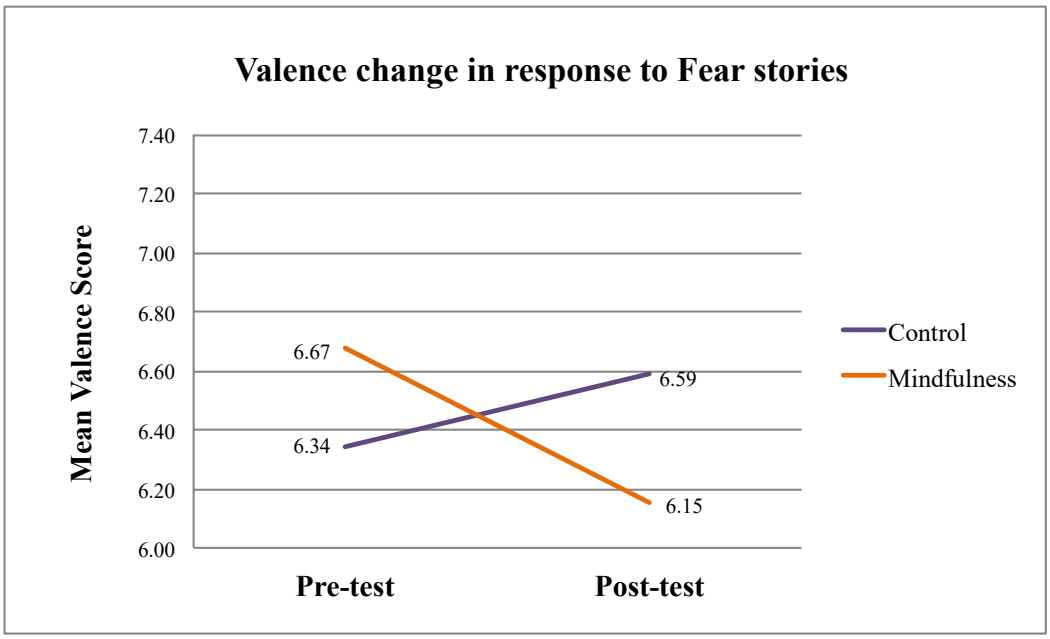

Figure 20. Change in mean *Valence* scores in response to fear stories from baseline to post- intervention by experimental condition. *Valence* measures the extent to which participants rated (1) *happy*, *pleased, satisfied, contented or hopeful*, or (9) *unhappy annoyed, unsatisfied, melancholic or bored* after they listened to a fear or anger clip. No significant effects were detected in response to fear stories.

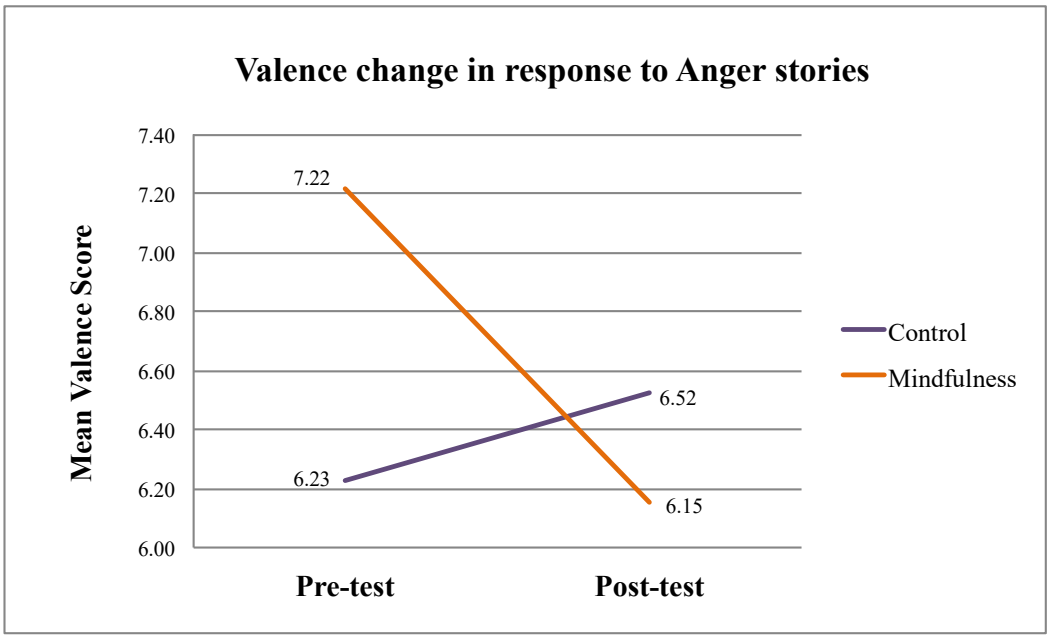

Figure 21. Change in mean *Valence* scores in response to anger stories from baseline to post-intervention by experimental condition. A significant difference between groups at baseline was detected in the response to anger stories. Paired *t*-tests detected a significant reduction in negative affect in response to anger stories for the mindfulness group (M = -1.07, SD = 1.72), t = -2.97, $p < .01$ with no significant change in the control group (M = 0.30, SD = -1.83), t = .76, $p < .46$.

mindfulness group reported significantly less negative affect in response to anger stories compared to the control. Paired *t*-tests detected a significant reduction in negative affect after anger stories in the mindfulness group compared to no change in the control condition. No significant effects were detected for the fear responses.

Arousal

Arousal measured perceived physiological activation and asked the participant to rate whether they felt *excited, stimulated, anxious, jittery or wide awake* (1) or *calm, relaxed, sluggish, sleepy or not aroused* (9) after they listened to each fear and anger story. Figures 22 and 23 illustrate the mean *Arousal* scores in response to anger and fear stories for each group at baseline and post-intervention. Table 8 presents results from ANOVAs. There were no main effects observed for time, $F(1, 43) = .05$, $p = .83$, $\eta^2_p = .00$, group $F(1, 43) = 1.02$, $p = .32$, $\eta^2_p = .02$, time by group, $F(1, 43) = .74$, $p = .40$, $\eta^2_p = .02$, emotion by group, $F(1, 43) = 2.94$, $p = .09$, $\eta^2_p = .06$, or time by emotion, $F(1, 43) = 2.45$, $p = .13$, $\eta^2_p = .05$.

A significant effect of emotion, $F(1, 43) = 14.63$, $p = .00$, $\eta^2_p = .25$, and a significant interaction effect of time by emotion by group was detected, $F(1, 43) = 5.22$, $p = .03$, $\eta^2_p = .11$. These results suggest a significant difference in group responding to fear versus anger stories from pre to post-test accounting for 11% of variance. When fear versus anger were analysed separately at baseline and post-test (Table 9) a significant difference in fear and anger responses by group was detected at pre-test accounting for 11% of variance, $F(1, 43) = 5.58$, $p = .02$, $\eta^2_p = .11$. To investigate the group by time by effect, emotion stories were analysed separately. No significant differences were detected for fear. A significant group by time effect was found for anger stories $F(1, 43) = 4.61$, $p = .04$, $\eta^2_p = .10$ with medium effect size. The mindfulness group decreased in perceived arousal and the control group increased from pre to post-test. There was a significant difference between groups at baseline for response to anger stories with the mindfulness group rating less arousal ($M = 4.38$, $SD = 1.61$) than the control group ($M = 5.89$, $SD = 2.06$), $t = 2.81$, $p < .01$. Paired *t*-tests detected a significant reduction in perceived physiological *Arousal* in response to anger stories in the mindfulness condition (M = -.89, SD = 1.81), t = -2.36, p < .03, with no significant change in the control group (M = -0.41, SD = -2.24), t = -.86, p < .40. No significant effects were detected for the fear responses.

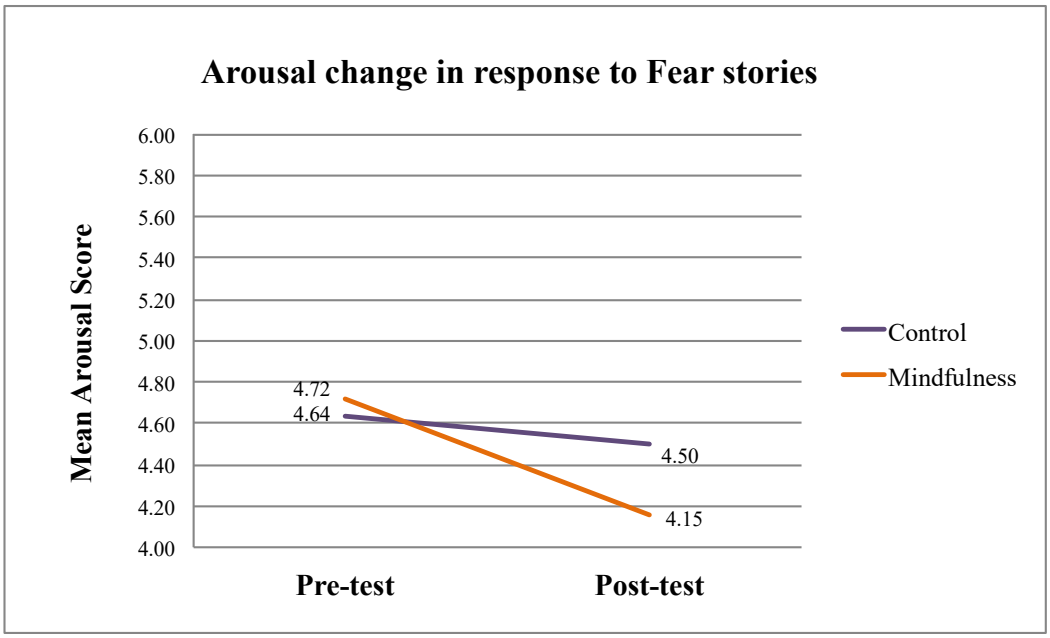

Figure 22. Change in mean *Arousal* scores in response to fear stories from baseline to post- intervention by experimental condition. Arousal measures the extent to which participants rated (1) *excited, stimulated, anxious, jittery or wide awake*, or (9) *calm, relaxed, sluggish, sleepy or not aroused* (9) after they listened to a fear or anger clip. No significant effects were detected in response to fear stories.

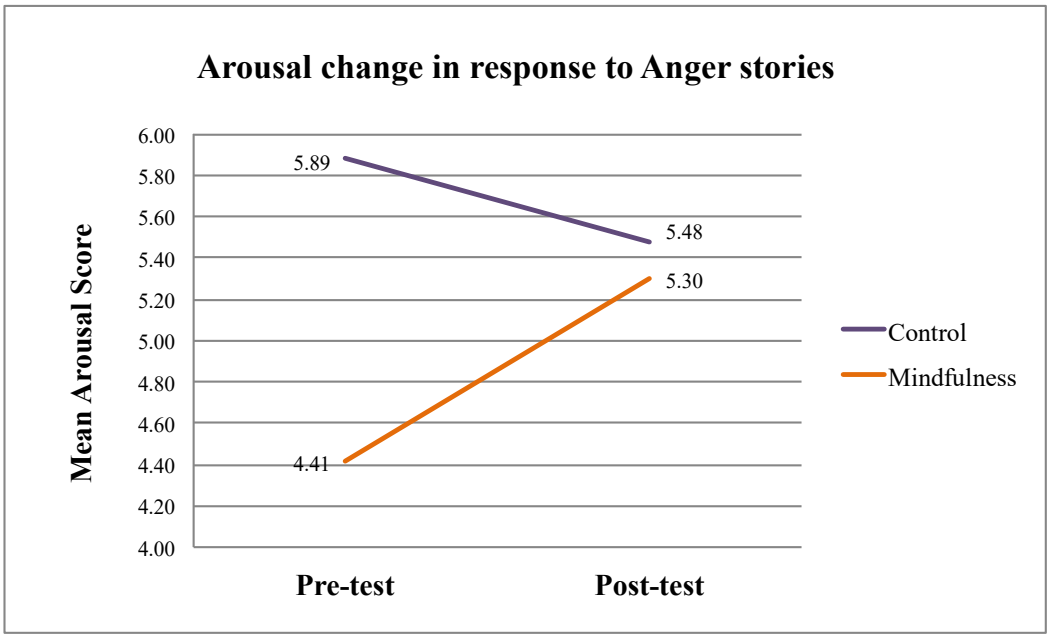

Figure 23. Change in mean *Arousal* scores in response to anger stories from baseline to post-intervention by experimental condition. A significant difference between groups at baseline was detected in the response to anger stories. Paired *t*-tests detected a significant reduction in perceived physiological arousal in response to anger stories for the mindfulness group (M = -.89, SD = 1.81), t = -2.36, p < .03, with no significant change in the control group (*M* = -0.41, *SD* = -2.24), *t* = -.86, p < .40.

In summary, these results may offer partial support for the hypothesis that the mindfulness condition would be associated with less emotional reactivity after listening to emotion stories compared to a control. A significant group by time effect was found for anger stories with a medium effect size. The mindfulness group significantly decreased reporting of perceived physiological arousal compared to the control group from pre to post-test. Paired *t*-tests detected a significant reduction in perceived physiological arousal (*Arousal*) in response to the anger stories in the mindfulness condition, with no change in the control condition. No significant effects were detected for the fear responses.

Dominance

Dominance measured how overcome by emotion the participant felt after listening to the fear and anger clips. Participants rated whether they felt *controlled, influenced, awed, submissive*, or *guided* (1) or *controlling, influential, in-control, dominant* or *autonomous* (9). There were no significant differences between groups across time for response to fear and anger stories (Table 8). No significant effects were observed for time, $F(1, 43) = 3.47$, $p = .07$, $\eta^2_p = .08$, group, $F(1, 43) = .56$, $p = .46$, $\eta^2_p = .01$, time by group, $F(1, 43) = 1.81$, $p = .19$, $\eta^2_p = .04$, emotion, $F(1, 43) = .86$, $p = .36$, $\eta^2_p = .02$, emotion by group, $F(1, 43) = .53$, $p = .47$, $\eta^2_p = .01$, time by emotion, $F(1, 43) = .25$, $p = .62$, $\eta^2_p = .01$, or time by emotion by group, $F(1, 43) = 1.25$, $p = .27$, $\eta^2_p = .03$. Figures 24 and 25 illustrate the mean *Dominance* scores in response to anger and fear stories for each group at baseline and post-intervention. Though non-significant, participants tended to endorse a higher *In control* response to anger stories and lower *Controlled* response to fear stories. This is in keeping with the conceptualisation that when feeling angry, one tends to feel more in control, whereas when feeling fearful, there is a tendency to feel small or weak. No differences in fear versus anger responding at baseline or post-intervention were detected (Table 9).

In summary, the results from this analysis do not support the hypothesis that a brief mindfulness intervention would promote the ability to be less overcome by emotion when listening to fear and anger stories, compared with a control condition. No significant effects were detected.

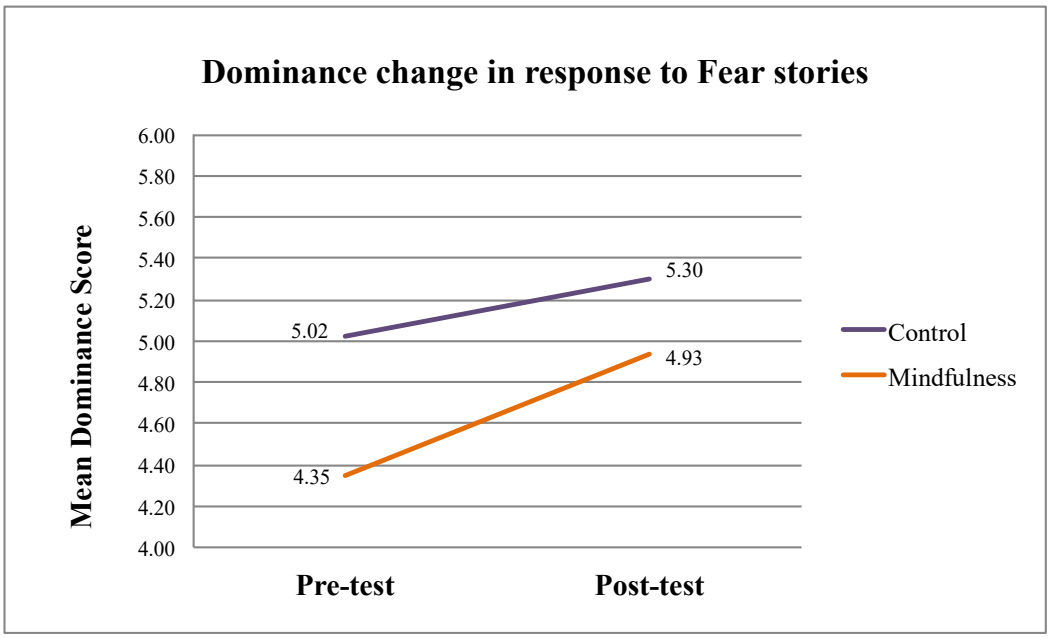

Figure 24. Change in mean *Dominance* scores in response to fear stories from baseline to post-intervention by experimental condition. Dominance measured the extent to which participants rated (1) *controlled, influenced, awed, submissive*, or *guided* or (9) *controlling, influential, in-control, dominant* or *autonomous* (9) after they listened to a fear or anger clip. No significant effects were detected.

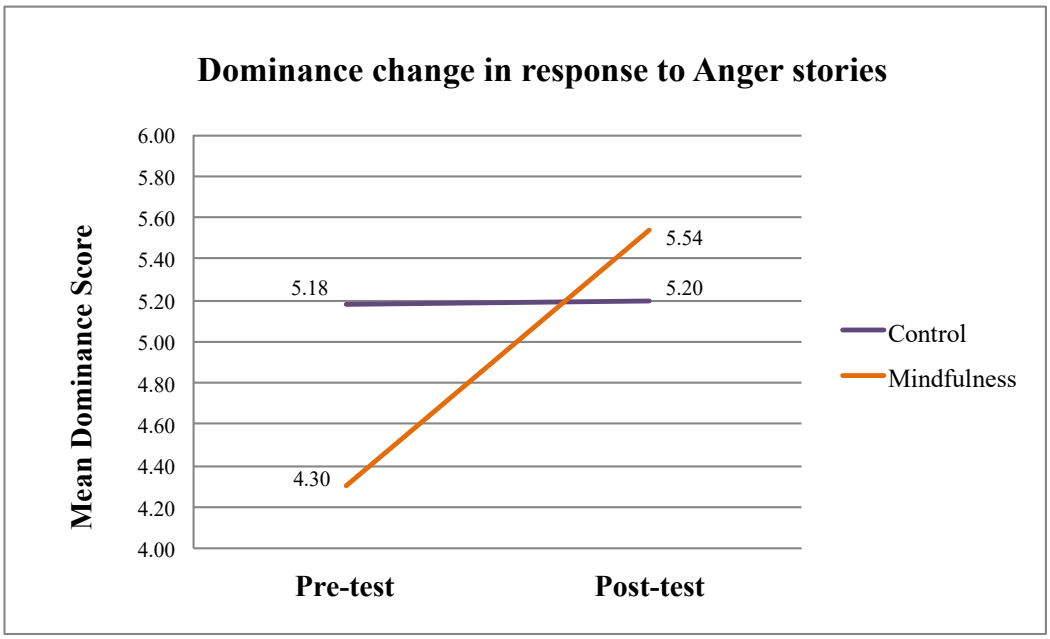

Figure 25. Change in mean *Dominance* scores in response to anger stories from baseline to post-intervention by experimental condition. *Dominance* measured the extent to which participants felt *controlled, influenced, awed, submissive*, or *guided* (1) or *controlling, influential, in-control, dominant* or *autonomous* (9) after they listened to a fear or anger clip. No significant effects were detected.

Table 8. 2x2x2 Repeated Measures ANOVAs for Subjective Affective Manikin (SAM) responses by emotion, group and time.

	Mindfulness (n = 23)		Control (n = 22)						
SAM measures	Pre M (SD)	Post M (SD)	Pre M (SD)	Post M (SD)	Source	df	F	p	η^2_p
Valence					Time (T)	1	1.63	0.21	0.04
- Fear stories	6.67 (1.53)	6.15 (1.58)	6.34 (1.61)	6.59 (1.59)	Group	1	0.11	0.74	0.00
- Anger stories	7.22 (1.44)	6.15 (1.53)	6.23 (1.65)	6.52 (1.94)	T x Group	1	6.81	0.01	0.14
					Emotion	1	0.65	0.42	0.02
					Emotion x Group	1	2.63	0.11	0.06
					T x Emotion	1	0.50	0.49	0.01
					T x Emotion x Group	1	0.70	0.41	0.02
Arousal					Time (T)	1	0.05	0.83	0.00
- Fear stories	4.72 (2.13)	4.15 (1.85)	4.64 (2.16)	4.50 (2.29)	Group	1	1.02	0.32	0.02
- Anger stories	4.41 (1.68)	5.30 (1.76)	5.89 (2.06)	5.48 (2.23)	T x Group	1	0.74	0.40	0.02
					Emotion	1	14.63	0.00	0.25
					Emotion x Group	1	2.94	0.09	0.06
					T x Emotion	1	2.45	0.13	0.05
					T x Emotion x Group	1	5.22	0.03	0.11
Dominance					Time (T)	1	3.47	0.07	0.08
- Fear stories	4.35 (2.02)	4.93 (1.94)	5.02 (2.22)	5.30 (2.30)	Group	1	0.56	0.46	0.01
- Anger stories	4.30 (1.77)	5.54 (2.28)	5.18 (2.34)	5.20 (2.59)	T x Group	1	1.81	0.19	0.04
					Emotion	1	0.86	0.36	0.02
					Emotion x Group	1	0.53	0.47	0.01
					T x Emotion	1	0.25	0.62	0.01
					T x Emotion x Group	1	1.25	0.27	0.03
Immersion					Time (T)	1	2.29	0.14	0.06
- Fear stories	3.00 (0.96)	2.95 (0.83)	3.12 (0.80)	2.83 (0.91)	Group	1	0.00	0.97	0.00
- Anger stories	3.08 (0.85)	2.73 (1.08)	2.88 (0.77)	2.88 (0.91)	T x Group	1	0.06	0.80	0.00
					Emotion	1	0.89	0.35	0.02
					Emotion x Group	1	0.01	0.91	0.00
					T x Emotion	1	0.00	0.97	0.00
					T x Emotion x Group	1	2.52	0.12	0.06

Table 9. 2x2 Repeated Measures ANOVAs for Subjective Affective Manikin (SAM) responses by emotion and group at pre-test and post-test.

	Mindfulness (n = 24)		Control (n = 21)						
SAM	Anger M(SD)	Fear M(SD)	Anger M(SD)	Fear M(SD)	Source	df	F	p	η^2_p
Valence									
Pre-test	7.16 (1.57)	6.60 (1.57)	6.23 (1.65)	6.34 (1.61)	Emotion	1	1.33	0.25	0.03
					Group	1	1.96	0.17	0.04
					Em x Group	1	3.04	0.09	0.06
Post-test	6.13 (1.53)	6.17 (1.59)	6.70 (1.89)	6.70 (1.57)	Emotion	1	0.01	0.92	0.00
					Group	1	1.71	0.20	0.03
					Em x Cond	1	0.01	0.92	0.00
Arousal									
Pre-test	4.38 (1.61)	4.54 (2.14)	5.89 (2.06)	4.64 (2.16)	Emotion	1	3.33	0.08	0.07
					Group	1	2.55	0.12	0.05
					Em x Group	1	5.58	0.02	0.11
Post-test	5.31 (1.72)	4.10 (1.77)	5.78 (2.26)	4.90 (1.77)	Emotion	1	21.14	0.00	0.30
					Group	1	1.42	0.24	0.03
					Em x Group	1	0.53	0.47	0.01
Dominance									
Pre-test	4.42 (1.81)	4.24 (1.97)	5.18 (2.34)	5.02 (2.22)	Emotion	1	0.36	0.55	0.01
					Group	1	2.06	0.16	0.04
					Em x Group	1	0.00	0.97	0.00
Post-test	5.33 (2.27)	4.65 (2.03)	4.66 (2.86)	4.86 (2.47)	Emotion	1	1.06	0.31	0.02
					Group	1	0.13	0.72	0.00
					Em x Group	1	3.61	0.06	0.07

Facial Electromyography

Implicit affective responses to the fear and anger stories were measured using electromyography (EMG) to record facial muscle activation. Muscle activity relating to anger (Corrugator supercilii), to fear (Frontalis), and positive affect (Zygomaticus major) were recorded while participants listened to fear and anger stories. This data was used to test the hypothesis that mindfulness training can improve a person's ability to respond to negative emotional experiences. The prediction was that participants in the mindfulness condition would have reduced facial muscle activation post-intervention compared with the control group, equating to less emotional reactivity to the fear and anger stories compared to the control. Muscle activity was measured during each story then subtracted from a baseline recording at the beginning of each story to create a change score of mean muscle activation. A positive value represents the level of muscle activation as a percentage of maximum muscle contraction. A negative value represents muscle relaxation as a percentage of maximum muscle contraction.

Data was analysed using a 2x2x2 mixed-design ANOVA with the within-subjects factors of time (pre-test, post-test) and emotion (anger, fear), and a between-subject factor of group (mindfulness, control). These results are presented in Table 10. To explore the pattern of emotional responding to fear and anger stories between groups at pre-test and post-test, separate ANOVAs with the within-subjects factor of emotion (anger, fear), and between-subject factor of group (mindfulness, control) were conducted for baseline and post-intervention measurements. These results are illustrated in Table 11. Teasing apart the different fear and anger responses can demonstrate patterns of emotion reactivity. If there are more pronounced differences between the levels of muscle activation for anger and fear, higher emotional reactivity or expressiveness is demonstrated. When the level of muscle activation is similar for both fear and anger, this signifies less emotional reactivity or discrimination. Where Mauchley's tests indicated that the assumption of sphericity had been violated, Greenhouse-Geisser estimates were reported.

Corrugator

Corrugator activation is a measure of an anger response and records the action of frowning. There were no significant differences between groups across time for

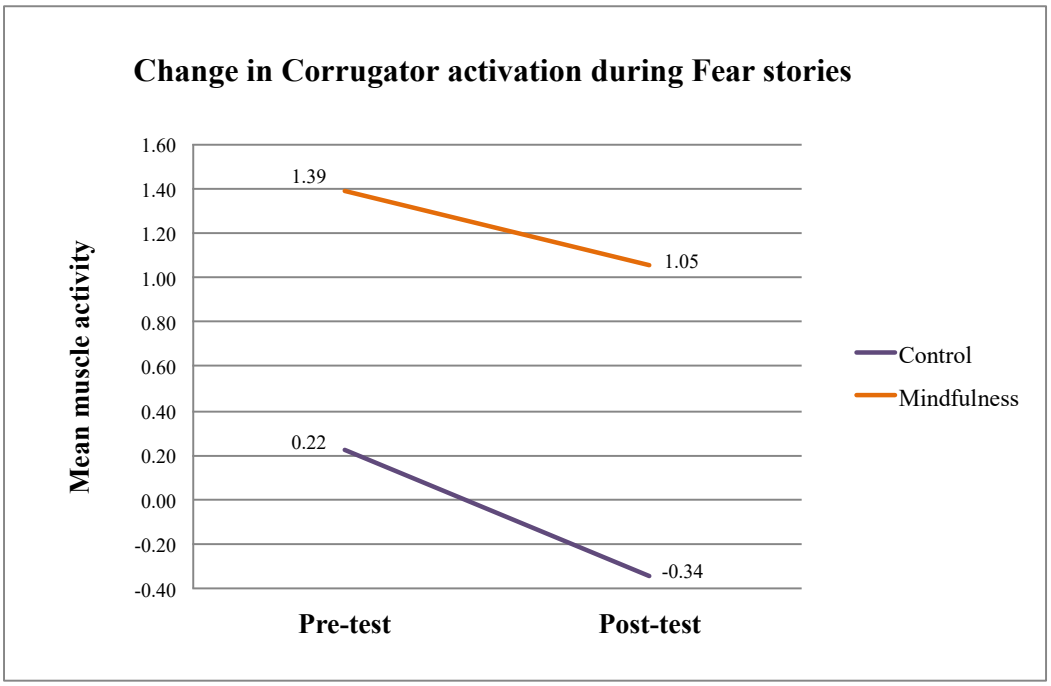

Figure 26. Change in mean corrugator activation during fear stories from baseline to post-intervention by experimental condition. No significant effects were detected.

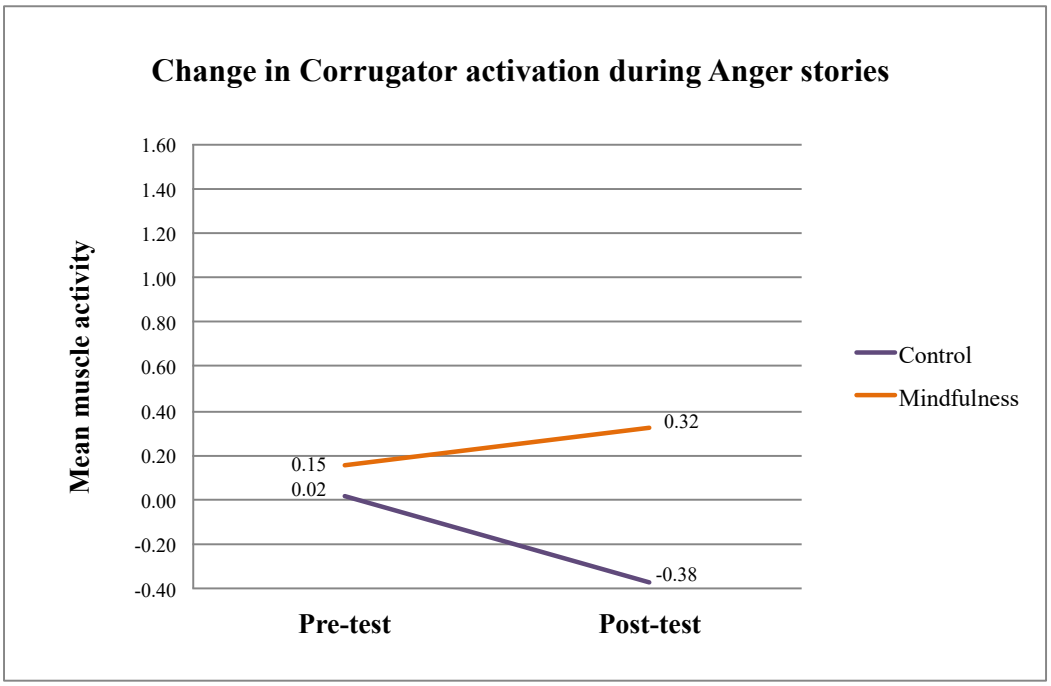

Figure 27. Change in mean corrugator activation during anger stories from baseline to post-intervention by experimental condition. No significant effects were detected.

response to fear and anger stories (Table 10). Figures 26 and 27 present the mean corrugator activation in response to anger and fear stories for each group at baseline and post-intervention. No significant effects of group, $F(1, 43) = 2.13$, $p = .15$, $\eta^2_p = .05$, or emotion, $F(1, 43) = .50$, $p = .48$, $\eta^2_p = .01$, were observed. No significant interactions were demonstrated for time by group, $F(1, 43) = 2.75$, $p = .11$, $\eta^2_p = .06$, emotion by group $F(1, 43) = .25$, $p = .62$, $\eta^2_p = .01$, time by emotion, $F(1, 43) = .70$, $p = .41$, $\eta^2_p = .02$, or time by emotion by group, $F(1, 43) = .17$, $p = .68$, $\eta^2_p = .00$. A significant effect of time, $F(1, 43) = 4.45$, $p = .04$, $\eta^2_p = .09$, was found demonstrating a parallel change in both groups from pre- to post-test in response to both fear and anger stories accounting for 9% of variance (Table 10). To investigate this effect, ANOVAs were calculated for fear and anger stories separately. No significant effects were detected.

To explore the patterns of emotional responding in each group, separate ANOVAs examined the effects of emotion (anger, fear) and group (mindfulness, control) at both baseline and post-intervention time points (Table 11). A significant difference in response to emotion was found at baseline, $F(1, 43) = 4.60$, $p = .04$, $\eta^2_p = .09$, demonstrating a different level of corrugator activation in response to fear versus anger stories accounting for 9% of variability. Both groups showed more corrugator activation to fear and less to anger stories at baseline, which was unexpected. An independent-sample *t*-test indicated a difference between groups approaching significance at baseline in response to fear stories with the mindfulness group showing increased activation ($M = 1.34$, $SD = 2.92$) compared to the control group ($M = 0.16$, $SD = 1.79$), $t = -1.74$, $p < 0.09$. At baseline, the mindfulness group exhibited a pronounced difference between fear and anger activation suggesting a higher level of emotional reactivity compared to the control group. This effect was not detected across time or at post-test. At post-test the mindfulness group displayed a pattern of reduced emotion reactivity compared to pre-test but this was non-significant (Table 11). There were no significant differences in post-test responding by group, $F(1, 43) = .80$, $p = .38$, $\eta^2_p = .02$, or emotion, $F(1, 43) = .45$, $p = .51$, $\eta^2_p = .01$.

In summary, the results of this analysis do not support the hypothesis that those in the mindfulness condition would demonstrate a pattern of reduced emotional reactivity to fear and anger stories, compared to a control condition. A significant effect of time was found demonstrating a parallel change in both groups from pre- to post-test with a medium effect size. Paired *t*-tests did not detect any significant changes from pre to post-test in either group.

Frontalis

Frontalis activation is a measure of a fear response and records the action of raising or furrowing the brow. There were no significant differences between groups across time for response to fear and anger stories (Table 10). No significant effects were observed for time, $F(1, 43) = 0.91$, $p = .35$, $\eta^2_p = .02$, group, $F(1, 43) = 1.83$, $p = .18$, $\eta^2_p = .04$, or emotion, $F(1, 43) = 1.63$, $p = .21$, $\eta^2_p = .04$. No other interaction effects were found for time by group, $F(1, 43) = 0.01$, $p = .91$, $\eta^2_p = .00$, emotion by group, $F(1, 43) = .00$, $p = .95$, $\eta^2_p = .00$, or time by emotion by group, $F(1, 43) = .20$, $p = .66$, $\eta^2_p = .01$. A marginal significant effect of time by emotion, $F(1, 43) = 3.41$, $p = .07$, $\eta^2_p = .07$, These results suggest a marginal difference in the response to emotion from pre to post-test in both groups. Figures 28 and 29 illustrate mean frontalis activation during anger and fear stories for each group at baseline and post-intervention. In response to anger stories, both groups demonstrated an apparent decrease in relaxation from pre to post-test. In response to fear stories both groups demonstrated an apparent increase in relaxation from pre to post-test. Paired *t*-tests could not detect any significant differences from pre to post-test for any emotion.

To explore the patterns of emotional responding in each group separate ANOVAs examined the effects of emotion (anger, fear) and group (mindfulness, control) at both baseline and post-intervention time points. Table 11 displays the results of these analyses. No significant differences between groups were found. Though non-significant it was observed that at baseline, both groups showed a pronounced difference between fear and anger activation suggesting a high level of emotional reactivity. Post-test the difference remained for the control but not the mindfulness group suggesting a non-significant trend in reduced emotional reactivity in the mindfulness group.

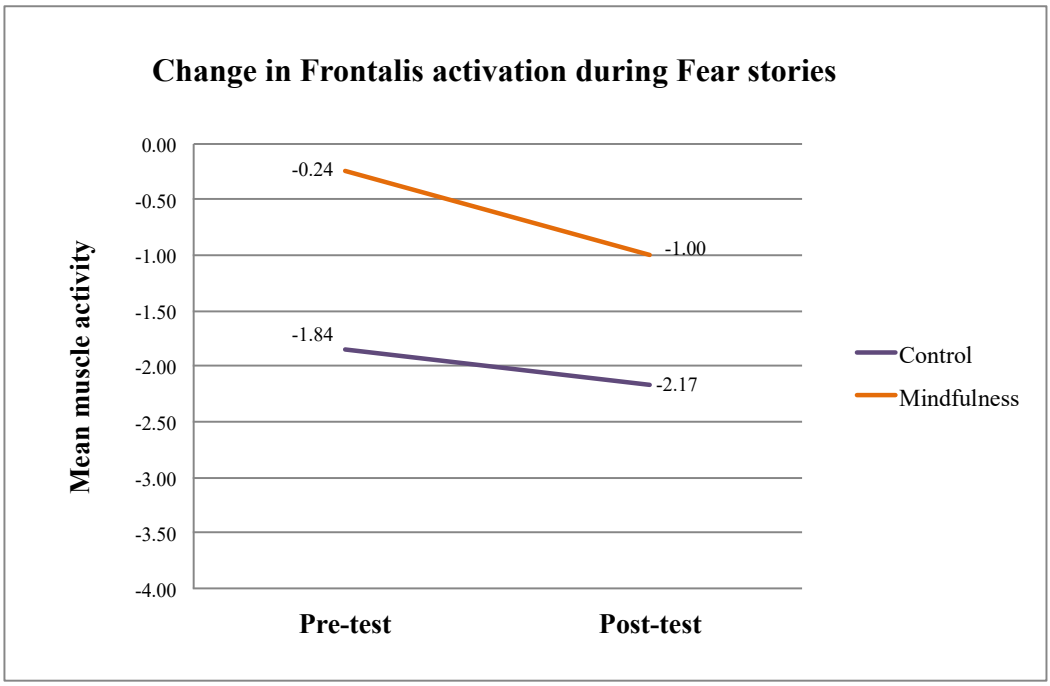

Figure 28. Change in mean frontalis activation during Fear stories from baseline to post-intervention by experimental condition. No significant effects were detected.

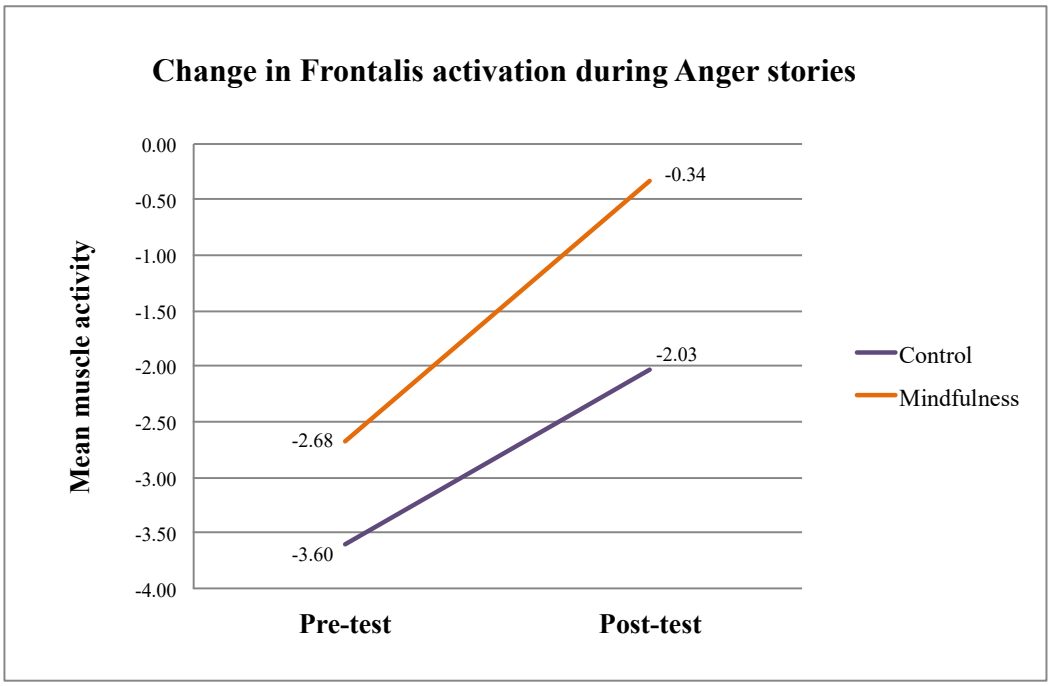

Figure 29. Change in mean frontalis activation during Anger stories from baseline to post-intervention by experimental condition. No significant effects were detected.

In summary, results from this analysis do not support the hypothesis that brief mindfulness training using a mobile phone app can improve the ability to respond more calmly to stress inducing stories compared to a control group. There were no significant differences between groups across time for response to fear and anger stories. No significant interaction effects or effects of time, group or emotion were detected.

Zygomaticus

Zygomaticus activation is a measure of positive affect and records the action of smiling. Figures 30 and 31 illustrate mean zygomaticus activation during anger and fear stories for each group separately at baseline and post-intervention. There were no significant differences between groups across time for response to fear and anger stories (Table 10). No effects were observed for time, $F(1, 43) = 1.36$, $p = .25$, $\eta^2_p = .03$, group, $F(1, 43) = 2.75$, $p = .10$, $\eta^2_p = .06$, or emotion, $F(1, 43) = .00$, $p = .96$, $\eta^2_p = .00$. No significant interaction effects were found for time by group, $F(1, 43) = .97$, $p = .33$, $\eta^2_p = .02$, emotion by group, $F(1, 43) = .05$, $p = .82$, $\eta^2_p = .00$, time by emotion, $F(1, 43) = .38$, $p = .54$, $\eta^2_p = .01$, or time by emotion by group, $F(1, 43) = .03$, $p = .86$, $\eta^2_p = .00$.

To explore the patterns of emotional responding in each group separate ANOVAs examined the effects of emotion (anger, fear) and group (mindfulness, control) at both baseline and post-intervention time points (Table 11). No significant differences between groups were found. Both groups demonstrated a non-significant relaxation of zygomaticus activation in response to both anger and fear stories.

In summary, the results from this analysis do not support the hypothesis that brief mindfulness training would improve the ability to regulate emotion when exposed to stress inducing stories compared to a control group.

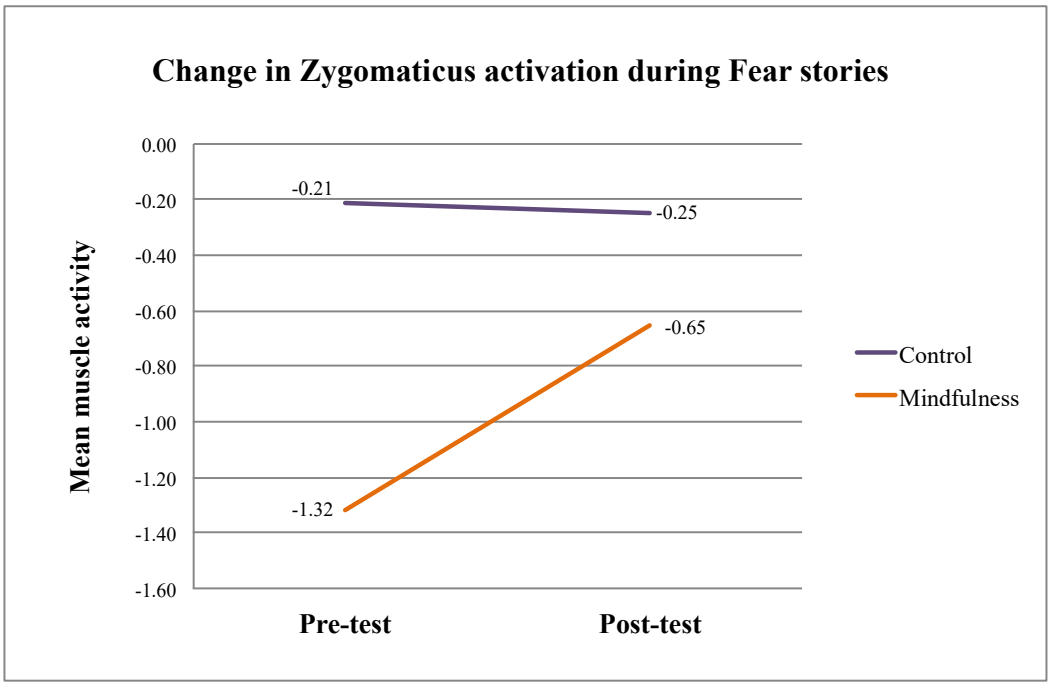

Figure 30. Change in mean Zygomaticus activation during Fear stories from baseline to post-intervention by experimental condition. No significant effects were detected.

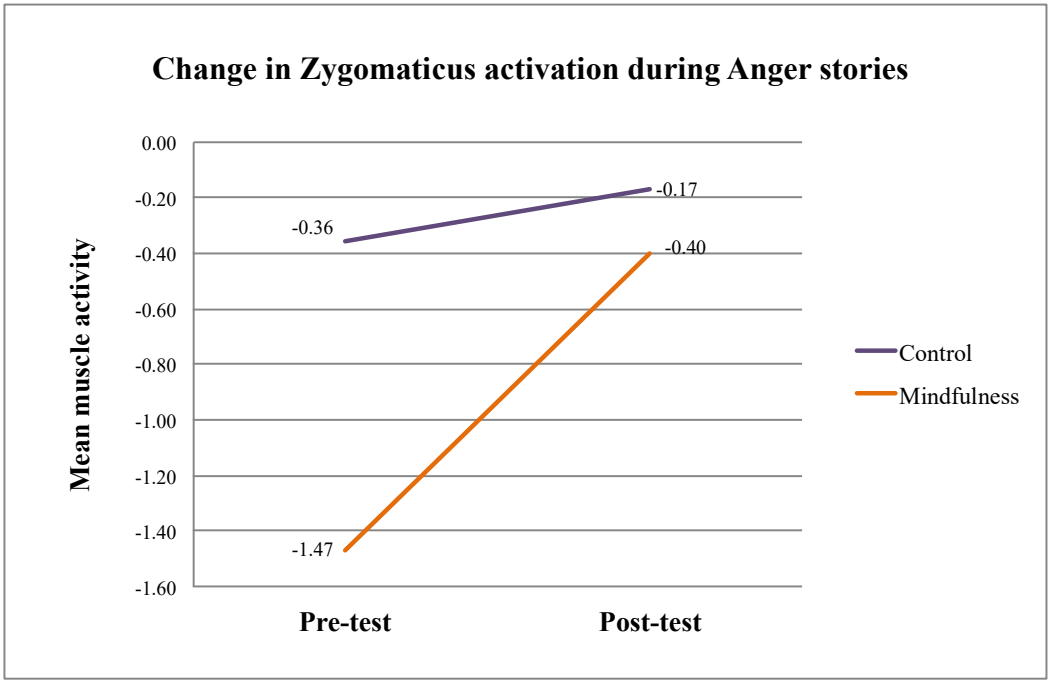

Figure 31. Change in mean Zygomaticus activation during Anger stories from baseline to post-intervention by experimental condition. No significant effects were detected.

Table 10. 2x2 Repeated Measures ANOVAs for facial electromyography (FEMG) by emotion, group and time.

	Mindfulness (n = 24)		Control (n = 21)						
FEMG activation	Pre M (SD)	Post M (SD)	Pre M (SD)	Post M (SD)	Source	df	F	p	η^2_p
Corrugator									
- Fear	1.39 (3.04)	1.03 (1.88)	0.22 (1.94)	-0.34 (3.81)	Time (T)	1	4.45	0.04	0.09
- Anger	0.15 (2.10)	0.32 (1.55)	0.02 (1.85)	-0.38 (3.76)	Group	1	2.13	0.15	0.05
					T x Group	1	2.75	0.11	0.06
					Emotion	1	0.50	0.48	0.01
					Emotion x Group	1	0.25	0.62	0.01
					T x Emotion	1	0.70	0.41	0.02
					T x Emotion x Group	1	0.17	0.68	0.00
Frontalis									
- Fear	-0.24 (4.17)	-1.00 (3.37)	-1.84 (3.73)	-2.17 (5.74)	Time (T)	1	0.91	0.35	0.02
- Anger	-2.68 (6.16)	-0.34 (3.87)	-3.60 (8.85)	-2.03 (4.02)	Group	1	1.83	0.18	0.04
					T x Group	1	0.01	0.91	0.00
					Emotion	1	1.63	0.21	0.04
					Emotion x Group	1	0.00	0.95	0.00
					T x Emotion	1	3.41	0.07	0.07
					T x Emotion x Group	1	0.20	0.66	0.01
Zygomaticus									
- Fear stories	-1.32 (3.70)	-0.65 (1.65)	-0.21 (1.20)	-0.25 (0.64)	Time (T)	1	1.36	0.25	0.03
- Anger stories	-1.47 (3.96)	-0.40 (0.88)	-0.36 (1.31)	-0.17 (1.26)	Group	1	2.75	0.10	0.06
					T x Group	1	0.97	0.33	0.02
					Emotion	1	0.00	0.96	0.00
					Emotion x Group	1	0.05	0.82	0.00
					T x Emotion	1	0.38	0.54	0.01
					T x Emotion x Group	1	0.03	0.86	0.00

Table 11. 2x2 Repeated Measures ANOVAs for facial electromyography (FEMG) by emotion and group separated by pre-test and post-test.

	Mindfulness (n = 24)		Control (n = 21)						
FEMG	Anger	Fear	Anger	Fear	Source	df	F	p	η^2_p
Corrugator									
Pre-test	0.20 (2.03)	1.34 (2.92)	0.05 (1.70)	0.16 (1.79)	Emotion	1	4.60	0.04	0.09
					Group	1	1.56	0.22	0.03
					Em x Group	1	3.15	0.08	0.06
Post-test	0.13 (1.77)	0.58 (2.49)	-0.38 (3.76)	-0.34 (3.81)	Emotion	1	0.45	0.51	0.01
					Group	1	0.80	0.38	0.02
					Em x Group	1	0.34	0.56	0.01
Frontalis									
Pre-test	-2.48 (5.95)	-0.19 (4.00)	-3.22 (8.16)	-1.91 (3.49)	Emotion	1	3.28	0.08	0.06
					Group	1	0.97	0.33	0.02
					Em x Group	1	0.25	0.62	0.01
Post-test	-0.42 (3.75)	-0.85 (3.28)	-2.03 (4.02)	-2.17 (5.74)	Emotion	1	0.16	0.70	0.00
					Group	1	2.09	0.16	0.04
					Em x Group	1	0.04	0.84	0.00
Zygomaticus									
Pre-test	-1.34 (3.83)	-1.24 (3.56)	-0.57 (1.51)	-0.21 (1.14)	Emotion	1	0.57	0.45	0.01
					Group	1	1.56	0.22	0.03
					Em x Group	1	0.18	0.67	0.00
Post-test	-0.38 (0.85)	-0.68 (1.79)	-0.17 (1.26)	-0.25 (0.64)	Emotion	1	0.44	0.51	0.01
					Group	1	2.13	0.15	0.05
					Em x Group	1	0.16	0.70	0.00

Emotion Stroop

The Emotion Stroop task was used as an implicit measure of emotion responding and attention regulation. The Emotion Stroop task tested the prediction that mindfulness practice can increase a person's ability to control their attention when faced with emotionally valanced distracters. The computer task assessed the participant's ability to attend to the colour of the word and ignore the emotion meaning of the word. It was hypothesised that the mindfulness group would have shorter completion times, make fewer mistakes in colour-naming words and a have a smaller interference score, than those in the control post-test.

A 4x2x2 repeated measures ANOVA was calculated, with word (panic threat, social, threat, positive, and neutral) and time (pre and post intervention) as within factors, and group (mindfulness and control) as between factors (Table 12). Where Mauchly's test indicated that the assumption of sphericity had been violated, Greenhouse-Geisser corrected tests are reported. No differences in group behaviour over time were detected demonstrating a statistically parallel time profile for the two groups; time by word by group, $F(3, 49) = 2.12$, $p = .10$, $\eta^2_p = .04$. A group effect that was approaching significance $F(1, 49) = 3.71$, $p < .06$, $\eta^2_p = .07$, suggested a possible difference in group behaviour. Figures 32 and 33 display the reaction time for emotion and neutral words by group at pre and post-test. At both pre and post-test, the control group responses appeared slower in all four-word types compared to the mindfulness group. The mindfulness group (M = 772.99, SD = 156.84) was significantly faster on positive words at baseline than the control group (M = 862.29, SD = 148.83), $t = 2.04$, $p < .05$). Post intervention, the control group was slower to respond to panic-threat words ($t = 1.99$, $p < .05$), social threat words ($t = 2.05$, $p < .05$) and neutral words ($t = 2.18$, $p < .04$). A difference between word responses over time for both groups was approaching significance and accounted for 6% of variability, $F(2, 49) = 2.74$, $p < .07$, $\eta^2_p = .06$. Paired sample *t*-tests did not detect any significant changes in reaction speed for any word response over time for either group.

To test the hypothesis that the mindfulness group would demonstrate enhanced ability to control their attention when faced with emotionally valanced distracters than those in the control group, interference scores were calculated by subtracting the mean reaction time for

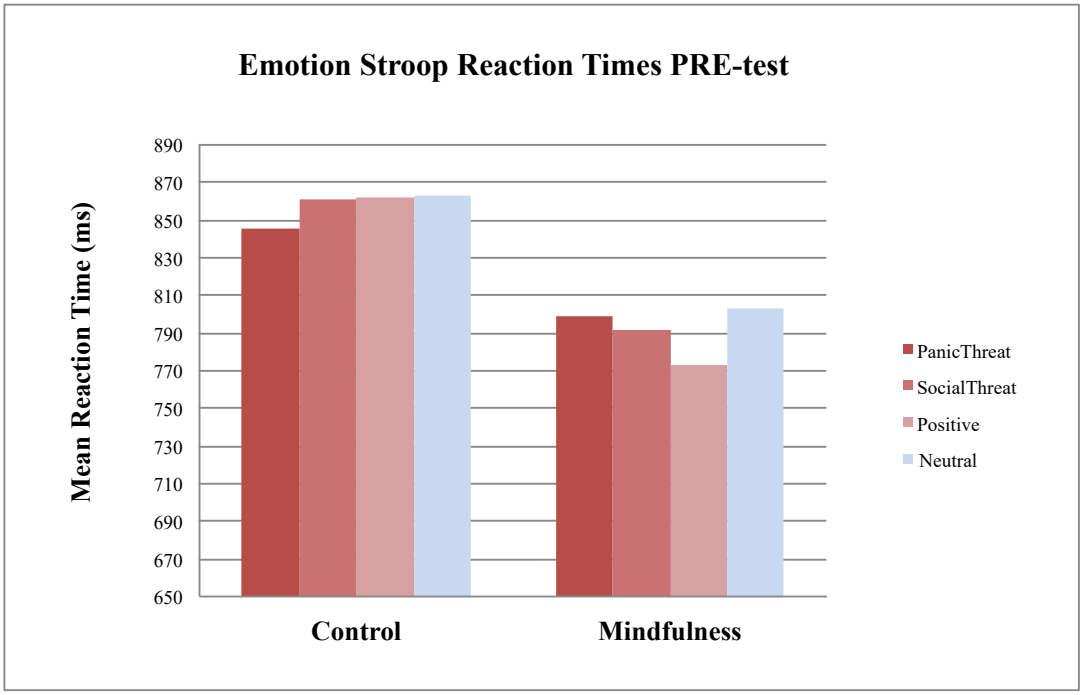

Figure 32. Mean reaction times at baseline (Post-test) to name the ink colour of emotion words (red columns) and neutral words (blue columns) by group. The control group was significantly slower to respond to Positive words pre-test compared to the mindfulness group.

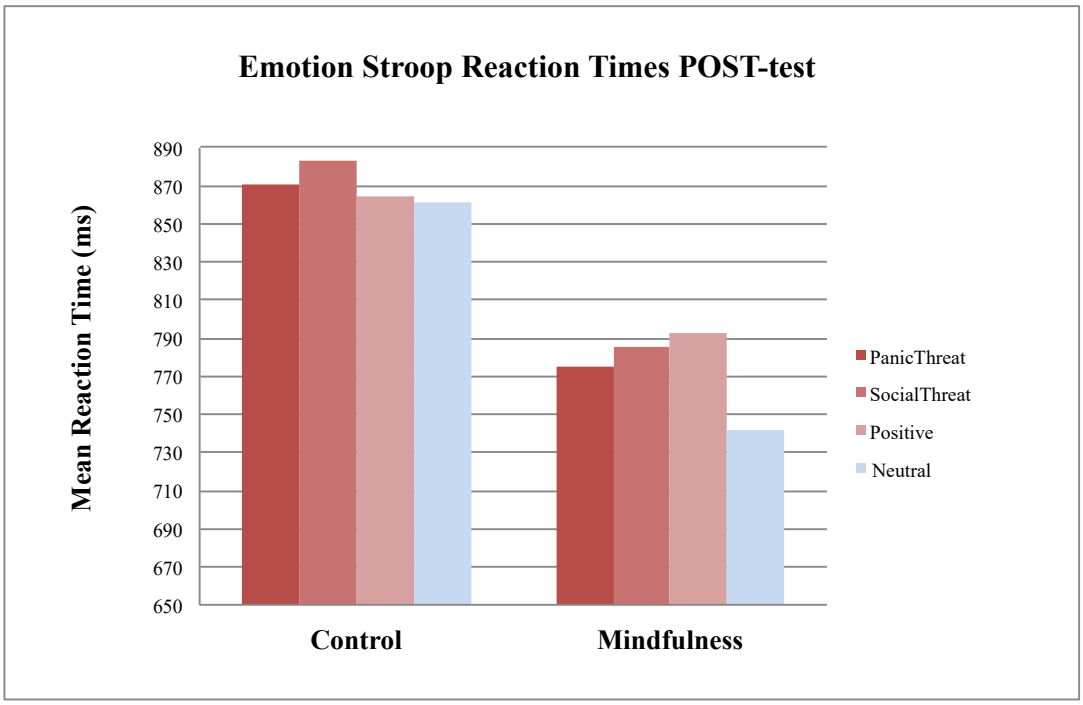

Figure 33. Mean reaction times post-intervention (Post-test) to name the ink colour of emotion words (red columns) and neutral words (blue columns) by group. The control group was significantly slower to respond to PanicThreat, SocialThreat and Neutral words post-test compared to the mindfulness group.

neutral words from the mean reaction time for emotion words. The degree to which colour naming is disproportionality slow on negative words compared to neutral words is taken as a measure of attentional bias to negative information (emotional distracters), i.e., difficulty ignoring the negative emotion content of these words. Contrary to the predicted Emotion Stroop Effect reported elsewhere (Lykins et al., 2012), both groups at baseline exhibited slower reaction speeds for neutral versus emotion words creating negative interference scores. Post-test this trend changed and both groups showed an increase in interference scores signifying increased distraction from emotion words versus neutral words.

A 3x2x2 repeated measures ANOVA was calculated, with interference score for emotion words versus neutral words (panic threat, social threat, and positive), and time (pre and post intervention) as within factors, and group (mindfulness and control) as between factors (Table 12). Figure 34 displays the change in interference scores for *Panic-Threat*, *Social-Threat* and *Positive* words. No significant interaction effects were detected for time by word by group, $F(1, 49) = 1.02$, $p < .32$, $\eta^2_p = .02$. A significant change over time was observed for both groups combined, Time $F(1, 49) = 4.56$, $p < .04$, $\eta^2_p = .09$, reflecting the increase in interference score in both groups. A marginal significant effect of time by word was found, $F(1, 49) = 3.26$, $p < .07$, $\eta^2_p = .07$, suggesting a change in the response to emotion words in both groups from pre to post-test. Paired *t*-tests did not detect any significant changes in interference from pre to post-test for *Panic-Threat* or *Social-Threat* words in either the mindfulness or control groups. A significant increase in interference for *Positive* words was detected over time within the mindfulness group ($t = -2.35$, $p < .03$) but not the control group. A significant difference in group responding to words was detected, word by group $F(1, 49) = 3.44$, $p < .04$, $\eta^2_p = .07$. Independent *t*-tests did not detect any significant differences in interference scores at baseline or post-intervention.

To test the hypothesis that the mindfulness group would make fewer mistakes selecting the correct colour for each word post-test compared to the control group a 2x2 ANOVA time by group was run. Both groups demonstrated a high level of accuracy (Table 12). No significant effects were detected for time $F(1, 49) = 3.44$, $p < .04$, $\eta^2_p = .07$, group $F(1, 49) = 3.44$, $p < .04$, $\eta^2_p = .07$, or interaction effects of group by time, $F(1, 49) = 3.44$, $p < .04$, $\eta^2_p = .07$. Accuracy did not differ significantly between groups at baseline; mindfulness

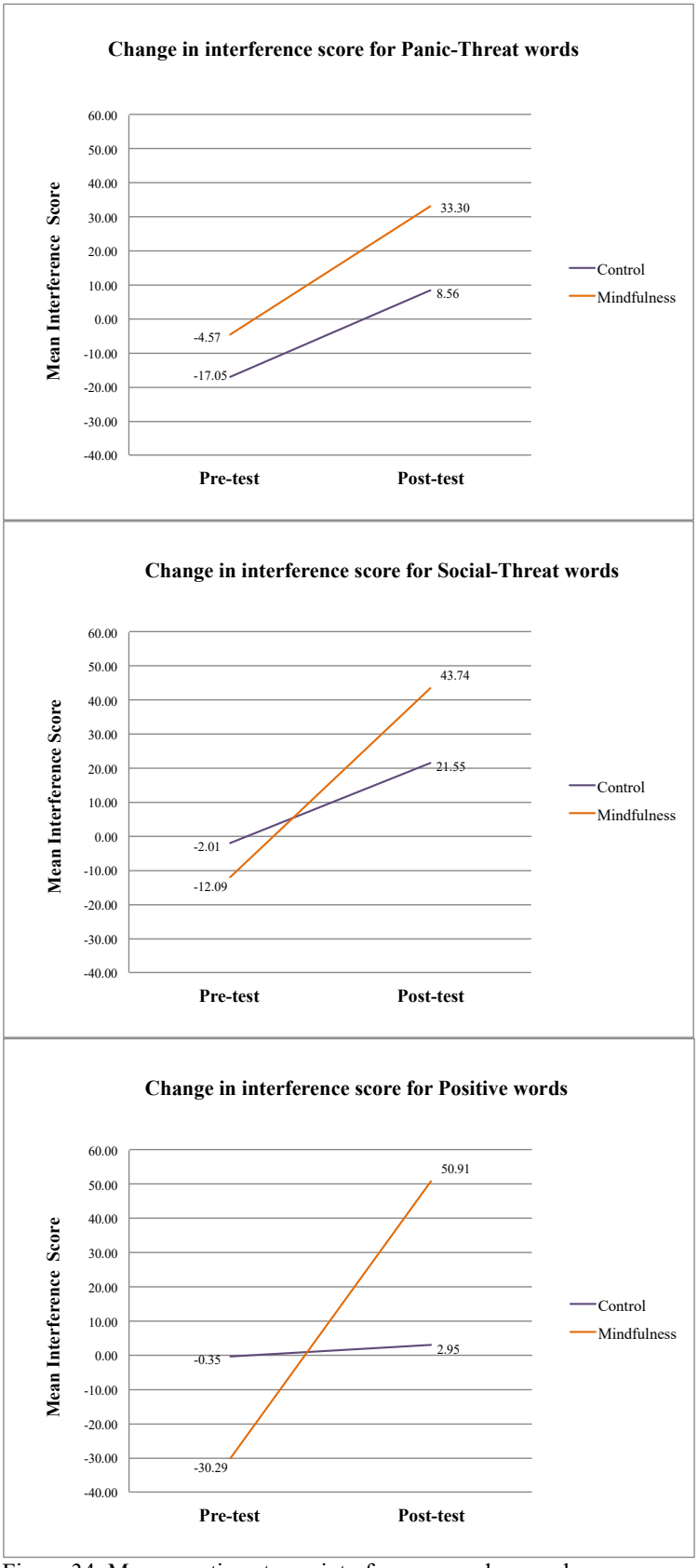

Figure 34. Mean emotion stroop interference word scores by group over time.

group (M = 97.54%, SD = 2.97) compared to the control group (M = 98.23, SD = 1.06), t = 1.07, $p < .29$; or post-intervention mindfulness (M = 98.0, SD = 1.13) compared to the control group (M = 97.78, SD = 2.24), t = -.83, p < .41.

The findings of the current study did not support the hypotheses. Both groups demonstrated a high level of accuracy with no significant differences. No differences in group behaviour over time were detected demonstrating a statistically parallel time profile for the two groups. Paired sample *t*-tests did not detect any significant changes in reaction speed for any word response over time for either group. A significant change over time was observed for both groups combined indicating an increase in interference score in both groups. Paired *t*-tests did not detect any significant changes in interference from pre to post-test for *Panic-Threat* or *Social-Threat* words in either the mindfulness or control groups. Contrary to the hypothesis, a significant increase in interference for *Positive* words was detected over time within the mindfulness group but not the control group.

Heart Rate Variability

Final processing of the heart rate variability data was unable to be completed for analysis in time to include it in the current thesis. Due to the scope of the project, it was agreed by the author and supervisors to leave the data out of the current analysis.

Table 12. Repeated Measures ANOVAs for Emotion Stroop Task by word, group and time.

	Mindfulness (n = 26)		Control (n = 23)						
Emotion Stroop	Pre M (SD)	Post M (SD)	Pre M (SD)	Post M (SD)	Source	df	F	p	η^2_p
Reaction Times (4x2x2 ANOVA: Word x Time x Group)									
- Neutral	803.28 (167.17)	742.16 (203.38)	862.63 (149.81)	861.68 (177.99)	Time	1	0.03	0.86	0.00
- Panic-Threat	798.71 (166.00)	775.46 (153.92)	845.58 (147.53)	870.24 (179.20)	Word	2	0.50	0.60	0.01
- Social-Threat	791.19 (158.74)	785.90 (157.60)	860.62 (151.88)	883.23 (175.29)	Group	1	3.71	0.06	0.07
- Positive	772.99 (156.84)	793.07 (169.73)	862.29 (148.83)	864.63 (179.84)	T x Word	2	2.74	0.07	0.06
					T x Group	1	1.01	0.32	0.02
					Word x Group	3	0.27	0.85	0.01
					T x Word x Group	3	2.12	0.10	0.04
Interference Scores (3x2x2 ANOVA: Word x Time x Group)									
- Panic-Threat	-4.57 (82.19)	33.30 (160.73)	17.05 (82.19)	8.56 (78.32)	Time (T)	1	4.56	0.04	0.09
- Social-Threat	-12.09 (105.07)	43.74 (182.61)	-201 (99.97)	21.55 (88.82)	Word	1	0.04	0.95	0.00
- Positive	-30.29 (82.33)	50.91 (171.90)	-0.35 (79.51)	2.95 (47.65)	Group	1	0.21	0.65	0.00
					T x Word	1	3.26	0.07	0.07
					T x Group	1	0.95	0.33	0.02
					Word x Group	1	3.44	0.04	0.07
					T x Word x Group	1	1.02	0.32	0.02
Accuracy (2x2: Time x Group)									
- Per cent accurate	97.54 (2.97)	98.20 (1.13)	98.23 (1.06)	97.78 (2.24)	Time	1	0.08	0.79	0.00
					Group	1	2.16	0.15	0.04
					T x Group	1	0.10	0.75	0.00

3.5 APP ENGAGEMENT

App use

Twenty-five participants recorded the amount of time they spent using the mindfulness app with the checklist provided (Appendix Q). On average participants used the mindfulness app for 18 minutes a day for seven days. Broken down, 60% of participants spent between 20-24 minutes per day, 28% between 13-19 minutes per day, and 12% completed under 10 minutes app use per day. Four participants did not return the checklist at the second lab. Fifteen participants in the mindfulness group had their phones checked using the app tracking function. Data from the app tracking function calculated a mean of 19 minutes of app use per day, which closely matches what was reported. Of the phones checked, 65% used the app on average between 20-23 minutes per day, 21% spent between 10-19 minutes per day and 15% spent under 10 minutes using the app per day.

Engagement

At the conclusion of the protocol the participants were asked to complete a debrief questionnaire to assess engagement with the relevant app for their condition. The mindfulness group generally enjoyed the mindfulness app more than the control group enjoyed the list app. In the mindfulness group 39% *Strongly agreed,* 46% *Agreed* and 15% were *Neutral*, compared with the control group where only 7.7% *Strongly agreed*, 39% *Agreed* and 35% were *Neutral*. Moreover, in the control group 15% *Disagreed* and 12% *Strongly disagreed*. When asked whether the app was easy to use, 69% of the mindfulness group *Strongly agreed* and 31% *Agreed*. For the control group 39% *Strongly agreed*, 31% A*greed*, 12% were *Neutral*, in addition 15% *Disagreed* and 4% *Strongly disagreed*. For those using the mindfulness app, 35% *Strongly agreed* that they would keep using it, 35% *Agreed* and 31% were *Neutral*. Whereas in the control condition, only 8% *strongly agreed* that they would continue using the list app, 23% *Agreed*, 19% were *Neutral*, whereas 50% said they would not continue using it (23% *Disagreed* and 27% *Strongly disagreed*).

To control for placebo effects, both conditions were told that the app they were using may assist with stress management. When asked if the app was helpful for managing stress the mindfulness group responded with 12% *Strongly agreeing*, 58% *Agreeing* and 31% *Neutral*. The control group rated the list app for managing stress with 15% *Strongly agreeing*, 35% *Agreeing*, 27% *Neutral* and 23% *Disagreeing*.

In summary, analysis of app use and engagement suggest that the mindfulness group were sufficiently engaged with the mindfulness app *Stop, Breathe and Think* and a large percentage of participants used the app according to the experimental protocol. Those in the control did not rate the list app *Tick Tick* as highly and were less likely to use the app again. In the mindfulness condition 85% said they enjoyed the mindfulness app compared with only 39% of the control group app. In terms of ease of use, 100% of the mindfulness app users found *Stop, Breathe and Think* easy to use, compared with 69% of the control group rating *Tick Tick* for ease of use. Of those using *Stop, Breathe and Think*, 69% thought they would continue using the app compared with 31% of those using the list app. This was expected as the list app has only basic functionality and the task protocol was used as an active control whereby the user was engaged with a placebo control using a technological analogue and completing a cognitive task. As this protocol was an active waitlist control, the control group were given the mindfulness app protocol at the conclusion of the second lab.

3.6 SUMMARY OF FINDINGS

This study was a RCT with the aim of assessing a brief (7-day) mindfulness intervention with the smartphone app, *Stop, Breathe and Think*. Based on previous research, it was hypothesised, that the novel approach to mindfulness training would demonstrate an increase in mindfulness and positive affect, and a reduction on measures of perceived stress, negative affect and emotion reactivity. Together, the findings of this research do not provide evidence that a brief mindfulness-based smartphone intervention can improve measures of perceived stress and mood compared to the control condition. No significant changes in self-reported perceived stress were detected. Regardless of condition, both groups exhibited a significant downward trend in negative affect. No changes in positive affect were observed.

Results from the two self-report mindfulness questionnaires (FMI, FFMQ) were inconsistent and only partially support the prediction that measures of mindfulness would increase in the experimental condition compared to the control. Both groups demonstrated a parallel increase on the FMI and FFMQ full scale with large effect sizes. When the facets of the FFMQ were examined, both groups demonstrated a significant increase on the *Non-React* facet with a large effect size. In support of the hypothesis, a significant increase was detected on the *Act-Aware* facet in the mindfulness condition compared to no-change in the control condition with a small effect size. No significant changes were detected for the *Observe, Describe* or *Non-Judge* facets.

Together the findings do not provide strong evidence to support the hypothesis that in response to the fear and anger stories, participants in the mindfulness group would demonstrate reduced emotional reactivity compared to the control condition. Both groups were equally immersed in the stories (*Immersion*). No significant variations were noted in the tendency to feel overwhelmed by the stories (*Dominance*). When listening to the fear stories, no significant changes in negative affect or perceived arousal were detected. In partial support of the hypothesis, the mindfulness group demonstrated a significant reduction in negative affect (*Valence*) and perceived physiological activation (*Arousal*) after listening to anger stories post-intervention compared to the control condition with

medium effect sizes. Conversely, no significant effects were observed in PANAS change scores. No differences in facial muscle activation relating to anger (Corrugator supercilii), fear (Frontalis), or positive affect (Zygomaticus major) were observed.

The results from the Emotion Stroop do not confirm the prediction that the mindfulness group would have shorter completion times, make fewer mistakes in colour-naming words and a have smaller interference scores for threat words, than those in the control post-test. No significant changes were observed in accuracy or reaction speed. In support of the hypothesis, the control group was slower to respond to *Panic-Threat*, *Social-Threat* and *Neutral* words post-test compared the mindfulness condition. However, no significant changes in reaction speed over time were found for either group. Contrary to the hypothesis, a significant increase in interference score for both groups was detected, suggesting both groups became more distracted by emotion words post-intervention. Paired *t*-tests did not detect any significant changes in interference from pre to post-test for *Panic-Threat* or *Social-Threat* words. A significant increase in interference for *Positive* words was detected over time within the mindfulness group but not the control group, which is in the opposite direction than what was expected.

DISCUSSION

4.1 DISCUSSION OF FINDINGS

Stress can have a significant negative impact on the health of students and is associated with maladaptive coping behaviours, burnout and psychological and physiological dysfunction (Kerrigan et al., 2017; Lacey et al., 2000; McKinzie et al., 2006; Stallman, 2012). The prevalence of students experiencing high levels of stress and the negative flow on effects of stress, provide a rationale for preventative services to promote wellness and assist university students to develop adaptive ways of respond to stress. Delivering support to students dealing with stress may alleviate some of the burden on the wider mental health system by stemming the increasing development of serious mental health problems in this population. Mindfulness-based treatments have shown promise in attenuating stress and improving psychosocial wellbeing in student populations (Creswell et al., 2014; Demarzo et al., 2017; Zimmaro et al., 2016). Previous research has highlighted that mindfulness is related to increases in positive affect and decreases in negative affect, and lower perceived stress and physiological reactivity (Bergin & Pakenham, 2016; Creswell et al., 2014; R. Jacobs et al., 2017; Snippe et al., 2017; Suyi et al., 2017; Zimmaro et al., 2016).

Several meta-analyses and systematic reviews support the use of MBIs on a number of health indicators (Chiesa et al., 2017; Khoury et al., 2015). Brief, self-directed and online interventions now include MBIs (Cavanagh et al., 2014) and findings support their use for improving wellbeing (Montero-Marin et al., 2017), increasing mindfulness (Ruscio et al., 2016), reducing stress (Aikens et al., 2014), and reducing symptoms of anxiety and depression (Dimidjian et al., 2014; Harnett et al., 2010; Manotas et al., 2014; Taylor et al., 2014b; Thompson et al., 2010). Mobile phones have become an appealing target for the delivery of health interventions and offer the potential to provide inexpensive and flexible mindfulness training to large groups of students (Demarzo et al., 2017). The development of mindfulness based smartphone apps is increasing, however, there is currently limited empirical evidence available to demonstrate positive effects from MBMA use (Plaza et al., 2013).

Previous research has indicated that the use of smartphone mindfulness apps may have benefits. Although research studies are sparse, initial findings have highlighted increases in mindfulness skills (Chittaro & Vianello, 2016; Ly et al., 2012; Morrison Wylde et al., 2017; Wen et al., 2017), positive affect (Howells et al., 2016; Wen et al., 2017), improved quality of life (van Emmerik et al., 2017), and a reduction in stress (Carissoli et al., 2015), depressive symptoms (Howells et al., 2016; Ly et al., 2014) and general psychiatric symptoms (van Emmerik et al., 2017). Table 1 presents an overview of current MBMA studies currently in print. Despite the preliminary positive results, several of these studies have noted methodological issues such as quasi-experimental protocols without control conditions, and consist of small samples sizes with low power. These methodological limitations make it difficult to draw conclusions from the findings of these studies. At the time of writing, three RCTs comparing a MBMA condition with a control condition were found in the literature (Carissoli et al., 2015; Howells et al., 2016; van Emmerik et al., 2017), with a further two parallel RCTs comparing two treatment groups without waitlist controls (Ly et al., 2014). Given the large variety of mindfulness apps available for use, additional investigations in this area are warranted. This study was designed to address a gap in the literature investigating the efficacy of MBMAs. This study utilised a RCT design to test a treatment group compared to a control condition and incorporated both self-report and objective measures.

The aim of this research was to test the efficacy of a MBMA intervention to train mindfulness skills in a university student sample to improve stress and mood. It was hypothesised that the mindfulness group would demonstrate an increase in mindfulness skills and positive affect and conversely a reduction in perceived stress, negative effect and emotion reactivity. In a non-blind RCT, participants were assigned to a mindfulness group or an active control group. The results of the analysis failed to provide support for the hypothesis that the brief MBMA would be associated with a reduction in perceived stress and negative affect and an increase in positive affect compared to a control. No significant group differences were detected. A significant decrease in negative affect for both groups over the seven days was observed. The effects observed in the current study indicated that participation in a brief mindfulness intervention with the support of a smartphone app, might cultivate the ability to *act with awareness*. A significant increase was detected on the

Act-Aware facet of the FFMQ in the mindfulness condition compared to no change in the control condition. No group differences were detected in mindfulness as measured by FMI and FFMQ as a whole scale, and both groups demonstrated an increase in mindfulness.

The experimental findings provide some tentative support that the brief MBMA intervention may reduce emotion reactivity after listening to anger stories. Participants in the mindfulness group rated less perceived physiological arousal and negative affect compared to the control after listening to anger stories. However, when taken together, the observed reduction in perceived physiological activation and negative affect is diminished by the failure to detect significant group by time effects on the other six SAM measures, the PANAS scale, facial muscle activation measured by EMG or the Emotion Stroop Task.

Considering that few MBMA studies to date have used control groups, it is possible that some of the positive outcomes reported in earlier studies are not true effects. Without a control condition there is no verification that the effects were due to the intervention alone, and not some other factor. The current study demonstrated an increase in mindfulness and decrease in negative effect in the mindfulness group, which is comparable to several MBMA studies that did not include a control group. As the current study controlled well for expectancy effects, the observed effects were verified against a control group and as a result were not attributed to the mindfulness intervention. A discussion of how the current study's intervention, participants or protocol may have contributed to the unexpected results is discussed below.

While the current study attempted to address a gap in the literature by conducting a RCT combining both self-report and objective measures, the current study did not overcome issues of low power and was conducted with a relatively small sample size. The sample size originally chosen for this study was expected to be adequate to detect a significant effect of the mindfulness training on perceived stress, mindfulness and emotion regulation from published work. However, follow up analysis suggests the current study is underpowered with only 54 participants. This study was largely exploratory in terms of using a novel, low intensity approach to mindfulness training. As a result, this study cannot draw strong conclusions from the current findings and lack of significance. Future statistical

examination may utilise Bayes Factor Analysis to test whether the non-significant results support a null hypothesis or whether the data do not have enough power to detect a significant result.

Intervention

The intervention was a novel and untested approach to training mindfulness with the support of a smartphone app for a brief period (20 minutes a day over seven days). In line with empirically tested mindfulness based protocols, *Stop, Breathe and Think* (Version 2.0) includes formal and informal guided mindfulness exercises that bring attention to the breath and body to train receptive and non-judgemental observations of thoughts, emotions and sensations as they arise moment to moment. Table 3 lists the guided mindfulness exercises available on the app. In addition to guided mindfulness practices, *Stop, Breathe and Think* includes a mood and physical check-in to record emotional and physical states. The app was selected for its ease of use, clear design, and relevant guided mindfulness meditations. Participants were instructed to start on the first day by reading an introduction to mindfulness practice and theory included in the app, then to complete the *Mindfulness of breath* and *Body scan*. Subsequently, participants were free to select when, where and how they interacted with the app, with an instruction to complete a minimum of 20 minutes of guided mindfulness practice each day. Participants could do two or three guided meditations at once for example, or spread them out throughout the day. Participants engaged on average 18 minutes a day over the seven days.

It is possible that the lack of expected results found in the current study were due to the dose or duration of the MBMA intervention. The current study prescribed 20 minutes mindfulness practice each day for the duration of seven days. In a RCT, Howells et al. (2014) established that using the mindfulness app *Headspace* for 10 minutes a day can significantly improve positive affect and reduce depressive symptoms after 10 days of mindfulness practice. However, they found no effect on satisfaction with life, flourishing or negative effect and the authors proposed that the length of their study might have been too short to capture those effects. The current study tested a brief, low intensity intervention with a novel approach to mindfulness training. Given that mindfulness is a skill that

requires regular practice and sustained effort over time it is possible that the brief duration of seven days practice for novice meditators was insufficient to train skills in mindfulness that would affect the response to stress or changes in emotion regulation.

Only one MBMA study has assessed perceived stress. Carissoli et al. (2015) demonstrated a reduction in perceived stress in both a MBMA condition (2x 15 minutes per day) and a music condition, compared to a waitlist control over 3-weeks. Given that both the mindfulness condition and the music condition exhibited a decrease in perceived stress, the authors concluded that the length of their 3-week intervention might not have been sufficient to exert the expected effects on perceived stress in the mindfulness condition. The authors proposed that an initial period is likely needed to learn the mindfulness skills and a longer duration of intervention might generate higher effects in the mindfulness group. Other research has demonstrated a dose response to mindfulness meditation, suggesting that the likelihood of positive outcomes increases with longer-term mindfulness practice (Creswell, 2017; Snippe et al., 2017). The current study failed to demonstrate a statistically significant reduction in perceived stress. A non-significant trend of reduced perceived stress was observed in both groups, which may indicate a decreasing trend given more mindfulness practice.

One of the limitations of the study was that there was no accurate data collected on the frequency and amount of time spent using the App each day. While the current study prescribed 20 minutes of mindfulness practice each day for seven days, the dose and sequencing of the mindfulness intervention was not verified. The MBMA intervention was assessed under real world conditions, whereby the participants were free to choose when to engage with the app, with no therapist input during the seven days. While there was a tracking function on the app, this was limited to *total time meditating* and was assessed in only 56% of the participants at the second laboratory. There was no tracking of daily meditation during the intervention, so there is no record of whether participants engaged regularly with the practice, or when they began. Frequent regular practice is paramount in order for individuals to benefit from mindfulness-based interventions (Plaza et al., 2013). Self-reported frequency has been associated with differences in mindfulness and measures of self-regulation (Semmens-Wheeler & Erskine, 2009). Future studies that accurately

record frequency of practice as well as duration and length of time are needed to understand the effects of mindfulness on measures of self-regulation. If participants did not adhere to the protocol and use the app regularly, the effect of the intervention may have been impaired. Future research that includes a more accurate picture of participant engagement and the frequency and duration of app use are necessary to understand treatment effects.

In support of the assertion that the current study's 7-day intervention was not long enough, another RCT demonstrated that self-help MBMA use over 8-weeks was associated with significant increases in mindfulness, as well as improvements in general psychiatric symptoms and psychological, social and environmental quality of life (van Emmerik et al., 2017). The study included a follow up at 6-months and found that most effects were maintained. Based on the findings described above, it is possible that the comparatively short length of the current study's intervention was not long enough to develop sufficient mindfulness skills or the ability to act mindfully or to elicit changes on measures of perceived stress or mood in novice meditators.

All other MBMA studies that have demonstrated positive effects have been 4 to 8-weeks in duration. In a quasi-experimental study Ly et al. (2012) found a significant increase in mindfulness skills after 8-weeks of a MBMA intervention. However no control group was used to compare the outcomes observed in this study and as such the benefits attained cannot be credited to the intervention per se. In a later study Ly et al. (2014) evaluated a smartphone delivered intervention for people diagnosed with major depressive disorder (MDD), with minimal therapist input. They compared a MBMA and a behavioural activation app over 8-weeks and demonstrated comparatively large reductions in depression for at least 6-months. Again, however, no control group was used to compare the effects, making it difficult to draw conclusions about the positive effects observed. The current study demonstrated an increase in mindfulness and decrease in negative effect in both the mindfulness and control conditions. Had this study not used a control condition the results would have been comparable to these studies reporting positive effects. These results highlight the need for more RCTs to assess the effects of MBMAs compared to a control condition.

Brief mindfulness interventions have demonstrated benefits in shorter time frames with therapist training and in laboratory formats (Creswell et al., 2014; Hwang et al., 2017). It may be however, that the format of delivery for self-directed mindfulness acquisition with a non-meditating sample requires more time to develop the practice and elicit changes in outcome measures. Mindfulness is a skill that requires practice to acquire. Carissoli et al. (2015) suggest that interventions that require time to learn and practice, such as mindfulness, may demonstrate more benefits when combined with contact with a trainer (either face-to-face or distance), to introduce the approach. The current study assessed the intervention in a real world context, whereby participants were instructed to use the app freely and could choose whether they listened to formal or informal mindfulness exercises (Table 3). The pragmatic design of the current intervention tested the application of a mindfulness app, as it would be normally used if downloaded independently. There was no therapist involvement during the seven days. At entry to the study the experimenter gave a brief introduction to mindfulness during the laboratory protocol.

Another factor affecting the outcome of this study may be the content of the mindfulness app used in the intervention. It is possible that the *Headspace* app structure and content provides a superior introduction to mindfulness concepts for youth participants or novice meditators compared to *Stop, Breathe and Think* app. Findings from three separate studies have found that the *Headspace* app is associated with an increase in mindfulness skills (Morrison Wylde et al., 2017; Wen et al., 2017), improved mood (Howells et al., 2016; Wen et al., 2017), and a decrease in depressive symptoms (Howells et al., 2016). However, of those effects reported, only Howells et al. (2017) compared effects to a control condition (Table 1). The *Headspace* app has a standardised and structured format, which takes the user on a stepwise 10-day program. *Headspace* also includes animations about the theory and practice of mindfulness. While *Stop, Breathe and Think* has comparable guided mindfulness content, the user is required to read the basics of mindfulness theory. For youth and participants new to mindfulness, the animated introductions in *Headspace* may provide a more helpful and engaging introduction to mindfulness concepts and practice.

It is possible that engagement with the app factored in the outcome of the study. Positive perception and pleasurable engagement with the app interface design and functionality is an

important aspect when testing an app as a viable instrument for any health intervention. Howells et al. (2016) reported a significant positive correlation between task enjoyment and wellbeing. The current study verified that the participants in the mindfulness condition enjoyed the app and found it easy to use. Eighty-five per cent of participants reported that they enjoyed the mindfulness app *Stop, Breathe and Think* and 69% thought they would continue using the app. While participants rated the app favourably, this may have been due to social desirability. The following section further explores aspects of participant engagement, motivation and compliance.

Participants

Characteristics of the sample, such as motivation, attitude, language and demographics may have influenced the findings. Attitude has been noted as a factor that has contributed to the positive effects demonstrated in previous studies, and may be an influence in the results of the current study. Howells et al. (2016) demonstrated that the combination of a 'happiness seeking attitude', with an empirically derived mindfulness app enhanced wellbeing compared with a placebo task. Like the participants in the Howells et al. (2016) study, the current study's participants were self-selecting. Research flyers advertising the study (Appendix B) suggested brief mindfulness practice may impact the way participants respond to stress or regulate their emotions. The research flyer introduced mindfulness training as a practice that cultivates present moment awareness with an attitude of openness and non-judgmental acceptance that involves learning to observe thoughts and feelings without judging them. While the flyer stated there were no guaranteed benefits to enrolling in the study, it was reported that mindfulness practice has demonstrated varied positive effects on physical and mental health. A $20 shopping voucher was offered as a re-imbursement at completion of the study. Participants enrolled were a mix of undergraduate and postgraduate university students aged 18 to 51 years.

Motivation to receive a benefit from the mindfulness practice may have influenced participant behaviour in the study. Motivation for enrolling in the study was not formally assessed. Anecdotally, via conversations with the experimenters some participants expressed interest in mindfulness as a positive way to manage stress and improve

wellbeing, some were psychology students and had enrolled due to their interest in psychological research. The issues of compliance and response bias are considerations for many research trials. A limitation of the current study was that it was non-blinded and both the participants and experimenters knew which condition participants occupied. It is a common phenomenon for participants to under or over report adherence to interventions due to social desirability bias. Both groups demonstrated an increase in mindfulness scores on the FMI and FFMQ whole scale. It is plausible, given that the advertising material described benefits of mindfulness and outlined the basic principles of mindfulness practice, that motivation to engage with mindfulness practice may have caused participants in the control group to willingly or unconsciously engage more mindfully, learn more about mindfulness, or endorse more mindfulness items.

As with all self-report measures there is the possibility of social desirability and expectancy effects. Non-compliance with the control condition or response bias may have therefore affected the results of the current study. The difficulty assessing mindfulness in RCTs is the problem with creating an adequate active control that could blind participants to the experimental conditions. It is possible that those in the mindfulness group endorsed more mindfulness items post-intervention knowing they were expected to improve on measures of mindfulness. Lyubomirsky et al. (2011) advises that self-selecting participants will be fully aware of the activities they are engaging in and may express biases that result in higher reported wellbeing gain. The strength of the current study is the ability to compare the observed increase in mindfulness and decrease in negative affect in the mindfulness group to an active control in order to test for expectancy and placebo effects. Whereas, the effects observed in Chittaro & Vianello, (2016), Morrison et al., (2017), Ly et al., (2012), Ly et al., (2014), and Wen et al., (2017) did not compare to a control group, therefore the results they observed may not be true effects.

Compliance in the mindfulness condition may also have contributed to the observed effects. The study used a real-world context and the participants could use the app when it suited to fit their schedules. Participants were asked to undertake a minimum of 20 minutes a day for seven days, and record the type of meditation and time spent on the checklist provided (Appendix Q). The app also had a tracking function that counted *Total time meditated*,

which was recorded at the post-intervention lab session. Not all participants brought their phones at the final laboratory and only 56% of participants had the tracking time checked on their phones. In some cases there were discrepancies between the time displayed by the app tracker and the time on the self-report activity log. On average however, time tracked (19 minutes per day) closely matched the average time recorded on the checklists (18 minutes per day), demonstrating that on average participants underestimated time spent. Given that just over half of the participants had their phones checked, it is possible that some participants did not comply with the intervention and exaggerated the time spent on the app due to social desirability.

Language may have influenced the effect of the intervention on the outcome measures of interest. It was taken for granted that participants entering the study would have a good knowledge and practice of the English language. The sample was a self-selecting mix of undergraduate and postgraduate university students in Auckland. Both experimenters noted that several participants spoke English as their second language. Some participants had difficulty interpreting and understanding the self-report questionnaires and asked the experimenters for clarification of words and terms. A limitation of the study was that English fluency was not factored in as an exclusion criteria and it was not noted how many participants had difficulty understanding the self-report measures. Given the complexity and number of the self-report questionnaires, having English as a second language may have invalidated some instruments due to misunderstandings. Engagement and benefit from the app was also likely compromised by English fluency. Practicing mindfulness in a language that is not the participant's first language is significantly more challenging (Plaza et al., 2013). The ability to engage with the mindfulness app and understand mindfulness concepts was likely impacted for several participants in the study. Ensuring participants have sufficient proficiency to understand and engage with the presented content is essential to accurate self-reporting. Unfortunately language was not formally assessed, and as such, this was not factored into the analysis. It is unknown to what extent this impacted on the results of the current study as it was not noted how many participants had difficulty with English fluency. These limitations of the study likely decreased participants ability to understand mindfulness concepts, engage with the mindfulness app, and accurately reflect on their own ability to be mindful.

In addition to English language proficiency, given that participants were new to mindfulness meditation, they may have found the mindfulness questionnaires difficult to interpret. There is some evidence to suggest that novice meditators find mindfulness questionnaires are hard to understand and difficult to differentiate between aspects of mindfulness (Eisenlohr-Moul, Peters, & Baer, 2015). Further discussion about the use of mindfulness self-report questionnaires to assess mindfulness is discussed in the protocol section below.

Characteristics of study status (part-time, full-time, post-graduate or undergraduate) combined with the timing of recruitment and data collection may have impacted on the results of the study. The time related effects observed may have been impacted by changes in study status or workload during the week they engaged with the study. Lab sessions were held from June through to September 2018. This time period captured a mix of students at different time stages in the university year with varying work-loads. During the week of study engagement some students were at the end of semester, others were across the semester break and some were at the beginning of semester. The workload questionnaire (Appendix I) was an attempt to capture whether university workloads were equalised across groups during randomisation. A limitation of this study is that this data was not accessed using a validated questionnaire, but was constructed by the author as part of the research protocol. If workload was not accurately assessed and it was not equalised across groups, this could have influenced the perceived stress scores and the observed time-related effects. Future research that more accurately considers timing of data collection across the academic year is needed to assess the validity of mindfulness interventions in university students.

Protocol

Features of the current study's protocol, including assessment of outcome measures and experimental protocols may have contributed to the unexpected results observed in this study on measures of mindfulness, perceived stress, mood and emotion reactivity. While several studies have demonstrated positive outcomes from MBIs, including the use of brief,

self-directed, and computer or smartphone aided formats, fewer studies have assessed mindfulness. Without measures of mindfulness, it becomes difficult to draw causal relationships and confirm whether the improvements in psychological functioning are due to an increase in mindfulness, or whether there are other contributory factors (Baer et al., 2009). This study aimed to add to the literature by investigating the mechanisms or processes by which mindfulness exerts beneficial outcomes. By including two mindfulness self-report questionnaires as well as experimental measures of emotion reactivity it was intended to provide information about the active components of mindfulness with relevance to perceived stress and increased wellbeing.

Developing valid tools for assessing mindfulness requires operationalising the construct. Mindfulness is difficult to conceptualise due to the interrelated and subtle aspects of mindful processes, and mindfulness as a construct remains contentious in the literature. Several measures have been put forward with varied definitions of the active components of mindfulness (Baer et al., 2009). Some authors have cautioned, that considering the complex epistemology of the mindfulness construct, the use of mindfulness assessments needs to be done with care (Goodman, Quaglia, & Brown, 2015; Qu, Dasborough, & Todorova, 2015). Measurement of mindfulness with the use of self-report measures is a relatively recent development. Understanding how different items are interpreted across varied sample groups is not yet resolved. It has been argued in the literature that sample populations that are new to mindfulness meditation may find it hard to understand and differentiate mindfulness concepts and consequently may find it difficult to report accurately on their own tendencies to be mindful (Belzer et al., 2013; Bergomi, Tschacher, et al., 2013a; Eisenlohr-Moul et al., 2015).

The short form FMI (Walach, Buchheld, Buttenmüller, Kleinknecht, et al., 2006)(Appendix F) was chosen for the current study because it was developed for use in a non-meditating sample, and has shown adequate to good internal consistency in several samples (Baer et al., 2009). Walach et al. (2006) advised that the 14-item short form is a robust version of the FMI, which is semantically independent from a Buddhist or meditation context. Some authors however, have challenged the construct validity of the FMI, suggesting that the modification of the wording in several items is necessary and that there is insufficient

construct validity to use the current FMI in samples new to mindfulness (Belzer et al., 2013). Belzer et al. (2013) showed that individuals without meditation experience systematically misunderstood items 1, 2, 3, and 7. The authors recommended reformulating these items (Bergomi, Tschacher, & Kupper, 2013b). Bergomi et al. (2013) argue that the FMI in its current from may be inappropriate for populations unfamiliar with mindfulness or Buddhist concepts since at least some items may be systematically misunderstood by individuals without meditation experience. They recommend that self-report measures of mindfulness need to be constructed with less abstract ideas and provide items that are unambiguous and semantically clear, especially for novice meditators.

Research suggests that the FFMQ facets measure skills that are cultivated by mindfulness practice in both long-term meditators and in non-meditating samples (Baer et al., 2009). The results of this study did indicate that the intervention was associated with a significant increase in the ability to *act with awareness* compared to a control condition. Previous studies using MBMAs have also demonstrated an increase of the facet *Act-Aware* (Morrison Wylde et al., 2017; van Emmerik et al., 2017), as well as *Non-React* (Morrison Wylde et al., 2017; van Emmerik et al., 2017), and *Observe, Describe* and *Non-Judge* (van Emmerik et al., 2017). Findings from the current study also demonstrated an increase on the *Non-React* facet in both groups. Given the moderate increase in mindfulness as measured by the FFMQ subscales in the current study compared to previous MBMA studies may provide further support for the argument that the intervention was not sufficiently long enough to exert the hypothesised effects. Van Emmerik et al. (2017) reported increases on all facets of the FFMQ in a RCT after 8-weeks compared to a control. Morrison Wyle et al. (2017) detected the effects on *Act-Aware* and *Non-React* after 4-weeks, however this was compared to traditionally delivered mindfulness. Given that the current study did demonstrate an increase in the facet *Act-Aware* after only 7-days, suggests that the intervention may have potential to elicit stronger effects over a longer duration. Considering that increased positive outcomes are observed with additional mindfulness practice, a longer intervention may also increase measures above possible expectation effects in the control condition.

In view of the aforementioned factors, it is plausible that difficulty understanding the mindfulness questionnaires may have affected the outcomes of the self-report measures of mindfulness. Contributing factors to this include language barriers, unfamiliarity with mindfulness concepts and the unresolved understanding of mindfulness as a construct within assessment tools. One of the arguments put forward for the reasons why assessment of mindfulness is contentious relates to two contrasting conceptualisations of mindfulness. Goodman et al. (2015) has highlighted the opposing conceptualisations of mindfulness either as a skill that requires development via formal training (Grossman, 2011), or as an inherent capacity of the mind (Kabat-Zinn, 2003). Goodman et al. (2015) reasons that these conflicting views raise questions concerning the development of mindfulness in non-meditating samples, which has implications for self-report measurements.

Previous research has identified that changes in dispositional mindfulness as measured by the FMI and FFMQ are sensitive to participation in mindfulness interventions (Bohlmeijer et al., 2011; Walach, Buchheld, Buttenmüller, & Kleinknecht, 2006). Research investigating MBIs has demonstrated increases in FMI scores in both meditating and non-meditating samples (Bruin, Meppelink, & Bögels, 2015; Ribeiro, Atchley, & Oken, 2017). Only one MBMA study has assessed mindfulness using the FMI; Wen et al. (2017) demonstrated a significant increase in FMI scores over 4-weeks in a sample of resident doctors, however, no control group was used to qualify the effect. The current study demonstrated an increase in FMI scores for both groups from pre to post-treatment. One possible explanation for the results is the exposure to mindfulness concepts with repeated mindfulness measures. It has been argued that the evidence for pre-post treatment mindfulness changes may only indicate that trainees are more likely to endorse more mindfulness scale items at the end of training than at baseline, and may not be indicative of actual mindful capacities (Goodman et al., 2015).

The development and use of mindfulness measures continues to advance and further testing and evaluation across different populations is necessary to clarify some of the issues raised in the literature. As with any instrument designed to capture a construct there will be strengths and weaknesses, which may affect the usefulness of the data, generated. As the literature on the assessment of mindfulness has highlighted, it is possible the sample

population, or the mindfulness measures used, impacted the results of the current study. Given the difficulty operationalising mindfulness into concrete scientific terms to compare across studies, it is essential that future research continues to question and test methods of mindfulness assessment. Based on previous research that has shown the FMI and the FFMQ can be responsive to mindfulness interventions in novice meditators, the measures were deemed appropriate for this sample.

Another potential explanation for why mindfulness scores increase in both groups is that some other aspect of the protocol impacted acquisition of mindfulness skills, such as the active control condition. It has been argued in the literature that much of the research that investigates the health effects of mindfulness interventions is problematic due to the lack of validated active controls (MacCoon et al., 2012). The current study attempted to address this by including an active control condition to allow for potential non-specific effects of intervention engagement (Josefsson et al., 2014). The protocol for the active control was adapted from a previous MBMA study by Howells et al. (2016). The active control condition was structurally equivalent to the delivery of the self-directed mindfulness training (mobile app based, includes tracking and check-in and requires active engagement for seven days). Participants in the control group were asked to make a list each day of what they did on the same day last week using the app for approximately 10 minutes. The study attempted to provide an active control that structurally matched the delivery of the self-directed mindfulness app so that the participants in the control were required to engage with an mobile phone activity they felt might benefit them. Providing an adequate control for mindfulness interventions is problematic due to difficulty creating a control that could blind the participants to the experimental condition. This study was not blind and could not control for mindfulness expectancy effects, as all those in the mindfulness group knew they were expected to show improvements in mindfulness. As mentioned previously, motivation to engage in mindfulness practice, exposure to information about mindfulness from both the research flyer and the multiple mindfulness questionnaires, as well as expectancy effects and response bias may also have impacted on participant's capacity to be mindful, or at least their likelihood of endorsing more mindfulness scale items post-intervention.

The control task was dissimilar to mindfulness practice and consisted of a simple memory task. The cognitive task was used as a mind activity that required a similar amount of time and focus, without the mindfulness techniques of non-judgmental present moment awareness. Early mindfulness practices involve an alert and active practice of directing the mind to attend to the breath and body while becoming aware of thoughts as they come and go, and re-directing attention back to the breath or body. The control task did not involve any instruction to be mindful or include any receptive practices. Due to the basic task instructions and the limited functions available on the control app, it was not expected that the control condition would impact participant's ability to be mindful (Howells et al., 2016). However, it is possible that they task may have encouraged participants to be reflective as it is based on autobiography as opposed to remembering a list of random items. The study that the protocol was adapted from did not assess mindfulness measures, and as such did not compare whether an increase in mindfulness was evidenced in the control and treatment groups. The issue of developing an appropriate and valid control for mindfulness interventions is a difficult one to remedy. Especially given the complexity of the mindfulness construct. That this intervention was delivered via a mobile phone app further complicated the factors necessary for an adequate control. Future research that elucidates the active components of mindfulness practice will help promote the development of appropriate controls that match mindfulness practice.

Numerous research studies have also demonstrated that mindfulness is associated with reduced negative affect and increased positive affect (Brown et al., 2007). Results of MBMAs measuring affect have demonstrated increases in positive affect (Howells et al., 2016; Wen et al., 2017), but no decreases in negative affect. The current study found no differences between groups for either positive or negative across the seven days. A significant reduction in negative affect was detected in both groups over time. Explanations for this include as mentioned above, some aspect of participant motivation, compliance or social desirability. Other possible reasons include some aspect of the protocol such as the active control condition, or a possible placebo effect. The control condition was described as a task that can hone one's mental recall and organisation skills. To equalise the placebo effect across groups and increase compliance a cover story that all participants (including controls) may increase their ability to cope with study stress was employed. These

instructions were given in accordance with procedures of standard placebo controlled designs, in which all participants are informed the 'treatment' that is being tested has a reasonable chance of working. It is possible that believing that the control condition was eliciting a positive effect may have caused the reduction in negative affect observed. Another consideration is that some aspect of the control condition was providing a positive intervention as discussed above. The cognitive recall task, for example, may have provided participants with some distraction from there everyday stresses, or allowed them to be reminded of what they had achieved the week prior.

Another element influencing the outcomes in this study was the design and use of experimental protocols investigating psychophysiological variables. Each experimental protocol was conducted appropriately and with trained experimenters based on recommendations from previous studies. A standardised procedure was scripted and built into a computer program for each lab session. It is therefore doubtful that the lack of hypothesised effects was due to issues with the individual protocols employed. However, as a result of the design of the study and the multiple measures used, the participants were required to attend two long laboratory sessions lasting approximately 1 to 1.5 hours. Table 2 lists the details the tasks involved in the protocol. The extended duration of the laboratory sessions may have caused participants to become fatigued or bored, which could have resulted in difficulty attending to the tasks. Participants were set up with electrodes then asked to complete several self report questionnaires, this took longer than expected for some participants due to language difficulties. After the 20-minute Emotion Stroop Task, participants generally displayed visual signs of fatigue or boredom, i.e., yawning, stretching, and sighing. It was at this time that the participants listened to the emotion induction stories. Ability to attend to each protocol individually may have been affected by the effort and concentration required to complete the combination of tasks. If a replication of this study was made, it may be better to separate out the study, both extending the period of time for the intervention and assessing the self-report questionnaires separately from the laboratory protocols, or conducting two separate studies.

It has been reported in the literature that mindfulness training can impact emotion regulation (Sayers et al., 2015). It has been put forward that the cultivation of open and

non-judgmental attention, produces a clarity and receptivity toward emotions (Heppner, Spears, Vidrine, & Wetter, 2015). It is thought that noticing and accepting emotions in this way over time predicts less avoidance of emotions, greater tolerance and increased emotion differentiation, and less reactivity to emotions (Heppner et al., 2015). Results of the current study did not demonstrate any group differences in ability to control attention when faced with emotional distractors (Emotion Stroop Task). In response to negative emotion stories, participants did not demonstrate any differences in implicit measures of emotion reactivity (facial electromyography). However, results of the current study did detect a significant reduction in negative affect (SAM *Valence*) and perceived physiological activation (SAM *Arousal*) after listening to anger stories post-intervention in the mindfulness group. These results provide partial support for the prediction that mindfulness training with a smartphone app can affect the way participants respond to emotions. However, when taken together with the null effects observed in the other measures, it does not provide strong evidence. It may suggest, like previously mentioned, that the short length or dose of the current intervention was not sufficient to exert the effects. Given that the current study did demonstrate some differences in emotional responding after seven days, it could indicate that the intervention may have potential to produce stronger effects over a longer duration.

Fostering mindfulness requires practice over time to learn to observe thoughts and emotions from an open and decentered perspective. It is likely that given the short duration of this study there was not enough time spent practicing mindfulness approaches to exert effects on measures of mindfulness, perceived stress and emotion regulation compared to a control condition. No previous studies investigating MBMAs have demonstrated changes in emotion reactivity. Two studies demonstrated an increase in positive effect after MBMA interventions in 10-days (Howells et al., 2016) and 4-weeks (Wen et al., 2017). Previous studies that have shown positive increases in mindfulness skills via app delivery after 4-weeks (Chittaro & Vianello, 2016; Morrison Wylde et al., 2017; Wen et al., 2017) and 8-weeks (Ly et al., 2012; van Emmerik et al., 2017), indicate that app delivered mindfulness interventions may require more time to exert effects, especially in non-meditating samples.

4.2 FUTURE DIRECTIONS

While the current study attempted to address a gap in the literature by conducting a RCT combining both self-report and objective measures, the current study did not overcome issues of low power and was conducted with a relatively small sample size. As such no strong conclusions can be drawn from the study findings. Effects observed in the current study serve to suggest hypotheses to investigate in future studies. As research on MBMA's and low intensity mindfulness interventions are in their infancy, this study makes an original contribution to the literature with strengths utilising a RCT design and incorporating both self-report and objective measures of relevant constructs. It is hoped that the discussion of findings from this study serve to inform future studies investigating MBMA's and mindfulness training.

There are several other notable limitations to this study discussed above. Firstly the study was non-blinded and both participants and experimenters were aware which condition participants undertook. Issues of compliance with the protocol by participants may have influenced the outcome of the study's results. There was a lack of internal control in this study due to increased emphasis on ecological validity. Future research that includes a more accurate picture of app use and participant engagement would be useful. Research that assesses MBMAs would benefit from more effective methods of monitoring compliance, such as an automatic updating system like the one employed by Chittaro and Vianello (2016), which allowed the researchers to remotely monitor the participants' use of the app throughout the intervention.

Based on the lack of expected results and the comparatively short length of the current study's intervention compared to other MBMA studies, future research could extend the length of the intervention. Given that the current study did demonstrate an increase in the FFMQ facet *Act-Aware* after only seven days, suggests that the intervention may have potential to elicit stronger effects over a longer duration. The current study employed extended laboratory protocols. The ability to attend well to each task may have been affected by the effort required to complete the combination of tasks. If a replication of this

study was made, it may be better to separate out the study. Extending the period of time for the intervention and assessing the self-report questionnaires separately from the laboratory protocols, or conducting two separate studies. Studies that have demonstrated effects of mindfulness on emotion reactivity in the lab have often used protocols that assess changes in mindful states immediately after mindfulness practice as opposed to measuring dispositional mindfulness (Sayers et al., 2015). Taylor et al. (2014b) instructed participants new to mindfulness to mindfully attend to images of differing emotional valences. These mindfulness instructions reduced self-reported emotional intensity experienced in response to the images across all valence categories (i.e., positive, negative, and neutral) (Sayers et al., 2015). In the current study, trait mindfulness was measured by the FMI and FFMQ after the seven day app intervention. Participants were not asked to be mindful during the laboratory protocols. Future research could replicate the laboratory protocols assessing emotion reactivity immediately after mindfulness induction to assess changes in state mindfulness.

As research in this area is in its infancy, there are limited studies available to contrast and compare with. Of those available, several have methodological weaknesses and do not compare the outcomes to a control condition. Future research that employs RCT designs will advance the understanding of the efficacy of MBMAs. Few studies assess changes in mindfulness as well as psychological outcomes. Future studies that utilise both mindfulness measures and psychological outcomes will help to determine whether participants learn mindfulness and related skills and if mindfulness skills are responsible for the improvements observed in psychological functioning.

Several of the measures used in this study were self-report questionnaires. As with all self-reported measures, there is the possibility of social desirability and response biases. Assessment of mindfulness with the use of self-report questionnaires continues to develop and some authors have raised concerns about ambiguous or abstract mindfulness terms used that may be difficult for participants to understand, especially those new to mindfulness practice. It is important that future research continues to test methods of mindfulness assessment in various sample groups to determine their relevance and acceptability. Future research that evaluates item understanding in sample populations with different meditation

experience may point to aspects of mindfulness that cannot be meaningfully self-evaluated by individuals who lack a certain degree of mindfulness. Future studies that also include objective measures of relevant constructs may assist the development of validated mindfulness tools for assessment.

4.3 CONCLUSION

The prevalence of students experiencing high levels of stress, and the negative flow on effects of stress, provide a rationale for preventative services to promote wellness and assist university students to develop adaptive ways of responding to stress. Mindfulness-based smartphone apps present an opportunity to provide a cost effective, flexible tool to deliver health interventions to university students. The convenience, portability, and ubiquity of mobile phones make them an accessible resource for engagement with mindfulness-based interventions that utilise evidenced based protocols and demonstrate perceived usefulness. The scarcity of studies testing the efficacy of MBMAs means the feasibility and potential of this format of intervention delivery remains largely unknown. Although research studies are sparse, initial findings have highlighted increases in mindfulness skills (Chittaro & Vianello, 2016; Ly et al., 2012; Morrison Wylde et al., 2017; Wen et al., 2017), positive affect (Howells et al., 2016; Wen et al., 2017) and quality of life (van Emmerik et al., 2017), and a reduction in stress (Carissoli et al., 2015), depressive symptoms (Howells et al., 2016; Ly et al., 2014) and general psychiatric symptoms (van Emmerik et al., 2017). However, several of the studies have methodological weaknessess and do not support strong conclusions. Research in this area is still in its infancy and given the widespread availability MBMAs, there is a need for methodologically sound studies testing their efficacy. The current study aimed to add to the literature investigating the effectiveness of a smartphone app to deliver brief mindfulness training utilising a RCT design with both self-report and objective measures of mindfulness, well-being and emotion reactivity.

This study was a non-blind RCT that tested the feasibility of a brief (7-day) self-directed mindfulness intervention with a smartphone app, to improve stress and enhance wellbeing in a student population. Based on previous research, it was hypothesised that the novel approach to mindfulness training would demonstrate an increase in mindfulness skills and positive affect, and reduce measures of perceived stress, negative effect and emotion reactivity. Contrary to the hypotheses no significant differences were found between groups over the seven days on measures of perceived stress or mood. Both groups demonstrated a significant parallel decrease in negative affect, with a large effect size. In support of the hypothesis the mindfulness group reported significantly more *acting with awareness*

compared to the control with a small effect size. Both groups demonstrated a significant parallel increase in mindfulness on the FMI, the FFMQ full scale, and the *Non-React* FFMQ facet with large effect sizes.

The experimental findings provide some tentative support that the brief MBMA intervention may decrease emotion reactivity after a negative emotion induction. The mindfulness group reported significantly less negative affect (*Valence*) and perceived physiological activation (*Arousal*) after listening to anger stories post-intervention compared to the control condition with medium effect sizes. However, when taken together, this observation is diminished by the failure to detect any significant group by time effects in the other self-report measures of emotion responding. No significant differences to fear stories, facial EMG or Emotion Stroop were detected.

Considering the positive results reported in longer MBMA RCTs, it is possible that the comparatively short length of the current intervention or the format of delivery was insufficient to capture changes on the measures of interest. Given that after seven days of mindfulness training with a MBMA, the mindfulness group demonstrated an increase in the *Act-Aware* mindfulness facet, and a reduction in emotion reactivity to anger stories compared to the control, lends support to the assertion that the intervention may have the potential to produce stronger effects over a longer duration. In line with previous research that has demonstrated positive affects with mindfulness-based interventions, it is possible that a smartphone app as as a form of mindfulness delivery may require more time to generate beneficial effects, especially in non-meditating samples.

While the current study attempted to address the methodological weaknesses of previous MBMA studies by conducting a RCT combining both self-report and objective measures, the current study did not overcome issues of low power and was conducted with a relatively small sample size. As such, this study cannot draw strong conclusions from the current findings and lack of significance. Due to the small sample size and low power of the study, it is possible that any effects noted were due to chance alone. More methologically robust studies are needed to assess the efficacy of MBMAs compared to a control condition.

To conclude: The results of this study failed to provide support for the use of a mindfulness smartphone app to improve the response to stress in a non-meditating student sample. The effects observed in this study indicate that participation in a brief, self-directed mindfulness intervention delivered by a smartphone app may cultivate the ability to *act with awareness*. The results provide partial support that engagement with a MBMA may reduce emotion reactivity to anger stories. However, these experimental findings should be viewed in the context of a failure to detect differences in the other of the measures of interest and the low power of the study. It is likely that MBMA as a form of mindfulness delivery may require more time to generate beneficial effects, especially in a non-meditating sample. Further research, is needed to assess the efficacy of MBMAs. Future studies should employ RCTs and include both measures of mindfulness and psychological outcomes, to compare effects in different populations. Research that includes attention to the facets of mindfulness and experimental measures of mindfulness will provide necessary insights to the understanding of how components of mindfulness contribute to positive outcomes.

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APPENDICES

Appendix A: Recruitment poster

Appendix B: Recruitment flyer

Appendix C: Information sheet and consent form

INFORMATION SHEET AND CONSENT FORM

Mindfulness & Emotion Regulation Study

PURPOSE OF STUDY

The purpose of this study is to explore how we perceive stress and respond emotionally to experiences.

PROCEDURES

Participation in the study will involve attending for a testing session, which will last around 60 minutes. During the testing session will be asked to complete several questionnaires, which ask about how you currently feel, and how you usually think, feel and behave in certain situations. You will be asked to do a task on the computer, then listen to some fictional stories. As you do this, we will measure your facial responses. This will mean wearing some electrodes taped to your face.

POTENTIAL RISKS AND ETHICAL CONSIDERATION

It is possible that you may experience discomfort when answering some of the questionnaires. You do not have to answer any question you do not wish to, and you are free to leave the study at any time.

Though brief, the four imaginary situations described may elicit some negative feelings or emotions. It is important to remember that you are free to leave the study at any time. If you experience any distress, the investigator can lead you through a relaxation exercise before leaving.

The recordings of facial muscles are not uncomfortable. However, we need to attach the electrodes to recently cleansed skin. So we will ask you to cleansing your face with a hypoallergenic wash just prior to starting the experiment.

No are risks are associated with the protocol used in this study. No adverse outcomes are expected.

BENEFITS

There are no guaranteed benefits to the participants. Participants may experience improved ability to cope with stress and a reduction in the adverse physiological and psychological effects induced by high stress.

CONFIDENTIALITY

The information you give will be kept strictly confidential, except as may be required by the law or professional guidelines for psychologists. All information will be identified by an identification code, not your name. Any form that requires your name (e.g., this consent form) will be stored separately from the other material. Your name or other identifying information will never be associated with any research reports or publications that use the results of your questionnaires or interviews.

WITHDRAWAL/PREMATURE COMPLETION

Your participation in this study is entirely voluntary, and you may discontinue at any time, without prejudice. Although you will be asked to complete questionnaires without omitting items, if you do not wish to answer a question you may omit it.

INVITATION TO ASK FURTHER QUESTIONS

Should you have any questions about the study you can ask these at any time. You will be given a specific opportunity to ask questions and discuss the study during the testing session prior to completing the consent form.

CONSENT

I give my informed consent to participate in this study of Student Stress and Emotion Regulation.

I have read and understand the consent form.

I understand that a portion of the testing session will be audio-recorded.

Upon signing below, I will receive a copy of the consent form from the study investigator.

Participant Name--Printed:

Participant Name--Signature: (Date)

Investigator (Date)

Questions or concerns about the study can be addressed to the Chair of the Ethics Committee, School of Psychology, Massey University.

Appendix D: Demographic questionnaire

Demographic,Questionnaire,

Please complete this questionnaire honestly and return via email. All information contained in this questionnaire is confidential and will remain anonymous. If there are any questions you do not wish to answer, you may leave them blank. Thank you.

1. Please type your age: _____

2. Please tick the box for your gender:
   - Male
   - Female
   - Other

3. Please tick the ethnic group(s) that you belong to:
   - NZ European/Pakeha
   - Māori
   - Pacific Nations
   - Asian
   - European (non-NZ)
   - Other (please specify) _____

4. Please tick the box for your current enrolment:
   - Undergraduate student
   - Postgraduate student

5. Please tick the box for your current enrolment:
   - Full-time student
   - Part-time student

6. Please tick the correct box for your situation during enrolment:
   - Work full-time during semester
   - Work part-time during semester
   - Full-time parent
   - Part-time parent (childcare assistance, daycare, kindy, school)

7. Are you colour blind? A computer task in this study requires colour differentiation.
   - Yes
   - No

8. Are you hearing impaired? If Yes, Would you have difficulty listening to a story with headphones?
   - Yes
   - No _____

9. Are you mobility impaired? If Yes, Do you need assistance to get to the lab?
   - Yes
   - No _____

10. Do you currently practise mindfulness? If Yes, How often? Session length? Over what period of time?
- ☐ Yes
- ☐ No _____

11. Have you ever practised mindfulness? If Yes, How often? Session length? Over what period of time?
- ☐ Yes
- ☐ No _____

12. Do you currently practise meditation? If Yes, How often? Session length? Over what period of time?
- ☐ Yes
- ☐ No _____

13. Have you ever practised meditation? If Yes, How often? Session length? Over what period of time?
- ☐ Yes
- ☐ No _____

14. Are you currently practising yoga? If Yes, How often? Over what period of time?
- ☐ Yes
- ☐ No _____

15. Have you ever practised yoga? If Yes, How often? Over what period of time?
- ☐ Yes
- ☐ No _____

16. Availability: Please specify what days/times/dates you prefer for the lab sessions?
- ☐ Mondays
- ☐ Tuesdays
- ☐ Wednesdays
- ☐ Thursdays
- ☐ Fridays
- ☐ Saturdays
- ☐ Sundays

- ☐ AM Session
- ☐ PM Session

- ☐ I am available to start next week

- ☐ I am available to start from: _____

- ☐ The dates I prefer are: _____

- ☐ I am not available during: _____

Please save this form and send back to amy.granberg@gmail.com

THANK YOU!

MASSEY UNIVERSITY
TE KUNENGA KI PŪREHUROA
UNIVERSITY OF NEW ZEALAND

Appendix E: Experimental protocol instructions

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Experimental Protocol Instructions

Participants in the study are required to attend 2x 1hr sessions spaced 7 days apart. They will be assessed using both physiological and psychological measures pre- and post- training to measure perceived stress, mindfulness and emotion regulation.

Step 1.

Session 1: Informed consent and demographic questionnaire

On the first session in the lab participants were required to complete written informed consent and a demographic questionnaire, which will act as a secondary screen for exclusion criteria.

Step 2. Psychophysiology set up and baseline recording

Electromyography (EMG) sensors are placed on the face to detect the electrical activity that results from muscle activation. Electrocardiography (ECG) sensors are placed under the clavicle and on the abdomen to record parasympathetic nervous system activity.

Set up computers

1. Turn on Eprime and Physiology computers. Eprime (right screen) controls the experiment and connects to the testing both (no user name or password). Turn on Biopac box (left).
2. Physiology (left screen) requires Login: **** and Password: ****
3. "Acknowledge 4.2" = <YES>
4. Open template = (.a file)
5. Save as (.acq file)

Prepare EMG electrodes

1. Remove one side of round sticker, centre electrode onto the sticker and place on side of desk. Hold electrode end not the wire end to prevent damage.
2. Place gel in syringe ensuring no air bubbles. Place syringe into the base of the electrode and squeeze sufficient gel to create a meniscus over the sticker. Take care to eliminate air bubbles

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Prepare participant and electrode sites

1. Inform the participant about placing EMG electrodes and their face. Ask if the participant is comfortable with this protocol before proceeding.
2. Direct the participant to the bathroom to wash their brow and left cheek using the facial cleanser provided.
3. Inform participant that their eyes may sting a little from the alcohol vapour, so they may wish to close their eyes before cleansing skin.
4. Clean areas of face where electrodes will be placed with alcohol swaps so that the optimal level of electrode to skin adhesion is achieved (Refer to electrode placement).
5. Rub a small amount of gel using a pointed cotton bud onto the area of the face where the electrodes will be placed.

Note. *Right* refers to experimenters right while facing the participant.

Placement of EMG electrodes

Place 7 prepared electrodes in the following order (Refer to picture 1 below). Each electrode should be pressed on firmly and smoothed out from centre to edge in a sweeping motion to secure attachment. Hold round electrode, not wires.

1. *Ground* = border of hair line centre upper brow
2. *Corrugator supercilli*:
   - Lower = Top of the nose at the base of right eye brow
   - Upper = Above right of lower (Close to sticker but not touching)
3. *Frontalis*:
   - Lower = Centre line of brow above *Upper Corrugator*
   - Upper = Centred above *Lower Frontalis*
4. *Zygomaticus major*
   - Lower = Right cheek, below jaw bone
   - Upper = Above right of lower, following line jaw bone
5. Ask participant to hold the wires

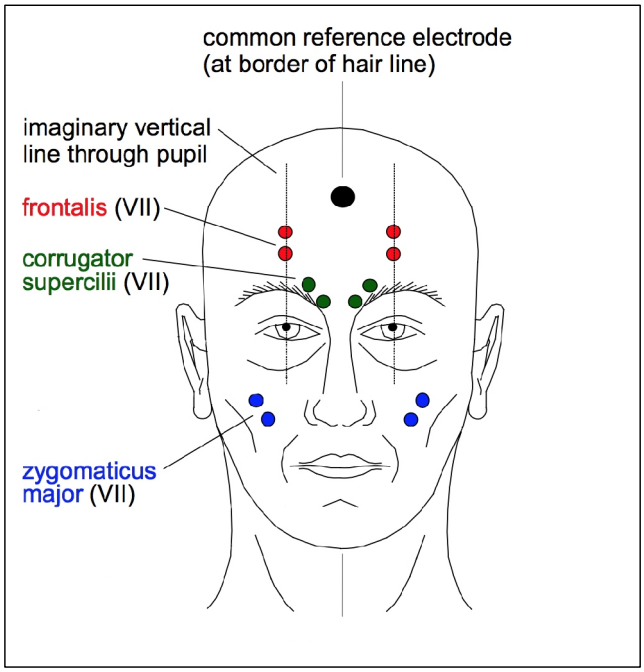

Figure 1. Electrode placement. Adapted from van Boxel, 2010.

Placement of ECG electrodes

1. Inform the participant about ECG electrodes and show on your body where they will be placed. Ask if the participant is comfortable with this protocol before proceeding. Ask if they would prefer to place the stickers and electrodes on themselves.
2. First electrode site = Under left clavicle
3. Second electrode site = Lower right from umbilicus
4. Attach or ask participant to attach clamps

   White = Clavicle

   Red = Abdomen

Record baseline measures

1. The participant will be directed to the testing booth.
2. Attach electrode plugs to sockets (refer to figure 2 below)
3. <Start> 5 mins
4. Check recordings are accurate

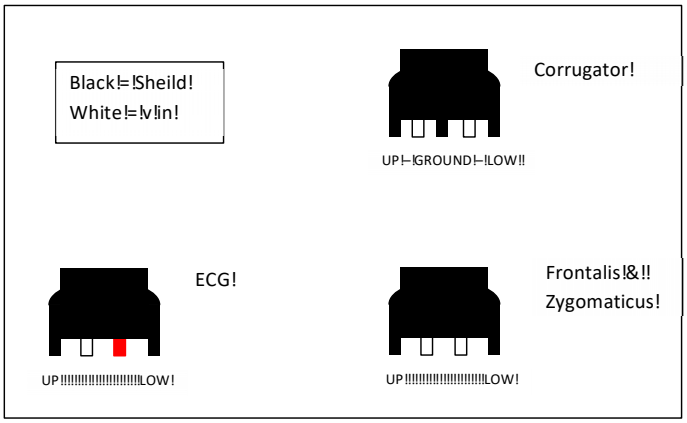

Figure 2. Electrode attachment protocols.

Step 3. Self-report questionnaires

Participants will be asked to fill in self-report questionnaires to assess mindfulness (FMI, FFMQ), perceived stress (PSS), emotion (RDEES, PANAS) and workload (WQ).

Step 4. Emotion stroop task

1. Direct participant to the emotion stroop task on the computer.
2. The participant will be asked to hit the appropriate colour key, as fast as possible, to indicate the ink colour of either the neural words (Neutral condition) or the emotional words (Emotional condition). One practice block (10 words) will be used at the beginning of the task.

Step 5. Emotion induction exercise, Subjective Affective Manikin (SAM)

The participant will listen to four stories developed to induce mild fear or mild anger. Randomised to

- *Session 1:* Set A *Session 2:* Set B
- *Session 1:* Set B *Session 2:* Set A

After listening to each audio clip, the participant will be directed to record their subjective emotional responses using the non-verbal response scale SAM.

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Step 6. Maximal muscle contraction

At the conclusion of the session the participant will be asked to give an exaggerated expression to record their maximal muscle contraction.

1. Frown or anger = Corrugator
2. Fear = Frontalis
3. Smile = Zygomaticus

Step 7. Remove electrodes – Safety check

1. Unplug the electrodes from the sockets
2. Ask the participant to come out to the testing booth.
3. Explain to the participant that removing the electrodes may pull a bit but should not hurt.
4. Pull the ECG stickers firmly and rapidly to remove. Do not pull on electrode wires.
5. Ask the participant if they are distressed by the stories and offer to conduct a brief relaxation exercise.

Step 8. Treatment protocols or debrief

Session 1: Treatment protocols

Each participant will be set up with their app ready so they can begin as soon as they leave

1. Group One – Mindfulness app set up, information sheet and task sheet.
2. Group Two – List app set up, information sheet and task sheet.

Session 2: Debrief

The experimenter will debrief the participant about the protocols in the study and offer to provide the participant with results from the study if they choose to leave their email address.

1. Group One – Debrief and information sheet.
2. Group Two – Debrief, information sheet and mindfulness app set up.

Appendix F: Freiburg Mindfulness Inventory (FMI)

Identifying number: _____ Date: ___/___/ 15

Freiburg Mindfulness Inventory

The purpose of this inventory is to characterise your experience of mindfulness. Please use the **last 7 days** as the time frame to consider each item. Provide an answer for every statement as best you can. Please answer as honestly and spontaneously as possible. There are neither 'right' nor 'wrong' answers, nor 'good' or 'bad' responses. What is important to us is your own personal experience.

1 =	**2=**	**3 =**	**4 =**
Rarely	**Occasionally**	**Fairly often**	**Almost always**

1.	I am open to the experience of the present moment	1 2 3 4
2.	I sense my body, whether eating, cooking, cleaning or talking.	1 2 3 4
3.	When I notice an absence of mind, I gently return to the experience of the here and now.	1 2 3 4
4.	I am able to appreciate myself.	1 2 3 4
5.	I pay attention to what's behind my actions.	1 2 3 4
6.	I see my mistakes and difficulties without judging them.	1 2 3 4
7.	I feel connected to my experience in the here-and-now.	1 2 3 4
8.	I accept unpleasant experiences.	1 2 3 4
9.	I am friendly to myself when things go wrong.	1 2 3 4
10.	I watch my feelings without getting lost in them.	1 2 3 4
11.	In difficult situations, I can pause without immediately reacting.	1 2 3 4
12.	I experience moments of inner peace and ease, even when things get hectic and stressful.	1 2 3 4
13.	I am impatient with myself and with others.	1 2 3 4
14.	I am able to smile when I notice how I sometimes make life difficult.	1 2 3 4

Appendix G: Five Facet Mindfulness Questionnaire (FFMQ-24)

Identifying number: _____ Date: ___/___/ 15

Five Facet Mindfulness Questionnaire – 24 item

Below is a collection of statements about your everyday experience. Using the 1–5 scale below, please indicate, using the numbers to right the right of each statement, how frequently or infrequently you have had each experience in the **last 7 days**. Please answer according to what really reflects your experience rather than what you think your experience should be.

1 =	**2 =**	**3 =**	**4 =**	**5 =**
Never or very rarely true	**Not often true**	**sometimes true sometimes not true**	**often true**	**very often or always true**

1.	I'm good at finding the words to describe my feelings	1 2 3 4 5
2.	I can easily put my beliefs, opinions, and expectations into words	1 2 3 4 5
3.	I watch my feelings without getting carried away by them	1 2 3 4 5
4.	I tell myself that I shouldn't be feeling the way I'm feeling	1 2 3 4 5
5.	It's hard for me to find the words to describe what I'm thinking	1 2 3 4 5
6.	I pay attention to physical experiences, such as the wind in my hair or sun on my face	1 2 3 4 5
7.	I make judgements about whether my thoughts are good or bad.	1 2 3 4 5
8.	I find it difficult to stay focused on what's happening in the present moment	1 2 3 4 5
9.	When I have distressing thoughts or images, I don't let myself be carried away by them	1 2 3 4 5
10.	Generally, I pay attention to sounds, such as clocks ticking, birds chirping, or cars passing	1 2 3 4 5
11.	When I feel something in my body, it's hard for me to find the right words to describe it	1 2 3 4 5
12.	It seems I am "running on automatic" without much awareness of what I'm doing	1 2 3 4 5
13.	When I have distressing thoughts or images, I feel calm soon after	1 2 3 4 5
14.	I tell myself I shouldn't be thinking the way I'm thinking	1 2 3 4 5
15.	I notice the smells and aromas of things	1 2 3 4 5
16.	Even when I'm feeling upset, I can find a way to put it into words	1 2 3 4 5
17.	I rush through activities without really being attentive to them	1 2 3 4 5
18.	Usually when I have distressing thoughts or images I can just notice them without reacting	1 2 3 4 5
19.	I think some of my emotions are bad or inappropriate and I shouldn't feel them	1 2 3 4 5
20.	I notice visual elements in art or nature, such as colours, shapes, textures, or patterns or light and shadow	1 2 3 4 5
21.	When I have distressing thoughts or images, I just notice them and let them go	1 2 3 4 5
22.	I do jobs or tasks automatically without being aware of what I'm doing	1 2 3 4 5
23.	I find myself doing things without paying attention	1 2 3 4 5
24.	I disapprove of myself when I have illogical ideas	1 2 3 4 5

Appendix H: Perceived Stress Scale (PSS)

Identifying number _____ Date ___/___/ 15

(1) **Perceived Stress Scale**

The questions in this scale ask you about your feelings and thoughts during the last 7 days. In each case, you will be asked to indicate by circling how often you felt or thought a certain way.

1 =	**2=**	**3 =**	**4 =**
Never	**Almost Never**	**Fairly Often**	**Very often**

1.	In the last 7 days, how often have you been upset because of something that happened unexpectedly?	1 2 3 4
2.	In the last 7 days, how often have you felt that you were unable to control the important things in your life?	1 2 3 4
3.	In the last 7 days, how often have you felt nervous and "stressed"?	1 2 3 4
4.	In the last 7 days, how often have you felt confident about your ability to handle your personal problems?	1 2 3 4
5.	In the last 7 days, how often have you felt that things were going your way?	1 2 3 4
6.	In the last 7 days, how often have you found that you could not cope with all the things that you had to do?	1 2 3 4
7.	In the last 7 days, how often have you been able to control irritations in your life?	1 2 3 4
8.	In the last 7 days, how often have you felt that you were on top of things?	1 2 3 4
9.	In the last 7 days, how often have you been angered because of things that were outside of your control?	1 2 3 4
10.	In the last 7 days, how often have you felt difficulties were piling up so high that you could not overcome them?	1 2 3 4

Appendix I: Workload Questionnaire (WQ)

Identifying number: _____ Date: ___/___/ 15

Workload Questionnaire

This questionnaire is about the work and life pressures that you are experiencing at the present time.
For each question, think about ***the last 7 days***.

1. On the scale of 1-5 (1 being *None* and 5 being *Highest Ever*) please indicate your university workload.

1	2	3	4	5
None				Highest Ever

2. On the scale of 1-5 (1 being *None* and 5 being *Highest Ever*) please indicate your home responsibilities workload.

1	2	3	4	5
None				Highest Ever

3. On the scale of 1-5 (1 being *None* and 5 being *Highest Ever*) please indicate your work/employment workload.

1	2	3	4	5
None				Highest Ever

4. Please tick all the boxes that apply to your current status ***over the last 7 days***. Tick all that apply to you.

☐ I am studying for exams
How many exams have you been preparing for?

1	2	3	4	5

☐ I am working towards assignment deadlines
How many assignments have you been preparing?

1	2	3	4	5

☐ Mid semester break
☐ Semester break – mid year break

☐ Working full-time
☐ Working part-time or casual work
☐ Neither working part-time or fulltime

Appendix J: Range and Differentiation of Emotional Experience (RDEES)

Identifying number: _____ Date: ___/___/ 15

Range & Differentiation of Emotional Experience

For each of the items below, please indicate how well it describes you and your experiences. To do this, circle the number that best describes how much the item seems to apply to you.

	1 = Does not describe me very well	**5 = Describes me very well**
1.	I don't experience many different feelings in everyday life.	1 2 3 4 5
2.	I am aware of the different names or subtleties of a given emotion.	1 2 3 4 5
3.	I have experienced a wide range of emotions throughout my life.	1 2 3 4 5
4.	Each emotion has a very distinct and unique meaning to me.	1 2 3 4 5
5.	I usually experience a limited range of emotions.	1 2 3 4 5
6.	I tend to draw fine distinctions between similar feelings.	1 2 3 4 5
7.	I experience a wide range of emotions.	1 2 3 4 5
8.	I am aware that each emotion has a completely different meaning.	1 2 3 4 5
9.	I don't experience a variety of feelings on an everyday basis.	1 2 3 4 5
10.	If emotions are viewed as colours, I can notice even small variations within one kind of colour (emotion).	1 2 3 4 5
11.	Feeling good or bad – those terms are sufficient to describe most of my feelings in everyday life.	1 2 3 4 5
12.	I am aware of the subtle differences between feelings I have.	1 2 3 4 5
13.	I tend to experience a broad range of different feelings.	1 2 3 4 5
14.	I am good at distinguishing subtle differences in the meaning of closely related emotion words.	1 2 3 4 5

Appendix K: Positive and Negative Affect Scale (PANAS) - Last 7 days

Identifying number: _____ Date: __/__/ 15

Positive and Negative Affect Scale (PANAS)

This scale consists of a number of words that describe different feelings and emotions. Read each item and then circle the appropriate answer next to that word. Indicate to what extent you felt this way over the **last 7 days**.

Use the following scale to record your answers.
(1) = Very slightly or not at all
(2) = A little
(3) = Moderately
(4) = Quite a bit
(5) = Extremely

	Very slightly or not at all	A little	Moderately	Quite a bit	Extremely
1. Interested	1	2	3	4	5
2. Distressed	1	2	3	4	5
3. Excited	1	2	3	4	5
4. Upset	1	2	3	4	5
5. Strong	1	2	3	4	5
6. Guilty	1	2	3	4	5
7. Scared	1	2	3	4	5
8. Hostile	1	2	3	4	5
9. Enthusiastic	1	2	3	4	5
10. Proud	1	2	3	4	5
11. Irritable	1	2	3	4	5
12. Alert	1	2	3	4	5
13. Ashamed	1	2	3	4	5
14. Inspired	1	2	3	4	5
15. Nervous	1	2	3	4	5
16. Determined	1	2	3	4	5
17. Attentive	1	2	3	4	5
18. Jittery	1	2	3	4	5
19. Active	1	2	3	4	5
20. Afraid	1	2	3	4	5

Appendix L: Positive and Negative Affect Scale (PANAS) - Right now

Identifying number: _____ Date: ___/___/ 15

Positive and Negative Affect Scale (PANAS)

This scale consists of a number of words that describe different feelings and emotions. Read each item and then circle the appropriate answer next to that word. Indicate to what extent you feel this way **right now**.

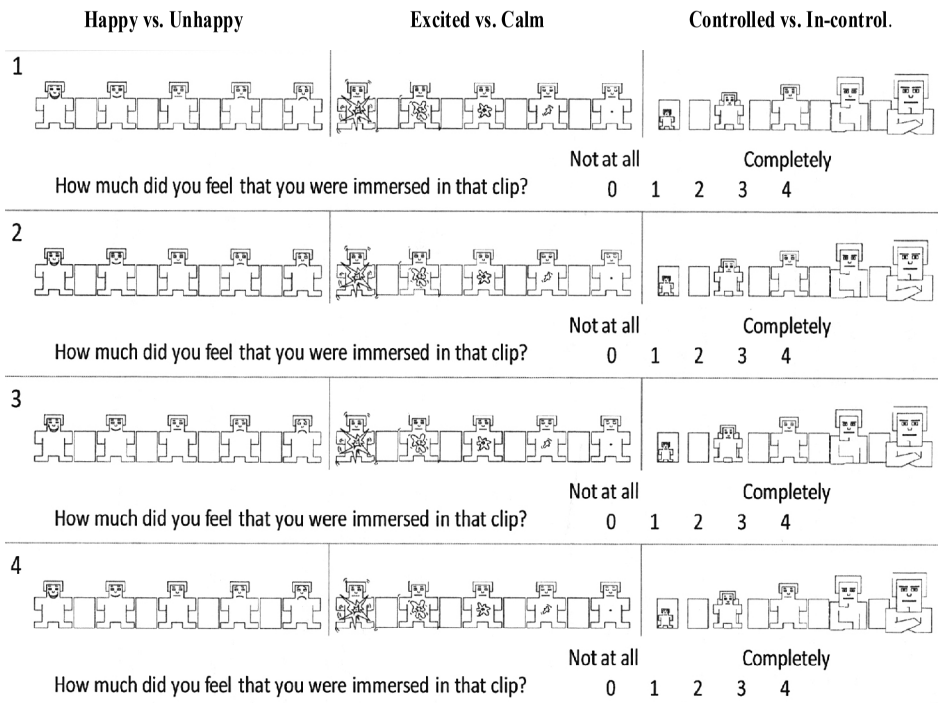
Use the following scale to record your answers.
(1) = Very slightly or not at all
(2) = A little
(3) = Moderately
(4) = Quite a bit
(5) = Extremely

	Very slightly or not at all	A little	Moderately	Quite a bit	Extremely
1. Interested	1	2	3	4	5
2. Distressed	1	2	3	4	5
3. Excited	1	2	3	4	5
4. Upset	1	2	3	4	5
5. Strong	1	2	3	4	5
6. Guilty	1	2	3	4	5
7. Scared	1	2	3	4	5
8. Hostile	1	2	3	4	5
9. Enthusiastic	1	2	3	4	5
10. Proud	1	2	3	4	5
11. Irritable	1	2	3	4	5
12. Alert	1	2	3	4	5
13. Ashamed	1	2	3	4	5
14. Inspired	1	2	3	4	5
15. Nervous	1	2	3	4	5
16. Determined	1	2	3	4	5
17. Attentive	1	2	3	4	5
18. Jittery	1	2	3	4	5
19. Active	1	2	3	4	5
20. Afraid	1	2	3	4	5

Identifying number: ____ Date: __/__/15

SAM Questionnaire

After each story you rate *HOW YOU FELT WHILE YOU WERE LISTENING TO THE STORY* by placing an X on each group of feelings.



Appendix N: SAM instructions

SAM INSTRUCTIONS

You are now going to listen to 4 stories. After each story you rate *HOW YOU FELT WHILE YOU WERE LISTENING TO THE STORY*. The rating should reflect your immediate personal experience, and no more.

This sheet, shows three rating scales for each story.

On the 1st one you rate how **Happy or Unhappy**, you felt during the story.

- If you felt completely ***happy*****,** *pleased, satisfied, contented or hopeful,* while listening to the story, you would place a cross through this figure on the left here.
- If you felt completely ***unhappy****, annoyed, unsatisfied, melancholic or bored,* while listening to the story, you would place a cross through this figure on the right here.
- The middle figure would indicate feeling neutral, neither *happy* nor *unhappy*
- The figures in between allow a range of feelings from *happy* to *unhappy*. You can place a cross either on the figure or in between the figures to demonstrate the range of your feelings

On the 2nd one you rate how **Excited vs. Calm**, you felt during the story.

- If you felt completely ***excited*****,** *stimulated, anxious, jittery or wide awake*, while listening to the story, you would place a cross through this figure on the left here.
- If you felt completely ***calm***, *relaxed, sluggish, sleepy or not aroused*, while listening to the story, you would place a cross through this figure on the right here.
- If you are *not at all excited nor at all calm*, place a cross through the figure in the middle of the row
- Again, if you wish to make a more finely tuned rating of how *excited or calm* you feel, place an 'X' in the spaces *between* the pictures.

On the 3rd one you rate how **Controlled** vs. **In-control**, you felt during the story.

- If you felt completely ***controlled***, *influenced, awed, submissive, or guided*, while listening to the story, you would place a cross through this figure on the left here.
- If you felt completely ***controlling***, *influential, in control, dominant or autonomous*, while listening to the story, you would place a cross through this figure on the right here.
- Note that when the figure is large, you feel important and influential, and when the figure is small you feel *controlled and guided*.
- If you feel *neither in control nor controlled* cross the middle
- Remember you can also represent your feelings by placing a cross in the spaces between pictures.

Finally, after each story, rate how **immersed** you were in the clip.

- This is about how much you were absorbed by the content of the story or how "real" the story felt to you.
- If you felt that you were completely ***unabsorbed****, separate, or uninvolved* in the story then you would circle "0" here.
- If you felt completely ***immersed****, absorbed, or involved* then circle "4" here.

Appendix O: Story scripts set A

Story Set A

Flatmates (anger)

You live in shared flat with three other people. You get on well with one of them – Jo, but you have never clicked with the other two. They are very close and have a group of friends who have always seemed a bit rude and dismissive of you and Jo. Also, the two of them don't seem to have any respect for your property, and have often borrowed your things without asking, some of which you are still waiting to get back from them. One weekend Jo goes home for a few days. When you return home on Sunday night after a night out with some friends, you find a party in full swing. Your flatmates didn't tell you they were planning this. You don't recognise anyone there, and as you walk through the door a drunk man crashes into you and then says "this is a private party". You try to tell him it's your flat, but he doesn't seem to care. You move round him and walk towards your room. When you open your door the first thing you notice is that one of your posters is hanging torn from the wall. It was a present from a friend and you had really liked it. You look down and see your new laptop lying on the floor, with the corner bashed in. Your bed has clearly been slept in, and there are jackets lying on it. You know it will do no good talking to your flatmates now, so you lock the door and take a look at your laptop. Sure enough it seems to be broken. You take the jackets out into the corridor and leave them by the front door. As you put them down, two girls say "hey, that's my jacket, don't just dump it on the floor". You put them down on the floor anyway, and they say something rude to you that you don't catch. You go back to your room and change the sheets on your bed. You decide to try to get some sleep. Just as you are drifting off despite the shouts outside, someone puts on loud music in the next room. You bang on the wall, but this just makes them turn it up louder. You lie there, unable to sleep, knowing that you have a class at 9am the next morning. When it gets to 1.30am you go through to your flatmates and ask them to turn the music down. They are pretty drunk and just ignore you. You ask them again. One of them starts laughing. You go over and turn the music down yourself, and go back to bed. Five minutes later the music comes on again, louder than ever.

Group project (anger)

You have been working very hard on a group project for several days. The deadline for handing it in is this coming Monday. Today is Sunday and you are going to meet up with the other two at your place for the final clean-up. They have not put much effort in the project so far, forcing you to do most of the work. From the beginning, you were the one who had to go to the library to check out all material; some of it was not always immediately available, so you had to spend time reserving various books, and you even had to buy some with your own money. You had to make all the decisions regarding the structure of the project, and you organized all the meetings with the others. Sometimes doing all this work meant you had to postpone or even cancel other important commitments. The other group members did not seem to appreciate your efforts, and every time you met up together they mainly relied on you for making progress on the project. You ended up writing most of the text and doing most of the research for it.
In preparation for the last meeting you gave bits of the draft to each of them, and asked them to read them carefully, to check out the grammar, spelling, references, and to add some of their own considerations. Now you are waiting at your place for them to show up, and they are already late. Half an hour later, no one has shown up yet. At some point the phone rings; it is one of them, who, sounding quite drunk, tells you that he has a hangover and cannot come to the meeting. He puts down the phone without even apologizing. You wait another 30 minutes and then call up the other group member. Her mobile rings for a long time and when she finally answers, she sounds surprised. She is out on a weekend trip and had completely forgotten about the meeting. She wishes you good luck with the final preparation, and hangs up.

Exam panic (fear)

You are just about to start the final examinations for your University course. Your marks have been ok so far but you know you need to do well in these exams to get you the grade you need. You have done quite a bit of preparation, but not as much as some people you know, and for the first exam you have taken the risk of not revising one topic in the expectation that two of the areas you have revised will come up. On the morning of the exam you go to the examination room along with the rest of your year. You file in silently, and take your seat. You sit for what seems like ages, staring at the back of the exam paper. Eventually the examiner says that you can turn over your exam paper. You turn over the paper, and immediately see that one of the compulsory questions is on the area you did not revise. You quickly read the other compulsory question, and find it is one you have revised, however you know that you have to answer both. You decide to tackle the one you can answer first. As you write, your mind keeps returning to the other question, and wondering how on earth you are going to answer it. You know that half the marks for that paper depend upon your answer to it, and your grade for this paper is already on the borderline. Because you are distracted you do not answer the current question as well or as quickly as you wanted to. A little after half way through the exam you finish your first answer and turn your attention to the second question. You wrack your brains for everything you can remember about the topic and manage to come up with a few concepts. However the detail is very sketchy and you are aware that there are large chunks of the topic that you just cannot recall. You try to sketch out a plan for your answer, but it is pretty weak. You look round the room – everyone seems to be writing furiously. By now it is two thirds of the way through the exam time. You think stretching your legs quickly might help so you indicate that you have to go to the toilets. On the way back, you notice that one of your friends is on to his second answer booklet so has clearly written a lot. You sit down and pick up your pen, but you do not feel any more able to answer the question than five minutes ago. You look at the time and see that you have 20 minutes left to write an answer that should take an hour.

Accident (fear)

Your two best friends from school, Chris and Jay, are coming to visit you for the weekend and you are really looking forward to it. They are due to arrive at 7 on Friday evening, and one of them, Chris, is going to pick up Jay, who lives half-way between the two of you. It's winter so it's dark by 5.30 and the weather is terrible, with high winds and rain. On the radio you hear that there has been a multiple pile up on the road between Chris and Jay's houses. The thought that Jay could be involved flashes through your mind, but you dismiss it. You tidy the flat, and get ready to go out – you're planning to get some food out together tonight. At 6 the phone rings. It's Jay, saying that Chris was due an hour ago but has not arrived, and that calls get diverted to voicemail immediately. You both know that this is not like Chris, who is usually on time and would generally call otherwise. You tell Jay about the accident. Neither of you says anything for a moment, and then Jay says "Well, he's probably stuck in traffic". What you do not say to each other, is that Chris has been really stressed recently, and had a minor car accident a few weeks ago that you think was because of stress. In fact because of this Jay had suggested taking the train instead of driving tonight, but Chris insisted on driving. 20 minutes later Jay rings again, having spoken to a colleague of Chris's who confirms that Chris left work on time to go and meet Jay. Neither of you know what to do next, so you agree to speak again at 7. You keep the radio on, but there is no further news about the accident. By 7, there is still no word from either of them. You call Jay, who tells you that there has been nothing from Chris. You try calling Chris, but it goes through to voicemail immediately. At 7.30 you call Jay to say that you think you should call Chris's parents. You try them, but their phone is engaged. You ring back 5 minutes later, but it is still engaged. You let Jay know, then check your email, but there are no messages from Chris. You spend the next few minutes on the internet, answering other messages and trying to keep yourself occupied. At around 8 an announcement about the accident comes on the radio. It tells you that five people were killed, including a family of four and another person in a second car. Four more people have been seriously injured. The report also says that traffic has been moving freely for the past hour. You start to think that you should call the hospital nearest to the accident, and you reach for the phone directory. Suddenly the phone rings.

Appendix P: Story script set B

Story Set B

Arrogant TA (anger)

You go to collect your latest essay from the person who marked it. He is a new graduate assistant who has a reputation for being arrogant. You worked really hard on the essay because you want to get a good mark and you think this module is one you are particularly good at. You pick up your essay, and find that you have been given a very low mark. This seems strange as you usually do very well in this module. Also you and your friends read over each others' essays this time, and they seemed very impressed with yours. You quickly look at the feedback sheet, but there is nothing written on it. You decide to speak to the marker to find out more. You ask him why you were given such a poor mark. He gives you a patronising look and says "because it wasn't very good". You ask him whether he could give you more specific feedback, and he replies that he doesn't have time to teach students how to write. You explain that you have always received good marks on this module before, and so you are surprised with this low mark. You tell him it would really help if he gave you some hints to help you do better next time. He sighs and rolls his eyes, then takes your essay and flicks through impatiently. "Look, you just don't know how to use commas" he says, pointing to one example. You ask him where the comma should have been, and what he suggests seems totally incorrect. He turns the page, then says "and here, you spell the name of this person incorrectly". These seem like very minor errors and do not seem to justify such a low mark. You ask him how you could improve the content and he says "it's all about answering the question" but does not tell you how you failed to do this. You get the sense that he has not even read your essay. He looks at his watch and says "we can't just give better marks to students who make the most fuss" then tells you he has an important meeting and that you have to leave. You email the paper coordinator, but she is away at a conference. Eventually she replies to your message, just to tell you it is up to the marker to give you feedback. You email the marker twice to ask for feedback, but he just ignores your messages.

Faulty bicycle (anger)

Your old bike recently broke down, and you have just bought a new one from a recommended store. It was more expensive than you would have liked it, but the salesman assured you that it is an excellent make, well worth the money. The first time you ride it to university, however, most of the gears keep skipping. The university is on a hill, and you have to get off the bike and push it up the hill because the gear is just not working properly. In the afternoon you bring the bike back to the store, where they are rude to you and imply that you did not handle the bike properly. You have to leave the bike with them for a whole week, and in the meantime you are forced to take the bus, which takes twice as long and is quite expensive. As you get the bike back everything seems to work ok. You ride to university, and park the bike in front of the library. It rains during the day, and when you set out to cycle back home, the seat is so drenched that you cannot dry it properly. In addition, the brakes do not work very well when the wheels are wet; so although most of the road home is downhill, again you have to get off the bike and push it, this time to avoid picking up too much speed. As you get home you are late, wet, and cold.

The next day you go back to the bike store to buy a waterproof seat cover, and to get the brakes fixed. Of course they only have expensive covers for the make of your bike, and you complain that given the high price you paid in the first place you should not have to buy this kind of accessory. They reply with a mocking attitude that you are supposed to keep the bike dry anyway. You point out that not all bike racks are sheltered, and they just reiterate that the bike you bought is an expensive bike which is not supposed to be parked outdoors. As a solution, they suggest, you may want to buy a full-bike cover for only 190 dollars! At this point you demand to have the bike replaced with another one more suitable to your needs. Even though you have used your bike only twice so far, apparently this is not possible. With a grin, the salesman tells you that if you really do not want that bike, he can buy it back from you for half its original price…

In the bush (fear)

You decide to go walking in the bush to explore an old trail. It's a cloudy day, and just an hour after you start walking, the clouds get lower and you are quickly surrounded by fog. You cannot see more than a metre ahead of you, and you have to rely on your map and compass. You continue slowly and carefully, making sure your steps are steady. It is very silent and you only hear the sound of your steps on the grass. Suddenly you hear a barking dog in the distance—hard to say how far—followed by a long howl. The howl continues for a while, interrupted every now and then by the dog's bark. Then silence falls again, this time even deeper. After 20 more minutes, you come across a low, old wall stone. You try to figure out how long it is, but the fog is too thick. You squint your eyes to see as far as you can, and in the mist you begin to detect the edge of some tall immobile shapes. A cold breeze picks up, and the fog gets thinner for a few seconds, long enough to reveal a group of very old stones organized in a circle. One of the smaller shapes starts to move… as it approaches you, you see that it's a huge wild boar. It stares at you for what feels like a very long time. You turn and run into the bush again and find yourself in thick fog again. You have lost orientation and you call out loud to see whether there's anyone else around, but you only hear the echo of your voice. You keep walking in what you can guess is the right direction, and just as you think you may be approaching a village, you reach a fast flowing river. You can't see a way to cross the river, so you have to follow it. The edges are rough and the ground is full of holes so you have to proceed very slowly. As you are trying to figure out how to cross the river, suddenly the sound of a building storm fills the air. You call out again, but all you hear are the roaring of the wind in the impenetrable thickness of the fog.

Shark attack (fear)

You are on holiday on a beautiful island famous for its marine life. One day you and a friend hire a small boat and take it round the coast to do some snorkelling. You anchor the boat in a quiet cove and both set off snorkelling nearby. After a few minutes you become aware of a dark shadow moving quickly somewhere to your left. You spin your head round and see a fin slicing through the water. It is about 30 feet away and moving parallel to you and your friend. You know that the fact the fin is out of the water all of the time means it is a shark. You call out to your friend, who is about 20 feet away, but her head is underwater and she cannot hear you. The fin keeps on moving, arking round so that it seems that the shark is circling you and your friend. You look over to the boat, but the way that the shark is heading means that it will be between you and the boat before you could reach it. You don't know what to do, whether to keep still and hope the shark does not know you are there, or whether to swim to your friend to warn her. Just then you see the shark's fin turn in the water so that it is pointing towards your friend. There is a pause, and then the shark starts to move towards your friend very fast. You scream out to your friend to warn her, but she does not hear. The shark is much closer to her than you are so you know you will not get to her before it does. The fin moves quickly towards her and suddenly water churns up around her and there is a terrible scream. Pulling off your mask you see that the water around her is a dark, churning red. You call to your friend, but she keeps screaming. The look on her face, and the sound she is making, is awful. You try to put your feet on the sea bed but it's too deep and your head slips under. You fight your way to the surface again to see your friend's body disappear under the water, and there is silence. You see the dark shape moving away in the water. You look around, but you are completely alone: there is no-one around, and no-one seems to have heard. The water where your friend was is dark red, and there is no sign of her. You look around again, and from the other direction you see another fin moving towards you. This time it's not circling but is coming directly for you, moving very fast. Frantically you swim towards your boat, but it's too far away and you know you will not reach it in time.

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Appendix Q: Mindfulness daily record

Daily Mindfulness Checklist

Please complete a minimum of 20 minutes mindfulness practice per day using the Mindfulness app. The first day is prescribed for you. After that you are free to use the app as you wish. The 20 minutes may be broken up into smaller 2x10 minutes, but ensure you complete a total of 20 minutes each day. You may use the app as often as you wish.

Explore the [**Begin] Check In** function that assesses your mood and recommends an appropriate meditation, or use the **[List of Meditations]** to choose your favourite ones each day. Please complete this checklist each day and bring this sheet with you to your 2nd lab session.

Day	Mindfulness Meditation i.e., Body Scan	Time spent
1	[Learn to Meditate] The Basics [Learn to Meditate] How it works [Learn to Meditate] Practice! Mindful Breathing Body Scan	 10 Mins 10 Mins
2		
3		
4		
5		
6		
7		

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Appendix R: Active control daily record

Cognitive Organisation Task

Please complete 5-10 minutes a day using the App. Each day, use the App to create a list of what you did on the same day a week prior.

In the spaces provided, please note down time spent using the App.

Day	Organisation Task	Time spent
1	Lab Session: Introduction	5 Mins
	Day 1 List: What I did on this day last week	10 Mins
2	Day 2 List: What I did on this day last week	
3	Day 3 List: What I did on this day last week	
4	Day 4 List: What I did on this day last week	
5	Day 5 List: What I did on this day last week	
6	Day 6 List: What I did on this day last week	
7	Day 7 List: What I did on this day last week	

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Appendix S: Mindfulness app debrief sheet

Identifying number _____ Date ___/___/ 15 !

Mindfulness App Debrief Sheet

The questions in this scale ask you about your experience using the Mindfulness App ***over the last 7 days***.
In each case, please indicate by circling your response.

1 = Strongly Agree	**2 = Agree**	**3 = Neutral**	**4 = Disagree**	**5 = Strongly Disagree**

1. Did you enjoy using the Mindfulness App?	1 2 3 4 5
2. Did you find this App easy to use?	1 2 3 4 5
3. Did you find using this App helpful for managing your stress?	1 2 3 4 5
4. Did this App increase your understanding of mindfulness practice?	1 2 3 4 5
5. Did this App help you to develop your own mindfulness practice?	1 2 3 4 5
6. Did you like the voice on the App?	1 2 3 4 5
7. Did you like the content of the mindfulness meditations in this app?	1 2 3 4 5
8. Did you want more information about mindfulness practice?	1 2 3 4 5
9. Would you recommend this App to a friend?	1 2 3 4 5
10. Will you keep using this App?	1 2 3 4 5

Please complete the other side of this page…..

! !
!

11. What did you **LIKE** about this App?

_____ _____

_____ _____

12. What did you **NOT LIKE** about this App?

_____ _____

_____ _____

13. What would you **CHANGE** about this App?

_____ _____

_____ _____

14. Have you used any other Mindfulness Apps? Please specify:

_____ _____

_____ _____

15. How would you rate this App? Please circle:

1 =	**2 =**	**3 =**	**4 =**	**5 =**
Strongly Like	**Like**	**Neutral**	**Dislike**	**Strongly Dislike**

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Appendix T: Active control debrief sheet

Identifying number _____ Date ___/___/ 15

Organisation App Debrief Sheet

The questions in this scale ask you about your experience using the Mindfulness App over the ***last 7 days***. In each case, please indicate by circling your response.

1 =	**2 =**	**3 =**	**4 =**	**5 =**
Strongly Agree	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**

1. Did you enjoy using this App?	1 2 3 4 5
2. Did you find this App easy to use?	1 2 3 4 5
3. Did you find using this App helpful for managing your stress?	1 2 3 4 5
4. Did you find using this App helpful for managing your time?	1 2 3 4 5
5. Did you find using this App improved your mental recall?	1 2 3 4 5
6. Will you keep using this App?	1 2 3 4 5

Appendix U: Guided imagery relaxation script

Guided imagery relaxation script

If you feel comfortable, close your eyes. Now imagine that you are somewhere you find deeply peaceful and safe. This might be outside, for example on a beach or in woodland, or indoors somewhere. Imagine it as if you are really there now. As you look around you, notice what you can see. Notice the colours and the shapes, and how the light is. Notice what you can hear – are the sounds near or far, quiet or loud? Notice what you can smell. Be aware of how it feels in your body to be in the place. Notice the temperature, and the pressure on your body from where you are sitting, standing or lying. Notice the sensations you feel against your skin. Now be aware of how being in this place is making you feel inside. Feel a sense of peace and safety as you stay in this place. If any unwanted thoughts come up, just let them slide away, and return to the peace and safety of this place. Feel your body relax, from your feet, through your legs, to your stomach and chest, through your arms and hands, and up through your neck. Feel your face and scalp relax. Allow your breathing to become soft and regular, letting the tension leave your body with each out breath. Keep noticing the sights, sounds and smells of this peaceful place.

When you are ready, gradually bring yourself back to the room, knowing that you will take this sense of peace and calm with you for the rest of the day. When you are ready, open your eyes.

Appendix V: Internship case study

ABSTRACT

This case study was completed during the authors 2016 internship at Comprehensive Care, Waitemata PHO. This review introduces mobile health innovations and their potential impact on the practice of psychological assessment and treatment. An outline of mindfulness and acceptance based approaches is presented, followed by a review of the current evidence investigating the use of mobile health apps in the acquisition of mindfulness skills and reduction in psychological distress. Included in this review are the preliminary results from the author's ongoing doctoral research examining the affect of a mindfulness smartphone app on measures of perceived stress and emotion regulation. Results from this review were presented to the Waitemata PHO with clinical relevance to the development of a mobile health app to complement the acquisition of mindfulness, acceptance and emotion regulation skills in conjunction with a 13 week Managing Mood group run at the organisation.

REVIEW ARTICLE

MOBILE HEALTH & PSYCHOLOGY

What is Mobile health?

Mobile health has been broadly defined as 'healthcare to anyone, anytime, and anywhere that removes locational and temporal constraints while increasing both the coverage and the quality of healthcare' (Varshney, 2014). Mobile health applications (apps) refer to programs on smart devices (phones, tablets, computers) for targeted delivery of interventions aimed at improving psychological or physical well-being (Jones & Moffitt, 2016). Mobile phones have become appealing for the delivery of health interventions because they are widespread, people tend to have them on their person at most times, and they have advancing technical capabilities that can facilitate different personalised functions (Klasnja & Pratt, 2012).

Mobile phone health apps are currently being developed and made available direct to consumers via app stores. Health-related apps are among the fastest growing app categories (Englehart, 2012). The availability of smart phone apps related to psychological health is rapidly growing. It was estimated that there are more than 13,600 health apps intended for use in Apple's App Store (Donker et al., 2013). Of the estimated 9,000 consumer health apps currently available, approximately 6% are targeted mental health outcomes, while 18% focussed on related health issues; 11% to stress management, 4% to sleep and 2%, to smoking cessation (Donker et al., 2013; Morris & Aguilera, 2012). In a year long study of smartphone users, people spent on average 30 hours a month using apps, which amounted to 2000 app launches per month and 142 apps downloaded per year (Kortum & Sorber, 2015).

The Future of Smartphone Psychology

It is predicted that the future of psychological practice will be linked with smartphone use to enhance psychological services (Miller, 2012). With increasing user dependency, mobile phones have the potential to influence psychological practice and research. Several authors suggest that smartphones will challenge existing methodologies and transform the delivery of psychological interventions (Howells et al., 2014; G. Miller, 2012). Their affordability and near ubiquity makes them a cost-effect means of targeting interventions to wide audiences and to complement the practice of psychological assessment and treatment. In a survey among the Australian general public, 76% of those surveyed indicated they would be interested in using mobile phones for the monitoring and self-management of depression, anxiety, and stress as long as privacy and security provisions are assured, the program is intuitive and easy to use, and the feedback is clear (Proudfoot et al., 2010).

Global sales of smartphones have more than tripled since 2009 (Plaza et al., 2013), by the end of 2016, it is estimated that 2 billion smartphones will be in use (Kortum & Sorber, 2015). By 2025, a projected 8 billion people worldwide will use smartphones (Miller, 2012). With advancing technologies, the smartphones of the future will have far greater capabilities, including better connectivity, sensor options and computing power offering a vast array of functionality. Currently, smartphones have already replaced a large number of other devices creating an unprecedented user dependency.

Technology is adopted when it has a high-perceived usefulness and is also viewed as being easy to use (Kortum & Sorber, 2015). Elements of portability, ubiquity, low cost, and the availability of large numbers of specialised apps make smartphone technology attractive to the user. Mobiles phones have taken on greater emotional and practical significance in people's lives (Morris & Aguilera, 2012). The integration of social networking, wearable and embedded sensors, photography, and other diverse applications, have transformed the mobile phone into a platform for self-expression, social learning, and role exploration. The emotional bond people experience with their smartphones has been described in popular culture and research (Morris & Aguilera, 2012). Some authors have reported that at the neuronal level, people respond to the iPhone sound as they do to a loved one, and that the phone may be experienced as an extension of the self (Morris & Aguilera, 2012). For many, the mobile phone has become an inescapable requirement of modern life. Leaving home without one can cause stress and a sense of social isolation. The strong attachment many users feel towards their mobile phones is evidenced by the numerous checks per day a person makes on their phone. It is estimated that on average people check their phones every 6.5 minutes, or 150 times per day (Howells, Ivtzan, & Eiroa-Orosa, 2016).

Given the high user dependency, perceived usefulness and technological capabilities, mobile phones have the potential to enhance psychological practice. Clinicians can make use of mobile technologies in a variety of ways including; psycho-education prior to treatment, guided practice and acquisition of skills learned in therapy, as well individualised tracking of mood and outcome ratings, homework and feedback. Approaches that utilise mobile health apps to deliver psychological services may become increasingly necessary as the demand for services becomes increasingly difficult to meet via the traditional model of individual level therapy (Kazdin & Blase, 2011).

Interventions in this format are considerably less costly than traditional psychological interventions and therefore may be made available to more mental health consumers (Howells et al., 2014). Delivery of psychological services via smartphone apps may reduce the stigma associated with mental health care and lower barriers to seeking treatment (Morris & Aguilera, 2012). Smartphones are portable, so content can be accessed in any geographical location or situational context (Chittaro & Vianello, 2016; Plaza, Demarzo, Herrera-Mercadel, & Garcia-Campayo, 2013). In addition, using a phone does not attract attention, so users can engage in the content without fear of judgement or stigma (Ly et al., 2014).

Mobile health apps could be utilised in numerous ways to enhance psychological practice and client learning. Daily tracking systems enable users to input and keep track of subjective mood and outcome ratings. An app can keep track of hours of sleep, anxiety levels, and medication use and can generate reports that could be sent to a family member, or a clinician. In the context of therapy, these assessments can be shared with the treating clinician, tracked over time, and presented in a useful visual display to characterise treatment outcome. Clinicians may provide therapeutic skills training, such as mindfulness techniques, for continued practice of skills outside session. Interactive or adaptive virtual training tools using audio or visual instruction could coach skill rehearsal to ensure successful skill acquisition. It is also possible for physiological variables to be monitored by an app that incorporates reinforcement for increased relaxation or behavioural activation.

MINDFULNESS AND ACCEPTANCE

Mindfulness-Based Approaches

Existing research suggests that engagement in mindfulness-based interventions in various formats is associated with reduced stress (Chiesa & Serretti, 2009), reduction in psychological distress (J. J. Miller et al., 1995), and demonstrated improvement in positive affect (Howells et al., 2014) in both clinical (Chiesa & Serretti, 2011; Hofmann et al., 2010) and non-clinical populations (Chiesa & Serretti, 2009). Mindfulness techniques have been shown to elicit beneficial effects on a number of psychological and stress-related symptoms and have been incorporated into numerous therapeutic approaches with positive results (Holzel, Lazar, Gard, & Schuman-Olivier, 2011; Keng, Smoski, & Robins, 2011). Validated mindfulness-based approaches include; Mindfulness-Based Stress Reduction (MBSR; Kabat-Zinn, 1982), Dialectical Behavioural Therapy (DBT; Linehan & Heard, 1992), Acceptance Commitment Therapy (ACT; Hayes, Strosahl, & Wilson, 1999) and Mindfulness-Based Cognitive Therapy (MBCT; Segal, Williams, & Teasdale, 2002).

Large amounts of empirical evidence has accrued to support the efficacy of mindfulness-based treatments for a variety of mental health difficulties (Keng et al., 2011). A recent review of empirical studies concluded that mindfulness practice can bring about various positive psychological effects including increased subjective well-being, reduced

psychological distress, and improved behavioural and emotional regulation (Nyunt, Lim, Yap, & Ng, 2012). MBSR has a focus on stress, pain and illness and has demonstrated numerous improvements across diverse clinical and non-clinical populations (Kabat-Zinn, 2003b; Kabat-Zinn, Lipworth, & Burney, 1985; Kabat-Zinn et al., 1992). The MBCT approach uses both cognitive therapy with mindfulness techniques. Recent systematic reviews of MBCT in randomised controlled trials support MBCT as a method for improving anxiety and depression (Coelho, Canter, & Ernst, 2013; Fjorback, Arendt, Ornbol, Fink, & Walach, 2011; Galante, Iribarren, & Pearce, 2013; Metcalf & Dimidjian, 2014; Segal, Williams, & Teasdale, 2013). In MBSR and MBCT participants learn to foster mindfulness in their lives through mindful practices and guided meditations including; the body scan, mindfulness of the breath, sounds and thoughts, mindful movement, and mindfulness of everyday activities (Cavanagh, Strauss, Forder, & Jones, 2014).

ACT is a trans-diagnostic approach that focuses on increasing psychological flexibility by emphasising mindfulness, acceptance, and values-based committed action (Räsänen, Lappalainen, Muotka, Tolvanen, & Lappalainen, 2016). The psychological flexibility model underlying ACT provides a unified model of behaviour change (Hayes, Pistorello, & Levin, 2012). In ACT, rather than changing or disputing negative thoughts, clients are taught to defuse from them using mindfulness and acceptance techniques that promote the process of disentanglement (Hayes, Strosahl, & Wilson, 2012). Instead of seeking to reduce uncomfortable emotions and sensations, clients are encouraged to mindfully accept these experiences with an emphasis on living in accordance with personal values (Hallis, Cameli, Dionne, & Knäuper, 2016). Support for the ACT model has been shown to have positive outcomes across a broad range of psychological problems (A-Tjak et al., 2015). The American Psychological Association has stated that ACT has modest research support for treating depression (American-Psychological-Association, 2016; Hallis et al., 2016).

Cultivating Mindfulness Skills

The construct of mindfulness has its roots in ancient Buddhist practices, and over the last 4 decades it has become integrated into western medical and psychological research literature. Kabat-Zinn (2003) has defined mindfulness as ‘the awareness that emerges through paying attention on purpose, in the present moment, and nonjudgmentally to the unfolding of experience moment by moment’ (Kabat-Zinn, 2003a). Bringing mindful attention to the

present moment experience in an attitude of openness and acceptance, is thought to enable individuals to engage in more adaptive coping behaviours in response to life's circumstances (Cavanagh et al., 2014). Through mindfulness awareness, it may become easier to disrupt unhelpful patterns of responding, and instead develop greater acceptance of one's internal experience that in turn, mediates behaviour (Crescentini, Urgesi, Campanella, Eleopra, & Fabbro, 2014)

Although mindfulness is conceptualised in varied ways, most authors agree that mindfulness involves directing attention to the present moment with a general attitude of openness and acceptance, and with an ability to describe or label the experience (Reese, Zielinski, & Veilleux, 2015). Mindfulness training often begins with tasks in concentration, whereby participants learn to restrict their attention to a specific focus (such as the breath) and repeatedly return their attention to this focus if they become distracted (Lykins, Baer, & Gottlob, 2012). After some degree of attentional control is attained, mindfulness training proceeds to receptive practices involving non-judgmental observation of all sensations, thoughts and feelings as they naturally arise (Lykins et al., 2012). A central component of mindfulness known as decentering involves perceiving thoughts and emotions as transient experiences, rather than enduring reflections of the self (Safran & Segal, 1996 as cited in Chittaro & Vianello, 2016). Research suggests that learning the technique of decentering may help reduce negative affect and distress (Hoge et al., 2015).

Mindfulness-based therapies promote the development of greater awareness and acceptance of emotions rather than an attempt to change or moderate the emotional experience (Corcoran, Farb, Anderson, & Sega, 2010). In an attempt to regulate difficult emotions, people can use strategies such as thought suppression and cognitive or behavioural avoidance (Desrosiers, Vine, Klemanski, & Nolen-Hoeksema, 2013). The labelling of experience in mindful practice fosters a simple acknowledgement of the experience. Rather than getting caught up in elaborative thought processes about one's experience and the implications, mindfulness involves a direct experience of events in the mind and body (Bishop et al., 2004). It is hypothesised that mindfulness practice permits a decentered awareness, or spacious quality of attention to thoughts and emotions, that may reduce the tendency to be routinely caught up in or attached to certain cognitions or emotions (Chambers, Gullone, & Allen, 2009). By encouraging observation of thoughts, feelings and sensations as they arise, and noting any tendency to judge, mindfulness cultivates positive reappraisal through which stressful events

or difficult internal experiences are reframed as beneficial, meaningful, or benign (Chambers et al., 2009; Holzel et al., 2011).

MINDFULNESS MOBILE HEALTH

Self-directed and Online Mindfulness Training

As the literature grows, different approaches to mindfulness training have emerged. A recent systematic review and meta-analysis of mindfulness-based interventions found that self-instructed mindfulness can result in reductions in depression and anxiety and increase in dispositional mindfulness (Cavanagh et al., 2014). The review reported effects of internet-based interventions, books, and audio recordings designed to promote mindfulness and acceptance. The researchers found no studies regarding singular use of computer or phone apps for mindfulness-based training. Their review concluded that irrespective of intervention approach format, medium to large effect sizes were found.

Studies investigating the efficacy of delivering mindfulness-based treatments online have demonstrated benefits for various health issues including; stress management (Aikens et al., 2014; Ljotsson et al., 2011; Morledge et al., 2013), and depression (Dimidjian et al., 2014; Thompson et al., 2010). In the first published randomised controlled trial (RCT) of MBCT self-help, a recent study tested the efficacy of an 8-week self-help version of MBCT in a student sample (Taylor, Strauss, Cavanagh, & Jones, 2014). The authors reported significant benefits in the self-help group compared to the waitlist control on measures of depression, anxiety, and stress symptom severity.

Recent studies have begun to investigate the effectiveness of ACT-based interventions using self-directed internet-delivered formats with some positive trends (Lappalainen et al., 2014; Lappalainen, Langrial, Oinas-Kukkonen, Tolvanen, & Lappalainen, 2015; Räsänen et al., 2016). One study tested the effectiveness of an online self-help ACT intervention compared with a face-to-face ACT intervention for depressive symptoms (Lappalainen et al., 2014). Participants (n60) were randomised to a 6-week internet program (iACT) or face-to face treatment. The iACT treatment group received access to an ACT-based internet program (*The Good Compass*) and supportive web-based contact over a period of 6 weeks. The face-to-face group received ACT-based treatment once a week over the same period of time. The internet

program *The Good Compass* consisted of six modules, and each week's module was allocated to one of the process; Creative hopelessness and Values, Values-based actions, Contact with the present moment, Cognitive Defusion, Self as Context, and Acceptance. In both groups, the results showed a significant effect on depression symptomatology, and general wellbeing after treatment and at the 18- month follow-up. There was a tendency for a slightly better recovery in the iACT group. The authors concluded that guided online ACT interventions can be as effective as ACT-based face-to-face treatment for outpatients reporting depressive symptoms. The authors suggested that the self-directed online program may offer some advantages over a face-to-face intervention. Participants in the iACT group reported having taken responsibility for their own wellbeing and becoming independent from the therapist. In addition, the internet program allowed access anytime to the site to conduct exercises and rehearse the content if they had not understood it for the first time and needed more time to reflect on it. Given the study design did not include a control group, no definitive conclusions can be made from the results.

Building on their earlier study, the authors replicated their results in similar study to provide to test whether brief online ACT interventions, continued to have a benefit after the cessation of the treatment (Lappalainen et al., 2015). The online ACT-based intervention (*The Good Compass*) over 6 weeks combined with weekly therapist feedback demonstrated a positive impact on depressive symptoms, psychological flexibility, and mindfulness skills. The study indicates that different aspects of psychological flexibility can be targeted and improved through a relatively short internet-based ACT treatment without any face-to-face contact. The authors concluded that brief online ACT interventions are potentially useful as an early-stage intervention for people suffering from depressive symptoms.

Mindfulness-based mobile apps

Mobile phone apps represent a potential opportunity to deliver cost-effective health based interventions to a wide audience. The usability and ubiquity of mobile devices has made them a promising target in the delivery of health interventions (Plaza, Demarzo, Herrera-Mercadal, & Garcia-Campayo, 2013). Mobile phone apps represent a potential opportunity to deliver cost-effective health interventions to a wide audience. Evidence supporting the use of mindfulness-based interventions in a variety of formats has prompted the development of mindfulness-based smartphone interventions. Mobile apps for mindfulness training may

support the need for regular practice and have the potential to provide individualised support for on-going skills acquisition. These approaches present mindfulness techniques in accessible, interactive and novel ways, that may be particularly attractive to a younger demographic or those new to mindfulness practice. Despite widespread availability of mindfulness apps, few studies have assessed their effectiveness.

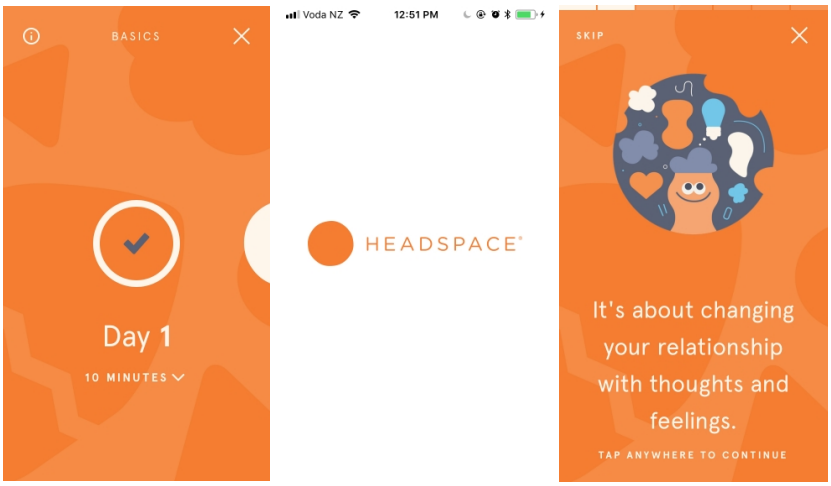

Figure 1. Screen shots of the app *Headspace* (Headspace, 2016).

Whilst research in the area is limited, preliminary evidence is beginning to emerge examining the viability of mindfulness-based mobile apps (MBMAs), with mixed results. Numerous mindfulness-based smartphone apps have been developed and are available direct to the public via the App Store. In a review of MBMAs, Plaza et al. (2013) found that 203 mindfulness-based apps were available on the market, and this number is rapidly increasing. Their review found that while there was a wide selection of MBMAs available, there was a complete lack of evidence supporting the usefulness of those applications. At the time of their review, they found no randomised controlled trials evaluating the impact of the various apps on mindfulness training or health indicators. In the first RCT investigating MBMA, Howells et al., (2016) assessed the effectiveness of the mindfulness-based smartphone app *Headspace.* Participants (n121) were randomly assigned to use either the mindfulness-based app, *Headspace*, or a control condition that used a task list app, *Catchnotes*, for 10 minutes a day for 10 days (Howells et al., 2016). The *Headspace* app provides the user with simple guided

mindfulness meditations each day to progress mindfulness practice and animated introductions to mindfulness. Screen shots from the *Headspace* app are presented in Figure 1 below.

The authors hypothesised that engaging with an empirically based mindfulness app would enhance wellbeing, and that there would be a positive correlation between task enjoyment and wellbeing. The results from the study found that participants in the mindfulness group had significant improvements in positive affect with a medium effect size, and significant decreases in depressive symptoms, with a small effect size. On both measures there were no significant differences over time for the control group. The authors detected no significant effects on negative affect, satisfaction with life, or flourishing. They concluded that their findings support the viability of a smartphone-based mindfulness intervention to significantly enhance elements of wellbeing. The authors emphasised the importance of the empirically based app content for beneficial outcomes.

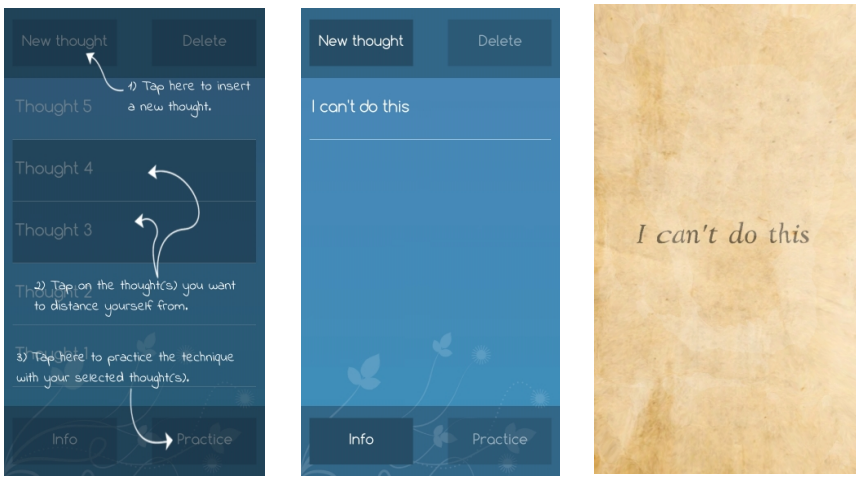

Figure 2. Screen shots of the app *Aeon (Chittaro & Vianello, 2016)*.

Chittaro and Vianello (2016) investigated the efficacy of a MBMA to teach the mindfulness technique, *decentering*. Participants (n136), 120 new to mindfulness and 16 experienced meditators were enrolled in the study by downloading the app, *Aeon*. Participants agreed to engage with the mindfulness-based app for 4-weeks and complete a series of self-report

measures at various stages. The app *Aeon* was designed to evoke the sensation that each thought is impermanent to help users achieve decentering. The interactive thought distancing app, allowed participants to type in a thought and watch it disappear. The authors reported that, after 2-weeks using the app, participants reported significantly higher decentering scores compared to baseline. After 4-weeks, scores had increased significantly yet again. Qualitative feedback provided by participants indicated that the app was positively perceived as beautiful and its usage elicited positive affect for most participants. Screenshots of the *Aeon* app are shown in Figure 2. A control group was not used in the study, so no causal connections can be drawn about the effect of the intervention per se.

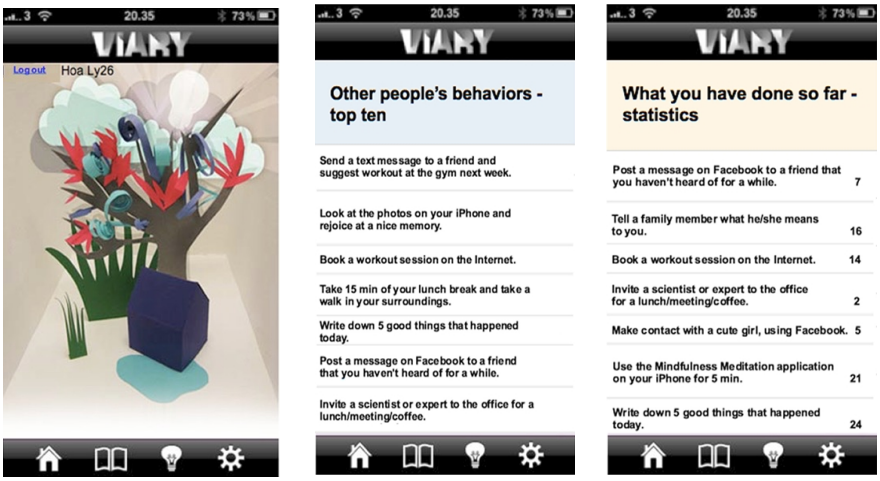

Figure 3. Screen shots of the app *Viary* (Ly, Dahl, Carlbring, & Anderson, 2012).

In an exploratory study, Ly et al. (2014) compared the effectiveness of an ACT-based smartphone app. The intervention employed a combination of an ACT-based smartphone-application and web-based psychoeducation as a self-help intervention for living consistently with one's values (Ly et al., 2012). The *Viary* app is shown in Figure 3. The *Viary* app allows users to track valued action in various life domains. The study used a quasi-experimental pre-test/post-test design without a control group. Eleven participants were enrolled in the study and randomly assigned to use either the mindfulness-based app or the behavioural activation app for 8 weeks. The group analyses showed that the participants increased their valued action and psychological flexibility significantly during the intervention. The qualitative questionnaire showed a general positive experience of the intervention. Due to the quasi-

experimental design of the study, no certain conclusions can by drawn, but the positive trend indicates the intervention may have a therapeutic benefit.

In a later study, Ly et al., (2014) evaluated and compared the effectiveness of two smartphone delivered treatments for mild to moderate major depression. Participants (n81) were randomly assigned to use either a mindfulness-based app (n41) or a behavioural activation based app (n40) for a period of 8 weeks with minimal therapist contact (maximum of 20 min per week, per participant). The mindfulness intervention consisted of a short web-based psychoeducation, and a step-by-step mindfulness practice programme, administered via a smartphone application. The mindfulness-based app's content included guided and unguided mindfulness exercises, and theory. The behavioural activation app was used to record behaviours to increase behaviour activation. Figure 4 presents a screenshot of the application.

Figure 4. Screenshot of the Mindfulness application (the native version) (Ly et al., 2014).

The authors reported the two smartphone interventions did not differ significantly. Large reductions in depression after both interventions were reported, that continued at 6 months follow up. When the sample was analysed according to depression severity, the behavioural analysis based app was more effective in reducing depression ratings for participants with more severe depression, whereas, for participants with less severe depression, the mindfulness-based app was more effective in reducing scores. The study was underpowered

and did not have a waitlisted control group. Despite the limitations, the authors concluded that the results of their study might indicate that the smartphone format used in this study could work well for a depressed population and may be effective in helping those with mild psychological problems. They cautioned the need for more studies investigating the samrphone format are necessary before any conclusions can be drawn.

Carissoli et al. (2015) conducted a RCT to evaluate the feasibility of an 18-day mindfulness-based mobile app intervention to improve the response to stress in a non-clinical adult sample (Carissoli, Villani, & Riva, 2015). Using a pragmatic trial approach the intervention tested the effectiveness of a brief self-help intervention under real life routine conditions. The final sample included 55 non-clinical participants randomised to three conditions: 1) an experimental condition that engaged in the mindfulness-based smartphone app; 2) an active control group that listened to music; 3) a waitlisted control group. Stress was measured by a questionnaire and with a psychophysiological measure: heart beats per minute (BPM). The mindfulness-based app *It's Time to Relax* was used twice a day to listen to 15 minute guided mindfulness exercises. Figure 5 shows screenshots from the app. Both thought distancing and mindful breathing exercises were included in the app.

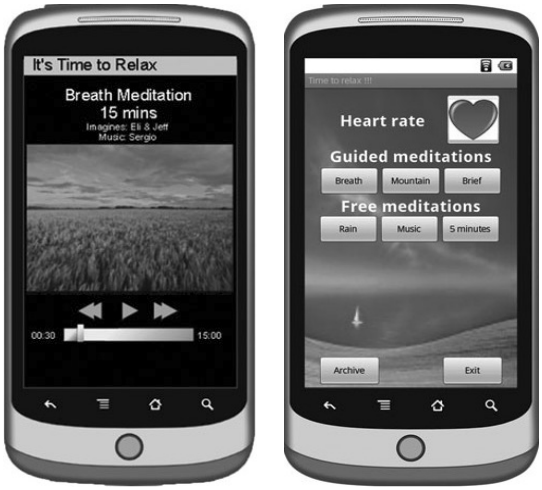

Figure 5. Screenshots of the app *It's Time to Relax* (Carissoli et al., 2015).

The results did not show any significant differences between groups, but both self-help intervention groups demonstrated an improvement in coping with stress and decrease in average heartbeats per minute after each session. The authors cited the small sample size and short duration of the intervention as limitations to their study. They suggest that future research should include psychophysiological sensors integrated within applications to verify the efficacy of mindfulness-based mobile protocols, as well as testing the long-term effects.

In a randomised controlled trial, Granberg (2016) assessed the efficacy of brief self-directed mindfulness training in a sample of 52 university students. The mindfulness training group completed 7 days of self-directed mindfulness practice using a freely available mobile phone app *Stop Breathe and Thin).* See Figure 6 for screenshots of the application. The mindfulness group completed a minimum of 2x guided meditations per day for a minimum of 10 minutes per session. The control condition was assigned to a active control condition using a note taking app *Tick Tick* for 10 minutes a day for 7 days. Pre- and Post- physiological and psychological measures assessed mindfulness, perceived stress, and implicit and explicit emotion regulation. It was hypothesised that the mindfulness training condition would be associated with reductions in measures of perceived stress and emotion reactivity and an increase in mindfulness. The study is ongoing and the psychophysiological variables and emotion regulation measures have not yet been analysed.

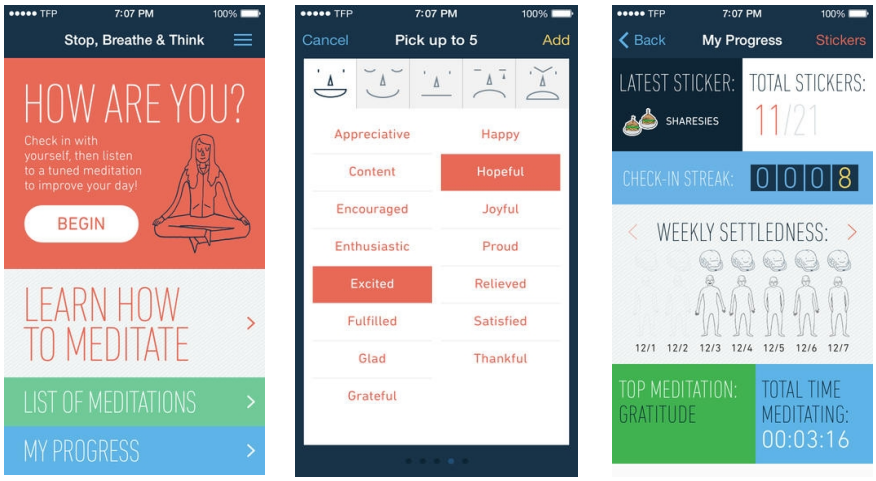

Figure 6. Screenshots of the app *Stop, Breathe and Think* (Version 2.0)(Tools for Peace, 2014).

Preliminary analysis of the self-report measures show improvements in mindfulness and a reduction in negative affect for both the mindfulness and the active control groups. Post intervention, the groups did not differ significantly on the measures of interest. On self-report measures, it was hypothesised that engagement in with the mindfulness app intervention would lead to reductions in perceived stress and negative affect, and an increase in mindfulness compared to the control. Preliminary results do not support the hypothesis. The preliminary findings prompt the consideration of whether the study's protocol, participants or intervention contributed to the unexpected results.

The length of the intervention of the study may have been a significant contributing factor in the unexpected results. No studies using an app as the method of delivery have demonstrated a benefit in less than 10 days. Howells et al (2014) demonstrated that using the mindfulness app *Headspace* can significantly improve positive affect and reduce depressive symptoms in 10 days compared to an active control condition. However, they found no effect on satisfaction with life, flourishing or negative effect and the authors proposed that the length of their study might have been too short to capture those effects. Given that *Stop, Breathe and Think* also uses empirically based formal and non-formal mindfulness exercises, it is possible that it may take longer than the parameters of this study (7 days) for the effects to occur. Carissoli et al. (2015) found that their 18-day mindfulness-based mobile app intervention did not exert the expected effects on stress and suggested that extending the length of the intervention may have led to the expected results. It is possible that the comparatively short length of the current study's intervention contributed to the lack of expected results.

Conclusion

The convenience, portability, and ubiquity of mobile phones make them an accessible resource for engagement with mindfulness-based app interventions that utilise evidenced based protocols and demonstrate good face validity and perceived usefulness. Studies investigating the effectiveness of these apps in improving various health outcomes are sparse, have several methodological limitations and have yielded mixed results. The scarcity of studies testing the efficacy of mindfulness-based apps means the feasibility and potential of this format of intervention delivery remains largely unknown. Some preliminary results from

studies suggest benefits after participant engagement in mindfulness-based smartphone apps. They have highlighted increases in positive affect (Howells et al., 2014) and mindfulness skills (Chittaro & Vianello, 2016), and reductions in depressive symptoms (Howells et al., 2014; Ly et al., 2014) and stress (Carissoli et al., 2015). There is a need for further research that examines the efficacy of mindfulness-based smartphone apps, utilising randomised controlled trials.

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