Mindfulness Meditation Training and Attention in Older Adults: An ERP Study

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Statement

I declare that this thesis is my own work and that, to the best of my knowledge and belief, it does not contain material from published sources without proper acknowledgement, nor does it contain material which has been accepted for the award of any other higher degree or graduate diploma in any university.

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Abstract

Given the current and predicted physical and financial costs of cognitive decline in older adults, considerable research attention has focussed on finding interventions effective in slowing or reversing this decline. More recently, mindfulness meditation practices, derived from Buddhist meditation techniques have been considered as possible attentional training tools. The present study examined the electrophysiological correlates of attention in healthy older adults before and after 10 weeks of mindfulness meditation training in the Vipassana tradition. A visual three-stimulus oddball paradigm was employed and accuracy and reaction time measures, as well as event related potentials (ERPs) were compared before and after the mindfulness meditation course. Mean amplitude and peak latency of ERP components P3a and P3b were measured in response to the novel and target stimuli in the oddball task respectively at the two time points. Participants were 16 healthy adults aged between 60-85 years (M = 68.13, SD = 7.22) with no previous meditation experience. Results failed to show support for the hypotheses that mindfulness training would be associated with improved performance on behavioural measures and reduced P3a and P3b amplitude and latency as elicited by the novel and target stimuli respectively. The implications of these results were considered in context of the varied results of previous work in the study of the relationship between mindfulness meditation and attention, particularly in older adults. Recommendations for future research centre on the need for rigorously conducted randomised controlled trials to further explore this relationship and the potential for mindfulness meditation to be incorporated into cognitive training programs.

Separate from the declines in cognitive domains seen in different forms of dementia, cognitive decline is also a normal consequence of ageing in otherwise healthy individuals (Epel, Daubenmier, Moskowitz, Folkman, & Blackburn, 2009; Slagter, Davidson, & Lutz, 2011). Older adults show not only general slowing of information processing, but also deteriorations in specific higher cognitive functioning. This age-related cognitive decline has been found to occur across a variety of cognitive domains, such as: episodic memory; visuo-spatial skills; and executive functioning including working memory and attention (Buckner, 2004; Hseih, Liang, & Tsai, 2011). Such declines may have a significant effect on an individual's ability to live independently and undertake various activities of daily living; and subsequently, their quality of life may decline (Wolinsky et al., 2006).

Given the current and projected increases in the number of elderly Australians (particularly over 65 years), concerns have not only been raised about the effect of such a decline in quality of life, but also regarding the financial impact that such age-related cognitive decline will continue to have (Australian Government, 2010). It is estimated that there were 266, 574 people living with dementia in Australia in 2011 and it is suggested that there are many more with cognitive impairment. This figure is projected to increase to 553, 285 people by 2030 and 942,624 people by 2050 (Access Economics, 2011). Tasmania, in particular, has shown the largest increase in median age over the past 20 years (1990-2010); including a 200% increase in the 85 years plus age group (Australian Government, 2010). Across all age groups, the number of people living with dementia in Tasmania in 2011 was 6,732 and this is projected to increase to 20,653 by the year 2050 (Access Economics, 2011). Cost estimates of the impact of cognitive decline in this ageing population vary; however, it is predicted that by 2060 spending on dementia will outstrip that of any other health condition. Total spending is projected to be $83 billion and will represent around 11% of the entire health and residential aged care sector spending (Access Economic, 2011). Previous research estimates that delaying the onset of Alzheimer's disease in individuals by five years could save up to $67.5 billion dollars by the year 2040 (Access Economics, 2007).

These concerns, combined with an increasing understanding of the neurophysiological consequences of ageing, have led to an increase in research focussing on interventions aimed at slowing cognitive decline in older adults (Slagter et al., 2011; Wolinsky et al., 2006). Much of this research has focussed on implementing and assessing the effectiveness of behavioural interventions aimed at increasing mental activity and therefore, it is argued, slowing the rate of cognitive decline in the ageing brain (see Beason-Held, Kraut, &Resnik, 2008). Research has provided mixed evidence as to the effectiveness of such behavioural interventions.

Whilst some large-scale longitudinal studies have indicated that such behavioural interventions may result in task specific learning and, consequently, slowing in specific areas of cognition, few have resulted in more than a slight improvement in any cognitive domain (Bablioni et al., 2006; Jennings, Dagenbach, Engle, &Funke, 2007; Slagter et al., 2011). Further, there are conflicting results regarding the effect of these interventions on more general cognitive functions, or of transfer of improvements into other areas of daily functioning. That is, training benefits are often stimulus or content specific rather than process specific (Slagter et al., 2011).

Accordingly, a number of researchers have suggested that providing training that is more process specific may help to overcome some of these limitations (Epel et al., 2009; Geng, Zhang, & Zhang, 2011; McHugh, Simpson, & Reed, 2010; Slagter et al., 2011). These processes, for example attention, are argued to be fundamental to a wide range of cognitive aspects and therefore contribute to performance over a wide range of cognitive tasks (Slagter et al., 2011).

Attentional processes

A strong modulator of cognition and affect, attention refers to the selective focus on specific aspects of our environment or to the concentration on specific mental thoughts and operations (Rabipor & Raz, 2012). One of the most consistent theoretical frameworks of attention suggests that it consists of three functionally distinct neural networks: sustained, selective and executive attention (Posner & Petersen, 1990). Sustained attention or vigilance, also known as alerting, refers to response readiness in preparation for an impending stimulus (Raz & Buhle, 2006). The orienting or selective attention network, on the other hand, involves selecting specific information from multiple sensory stimuli and limiting attention to this subset of possible sensory input (Rabipour & Raz, 2012). According to this model, executive attention, or divided attention or conflict monitoring, prioritises among competing thoughts and actions (Chiesa, Calati, & Serretti, 2011; Chiesa & Serretti, 2010). That is, executive attention is said to mediate voluntary control and activates in situations requiring the monitoring and resolution of conflicts, such as error detection and overcoming habitual actions. Executive attention involves processes of self-regulation that include effortful control, the ability to suppress a dominant response, as well as inhibitory control (Chiesa et al., 2011; Kozasa et al., 2012). In addition to these three subsets of attention, several other theoretical models of attention also include attention switching; the ability to shift attentional focus in a manner that is flexible and adaptive (Chiesa & Serretti, 2010).

Mindfulness meditation

Mindfulness meditation is one such cognitive training practice that is said to train and cultivate multiple aspects of attention (Bishop et al., 2004; Hodgins & Adair, 2010) and experiential acceptance (Cayoun, 2011; Chiesa et al., 2011). Whilst discrepancies exist across current operational definitions of mindfulness (Chiesa, et al., 2011), a widely accepted definition posits that mindfulness involves "paying attention in a particular way: on purpose, in the present moment, and nonjudgementally" (Kabat-Zinn, 1994, p. 4). Despite the discrepancies in operational definitions, it is widely agreed that training of attentional functioning is an essential aspect of any form of meditation practice (Chiesa & Malinowski, 2011).

Based on Eastern meditative traditions and gaining widespread popularity as a fundamental aspect of psychological intervention, the clinical benefits of mindfulness meditation are widely established (Chiesa et al., 2011; Hodgins & Adair, 2010). Studies have shown that mindfulness meditation practices result in improvements in cognitive control and emotional regulation, as well as sustained and selective attention (Bishop et al., 2004; Epel, et al., 2009; Jha, Stanley, Kiyonaga, Wong, & Gelfand, 2010; Slatger at al., 2011). Whilst traditional mindfulness meditation practices typically involve formal 'sitting' meditation, modern psychologically oriented definitions of mindfulness have been incorporated into a range of psychological interventions such as dialectical behaviour therapy (DBT; Linehan, 1993) and acceptance and commitment therapy (ACT; Hayes, Strosahl, & Wilson, 1999). Cognitive behavioural approaches have also been incorporated into more formal meditation practices in the form of group-based and individual therapeutic interventions such as mindfulness integrated cognitive behaviour therapy

(MiCBT; Cayoun, 2011) and mindfulness-based cognitive therapy (MBCT; Segal, Williams, & Teasdale, 2002).

As mentioned, discrepancies exist with regard to operational definitions of mindfulness and a thorough review of mindfulness meditation and mindfulness based practices is beyond the scope of this study. However, whilst there are numerous different ways that meditation practices have been classified, many of the more modern operational definitions of mindfulness are rooted in Buddhist meditation practices such as Vipassana and Zen meditation (for review see Chiesa & Malinowski, 2011).

In an attempt to further categorise mindfulness approaches for the purposes of research, two main meditative styles have been proposed: mindful types (or open monitoring) and concentrative types of meditation. It is argued that the way in which attentional processes are directed during meditation will determine where on the continuum between these two types the meditative technique will lie. Proponents of this classification posit that mindful approaches are characterised by open, nonjudgemental, experiential awareness of sensations and cognitions, whereas concentrative types of meditation are said to cultivate attention through the focus of attention on an object such as the breath (Cahn & Polich, 2006; Chiesa & Malinowski, 2011).

More recently, however, researchers have begun to suggest that the practice of focussed attention in mindfulness meditation, typically involving focusing on the breath, in fact precedes and compliments the experiential acceptance that is typically developed later in the practice (Chiesa & Malinowski, 2011; Epel et al., 2009). Such focussed attention is said to involve the development of attention switching and selective attention and later, as the practice develops, sustained attention. That is, mindfulness meditation practitioners typically attend to the breath, choose to disengage from any stimuli that may distract them as it arises, and return their attention to the breath (Chiesa et al., 2011; Moore, Gruber, Derose, & Malinowski, 2012). Therefore, the nonjudgemental attitude cultivated through experiential awareness of, but disengagement from, sensations and cognitions, develops as a result of and alongside the development of focussed attentional processes. This approach posits that the orienting and conflict monitoring aspects of attention are developed in this earlier focussed attention, or concentrative stage of training; followed later by development sustained attention or alerting (vigilance) processes through receptive (open monitoring) skill development (Jha, Krompinger, & Baime, 2007).

Mindfulness meditation practice. Formal mindfulness meditation practice in the Vipassana tradition, such as that practiced within Mindfulness-integrated Cognitive Behaviour Therapy (MiCBT; Cayoun, 2011), involves the cultivation of both focussed attention and nonjudgemental, experiential acceptance of experiences (known as equanimity). Instructions for the formal practice of mindfulness meditation typically entail directing attention to the experience of sensations and cognitions in the present moment with an attitude that is curious, accepting and nonjudgemental (Epel, 2009). Typically, practitioners are encouraged to adopt an upright sitting posture with eyes closed, to allow the body to relax whilst the mind remains alert. Attention is directed to an object such as the localised sensations involving the breath. As thoughts, feelings, physical sensations or other potential distractions arise, practitioners are encouraged to notice the experiences fully, but without judgement and return attention back to the intended object (the breath). The process of returning the attention to the breath following distraction is repeated throughout the initial stages of meditation practice (Cayoun, 2011; Epel, 2009).

Once practitioners have become comfortable with returning their awareness to the gross physiological sensations of the breath, the practice of body scanning is introduced. At this stage of practice, the attention is dynamically drawn to scan the body for physiological sensations. Practitioners are instructed to focus on an area of the body five to ten centimetres in diameter and nonjudgmentally notice the physical sensation there, be they salient or faint. Structured scanning of the body in this manner involves moving the attentional focus to an adjacent body part as soon as sensations are noticed. The speed and structure of this scanning technique changes as the practitioners become more advanced (see Cayoun, 2011 for detailed implementation).

Proponents of mindfulness mediation techniques argue that nonjudgemental experiential acceptance of sensations and cognitions, thought to underlie many of the therapeutic benefits of mindfulness training, must be preceded by awareness of these experiences; and body scanning techniques ultimately develop this awareness (Chiesa & Malinowski, 2011; Epel, 2009). Further, such techniques are thought to contribute to the cultivation of attentional resources.

Neurophysiology of mindfulness training. Although the study of mindfulness meditation is still in its relative infancy, research indicates that experienced meditation practitioners show changes in cortical activity, as well as significant structural changes involving both white and grey matter in a variety of neural areas compared to meditation-naïve controls (e.g., Barnhofer, Chittka, Nightingale, Visser, & Crane, 2010; Chiesa & Serretti, 2010; Epel et al., 2009; Lazar et al., 2005; Tang et al., 2010). Recent longitudinal MRI studies complement the cross-sectional outcomes by revealing increases in grey matter density as a consequence of mindfulness-based stress reduction (MBSR; Kabat-Zinn, 1994) interventions over 8 weeks, particularly in areas related to attention and response selection (Hözel et al., 2011; Luders, Toga, Lepore, &Gaser, 2009). In a study involving diffusion tensor imaging to investigate white matter integrity, Tang at al. (2012) showed enhanced white matter density following 4-weeks of a form of mindfulness training compared to 4-weeks of relaxation training.

As mindfulness is dependent on the investment, or reinvestment of attention on a moment-by-moment basis, it is posited that mindfulness training should lead to increased cognitive flexibility, or less reliance on habitual actions (Moore et al., 2012). That is, mindfulness should improve selective and executive attention processes, improving control of otherwise automatic, stimulus-driven processes. There is growing support for this position. For example, Wenk-Sormaz (2005) showed that engaging in meditative practice resulted in a reduction of interference in the widely utilized Stroop Colour-Word Interference Task (Stroop). The Stroop task is a commonly used research paradigm and improved performance on the task is indicative of improved cognitive control, increased selectivity of attention and reduced automaticity of responding (Moore et al., 2012). More recently, Moore and Malinowski (2009) found decreased Stroop interference in experienced meditators compared with non-meditators. However, a study by Anderson and colleagues failed to find an improvement of attentional functions after participation in an 8-week MBSR program as assessed by various measures of attention, attention switching and Stroop interference (Anderson, Lau, Segal, & Bishop, 2007). In another study, improvements were shown in discrimination (reduced errors of omission) on a vigilance task (Continuous Performance Task; CPT) following one month of twice-daily mindfulness meditation practice; but this enhanced attentional performance was not matched by participants who had engaged only in progressive muscle relaxation, or by a wait-list control. However, no significant difference in performance between groups was found on other performance measures on the CPT (including correct responses and reaction time to target), or on the Digit Symbol Substitution or the Stroop task (Semple, 2010).

One criticism of mindfulness meditation research is that many of the studies are cross-sectional and involve experienced mediation practitioners (Chiesa et al., 2011; Moore et al., 2012; Slatger et al., 2011). This makes it difficult to argue a causal link between mindfulness meditation and any cognitive or physiological changes that may be evident. However, a number of studies show that even moderately brief mindfulness training, such as an 8 week program may improve sustained, and particularly selective and executive attention in participants with no prior meditation experience (Chiesa et al., 2011). Also, a number of studies report significant improvement in sustained and selective attention, as measured by Stroop tasks, attentional blink tasks and auditory oddball paradigms, following mindfulness training in comparison to no treatment or relaxation conditions (Moore et al., 2012).

In another study, compared to wait-list controls, meditation retreat participants showed enhanced perceptual discrimination and vigilance on a sustained visual attention task requiring participants to discriminate between a rare short line and a standard long line. Further, these improvements were shown to be present 3 months following the retreat (Maclean et al., 2009). Another study found that relative to a non-meditating control group, participants in an intensive 10-day Vipassana mediation retreat showed significant improvement in performance measures of sustained attention (Chambers, Lo, & Allen, 2008). This research, and other studies in which participants were not engaged in formal meditation practice during the task performance, provide support for the argument that meditation training provides process specific improvements in attention (Moore et al., 2012; Slatger et al 2011). These results indicate that these improvements are not limited to the domain in which they are trained (thereby are not task specific) and further, this learning persists beyond the actual meditation practice.

Electrophysiological correlates of attention

Electroencephalogram (EEG) is a widely used neurophysiological technique that provides good temporal resolution of neurophysiological changes. This high temporal resolution, along with EEG being non-invasive and easily accessible when compared to other neurophysiological measures such as functional magnetic resonance imaging (fMRI), result in it being a commonly used measure of the electrophysiological correlates of attentional processes (Cahn & Polich, 2006; Polich, 2007). The waveforms that result from the EEG activity in response to the onset or presence of a stimulus are known as event-related potentials (ERPs). ERPs are elicited in response to the presentation, and with cognitive task processing of stimuli (Cahn &Polich, 2006).

Studies of attentional processes commonly investigate the different aspects of these ERPs. Typically, the most widely studied components of ERPs related to the cognitive processing of stimuli are a negative-going waveform elicited approximately 200ms post stimulus (N200) and the positive-going waveform elicited approximately 300ms post stimulus (P300). These waveform components are depicted in Figure 1.

It should be noted that significant discrepancies exist as to the nature and purpose of these different components of ERPs (see Polich, 2007 for review);

however exploration of varying theories is well beyond the scope of this present research. Also beyond the scope of this present research is thorough discussion regarding the numerous other ERP components related to attention. Therefore, the widely accepted categorization and nomenclature, N200 (N2) and P300 (P3; further categorised below), will be used from this point forward to discuss only those relevant to this present study and related previous research. Further, despite these theoretical discrepancies, P3 measures are considered to be a reliable assessment of cognitive capability (Polich, 2007).

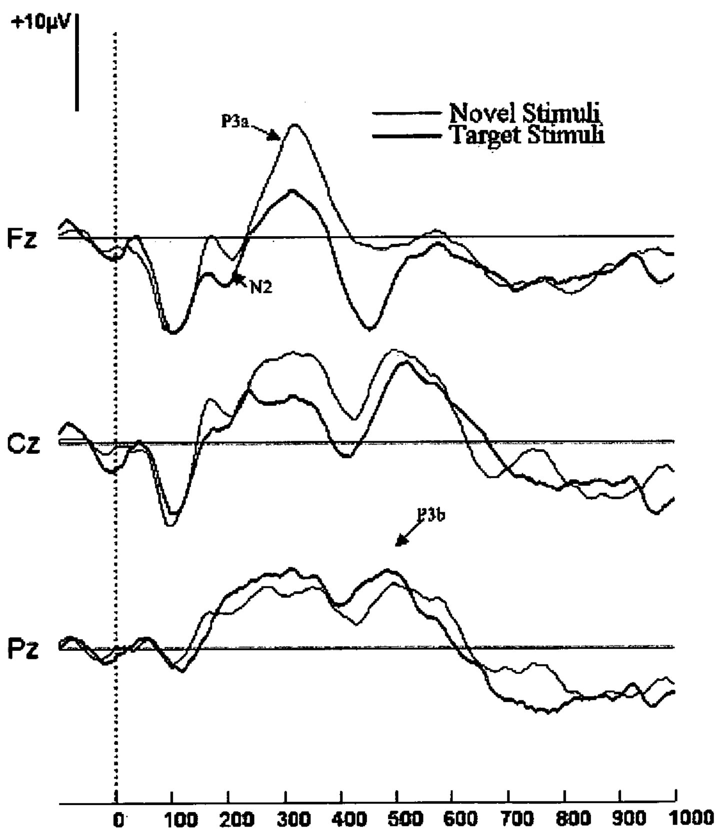

Figure 1. ERP components in response to various stimuli presentations (Segalowitz & Davies, 2004)

The ERP component N2 has been demonstrated to reflect conflict processing, attentional shifting, inhibition of motor responses, and detection of novelty or mismatched stimuli and is most typically elicited by auditory stimuli (Egner et al., 2007). On the other hand, the different P3 components of ERPs have been widely used to separate the temporal involvement of different cognitive processes and inferences about selective effects of age on specific cognitive processes are often drawn based on P3 studies (Fjell, Rosquist, & Walhovd, 2009; Polich, 2007).

The P3a and P3b components of the P3 ERP are often elicited approximately 300-800ms post-stimulus in a variety of attentional tasks, particularly oddball paradigms. The three-stimulus oddball task presents an infrequent target in a background of frequently occurring standard stimuli and infrequently occurring distracter (novel) stimuli. In this paradigm, P3a is elicited by distracter stimuli, which are rarely occurring and highly salient. P3b on the other hand, is elicited later than P3a by successful discrimination of target stimuli from frequently occurring standard stimuli. It is argued that P3a reflects involuntary and transient allocation of attention to salient changes in stimuli and to novel stimuli, whilst P3b is interpreted as being related to controlled cognitive stimulus evaluation processes (Polich, 2007).

These neurophysiological correlates are typically analysed using measures of amplitude and latency. Amplitude has been used as an index of the role of attentional resource allocation, or the cognitive demands of task processing. Latency, on the other hand, has been regarded as a measure of classification speed; or the time required to detect and evaluate a stimulus (Fjell et al., 2009). Individual differences in ERP component latency, in particular P3 latency, are correlated strongly with mental function speed, such that shorter latencies are related to superior cognitive task performance (Polich, 2007). P3 latency has been shown to increase with normal aging (Fjell & Walhovd, 2004) and component latencies also become longer as dementia increases (Polich, 2007).

ERP studies of mindfulness. Although electrophysiological evidence of the longitudinal effects of mindfulness meditation on attention is limited, studies indicate both a reduction in P3 latency as well as changes in aspects of P3 amplitude in response to auditory and visual distracter processing in experienced meditators (Chiesa & Serretti, 2010; Moore et al., 2012).

In one study that compared elderly experienced transcendental meditation practitioners with an elderly control group on auditory and visual oddball tasks, P3 latencies in response to the visual oddball task were found to be shorter in meditators compared to controls (Goddard, 1992). In another study of experienced meditation practitioners, reduced N2 amplitude was observed in response to an auditory oddball paradigm presented during meditation (Cahn & Polich, 2009). Such changes indicate a reduction in processing of distracter stimuli. A number of these studies, however, have been conducted whilst experienced meditation practitioners were meditating. One exception is the study by Slagter and colleagues (2007) in which participants were tested on an attentional blink task involving line discrimination following 3 months of intensive meditation practice. Elaborative processing of the first of two target stimuli was reduced, as indexed by reduced P3b amplitude. This reduction in elaborate processing was also linked to improved detection of the second target stimuli (Slagter et al., 2007, 2011).

A more recent study by Moore and colleagues (2012) showed a decrease in P3 amplitude in incongruent trials of a Stroop task in participants who had undergone 16 weeks of regular, brief mediation practice compared to matched controls. Whilst these improvements were not accompanied by improved behavioural performance (accuracy and reaction time), the results suggest that as attentional resources are improved, processing of incongruent or distracter stimuli becomes less demanding (Moore et al., 2012).

Mindfulness training and older adults.

Despite the increased research focus in the neural consequences of mindfulness meditation, there is little research into the effects of mindfulness training in older adults. One study investigated a range of cognitive and health related outcomes in elderly participants comparing the effect of transcendental meditation, a guided attention technique and relaxation with a non-active control group. Results indicated that, in general, transcendental meditation experience was related to improved cognitive performance on tasks of verbal fluency and Stroop interference when compared to the other experimental groups and the control (Alexander, Langer, Newman, Chandler, & Davies, 1989).

Another, more recent study by Lazar et al. (2005) used Magnetic Resonance Imaging (MRI) techniques to compare cortical thickness in elderly experienced meditation practitioners with that of elderly controls and found increased thickness in a number of cortical regions related to somatosensory, auditory, visual and interoceptive processing. However, there was no significant difference in the mean thickness across the entire cortex between the two groups, adding support for the hypothesis that the difference in cortical thickness were contributed to by the meditation practice. Further, results suggested reduced age-related thinning of specific areas of the prefrontal cortex said to be associated with executive functioning (brodmann areas 9/10) may result from regular meditation practice (Lazar et al., 2005).

Similarly, Pagnoni and Cekic (2007) utilised MRI techniques and measures of sustained visual attention to examine age-related decline of cerebral grey matter volume and attentional performance in a group of experienced Zen meditation practitioners and a group of matched control participants. Whilst the control group displayed the predicted negative correlation of both grey matter volume and attentional performance (correct target detection) with age, meditators did not show the same significant correlation of either measure with age. However, results also indicated that whilst there was a significant effect of age on reaction time, there was no significant difference in reaction time between groups (Pagnoni & Cekic, 2007).

These findings contribute to the current evidence of the effect of mindfulness meditation practices on cortical activity and cognitive functioning and suggest that there may be some benefits of these practices for older adults (Chiesa & Serretti, 2010). More specifically, mindfulness meditation potentially provides a mechanism by which more process-specific learning may occur and these improvements in process specific functions, such as attention, may lead to better generalisation of learning to a variety of cognitive domains (Slagter et al., 2011).

The cultivation of present moment awareness that occurs as a result of mindfulness meditation is argued to result in a reduction of elaborative processing of previous stimuli (Chiesa & Serretti, 2010; Moore & Malinowski, 2009; Slagter et al., 2011). This, therefore, allows an increase in attentional resources to be directed toward presenting stimuli. Furthermore, changes in neural activity and structure, particularly in the prefrontal cortex, are thought to underlie some aspects of age-related cognitive decline (e.g., Babiloni et al., 2006; Papaliagkas, Kimiskidis, Tsolaki, & Anogianakis, 2011). Therefore, the association between mindfulness meditation practices and cortical activity and structure suggest that mindfulness meditation may be a useful intervention for cognitive decline in older adults.

Present study

The current study aimed to investigate the neurophysiological correlates of attention following regular, brief mindfulness training. In order to address some of the limitations of previous research (e.g., Moore et al., 2012; Slagter et al., 2009), the current study assessed attentional processes of participants with no previous meditation experience using a visual three-stimulus oddball paradigm both before and after 10 weeks of mindfulness meditation training. As well as being a widely researched measure of sustained and selective attentional processes, the oddball paradigm consists of shapes and therefore does not involve the lexical processing of the Stroop task. A community sample of healthy older adults was recruited as participants in order to contribute to the limited body of research investigating the effect of mindfulness meditation on the attentional processes in this population.

It was hypothesised that participants would show improved accuracy and shorter reaction time on the behavioural measures of the oddball task following mindfulness training. In particular, participants would respond to more target stimuli and respond to them more rapidly.

In line with the hypothesised improvement in attentional processes, it was also hypothesised that there would be a reduction in P3 latency. In particular P3a latency in response to novel (distracter) stimuli and P3b latency in response to target stimuli following mindfulness training; suggesting a greater ability to allocate their attentional resources more quickly following mindfulness training. It was also hypothesised that there will be a reduction in P3a amplitude in response to the novel stimuli following mindfulness training. Similarly, it was hypothesised that reduced elaborate processing of the target stimuli will result in reduced P3b amplitude to target stimuli following mindfulness training.

Method

Participants

A community sample of 23 healthy older adults participated in all stages of the research. Recruitment occurred through radio and printed advertising (Appendix A) and of those who responded to the advertisements, 89 were screened for eligibility. Twenty-eight of those screened were found to meet the inclusion criteria. Of those 28 who were invited to attend an initial cognitive assessment session, 25 participated in the mindfulness meditation course. One participant did not complete the mindfulness course citing personal reasons; one participant did not attend the final EEG testing session; and data from a further seven participants were excluded from the analysis due to incomplete data, or data that were inadequate for analysis due to unacceptable levels of noise artefacts or an insufficient number of sweeps. Therefore, the final participant sample used for analysis comprised 16 adults (11 female, 5 male) aged between 60 and 85 years, with a mean age of 68.13 (*SD*=7.22) and mean average estimated full scale intelligence quotient (FSIQ) score of 111.82*(4.38).*

To ensure the absence of any medical conditions that might affect EEG measures, participants were screened for physical health history including: neurological impairment; dementia diagnosis of any kind; history of stroke or any head injury involving loss of consciousness; psychological health status; alcohol and cigarette consumption; and medication use(Appendix B). Questions regarding the participants' history of alcohol and cigarette use were included as it has been reported that those who use a substantial amount of alcohol (e.g., Courtney & Polich, 2010) and tobacco (e.g., Knott & Venables, 2007) have distinct EEG patterns compared to those who do not. All participants had normal or corrected-to-normal vision and no previous meditation experience. As this study formed part of ongoing research, to ensure consistency across all studies, all participants were reimbursed $20 for their participation in the EEG testing.

Materials

Neuropsychological testing and questionnaires. Participants were provided with an information sheet (Appendix C) and written informed consent was obtained prior to participation in the study (Appendix D). Participants were required to complete several measures of cognitive functioning; both to obtain a baseline and to ensure eligibility for participation in the study.

The Dementia Rating Scale (DRS-2) was administered to assess the participants' level of cognitive functioning and to screen for the presence of dementia. Total raw scores were converted to age and education corrected Mayo's Older Americans Normative Studies (MOANS) scale scores, with a MOANS score of nine or more indicative of intact cognitive functioning. Intact cognitive functioning based on these scores was an inclusion criteria for the current study. The Depression, Anxiety and Stress Scale (DASS) is a self-report measure used to assess recent psychological functioning (Lovibond & Lovibond, 1995) and was used to screen for the presence of elevated levels of depression, anxiety and stress. Respondents with scores above mild (z scores greater than one) on any of the three DASS scales were deemed ineligible for participation in the current study. Estimates of pre-morbid intellectual functioning, based on reading of irregular words, were obtained using the Wechsler Test of Adult Reading (WTAR; Wechsler, 2001).

EEG protocol

The EEG was recorded continuously during the three-stimulus visual oddball task using Advanced Source Analysis (ASA 4.7) software ('high-density' amplifiers, Advanced Neuro Technology, Enschede, Netherlands). The equipment contains full-band EEG DC amplifiers. The electrodes were placed in accordance with the international 10-20 system (Jasper, 1958). A total of 30 electrodes (AG/AgCl) were used for recording: Fp1, Fpz, Fp2, F7, F3, Fz, F4, F8, FC5, FC1, FC2, FC6, T7, C3, Cz, C4, T8, CP5, CP1, CP2, CP6, P7, P3, Pz, P4, P8, POz, O1, Oz, O2. The layout of these electrodes across the scalp is illustrated in Figure 2.

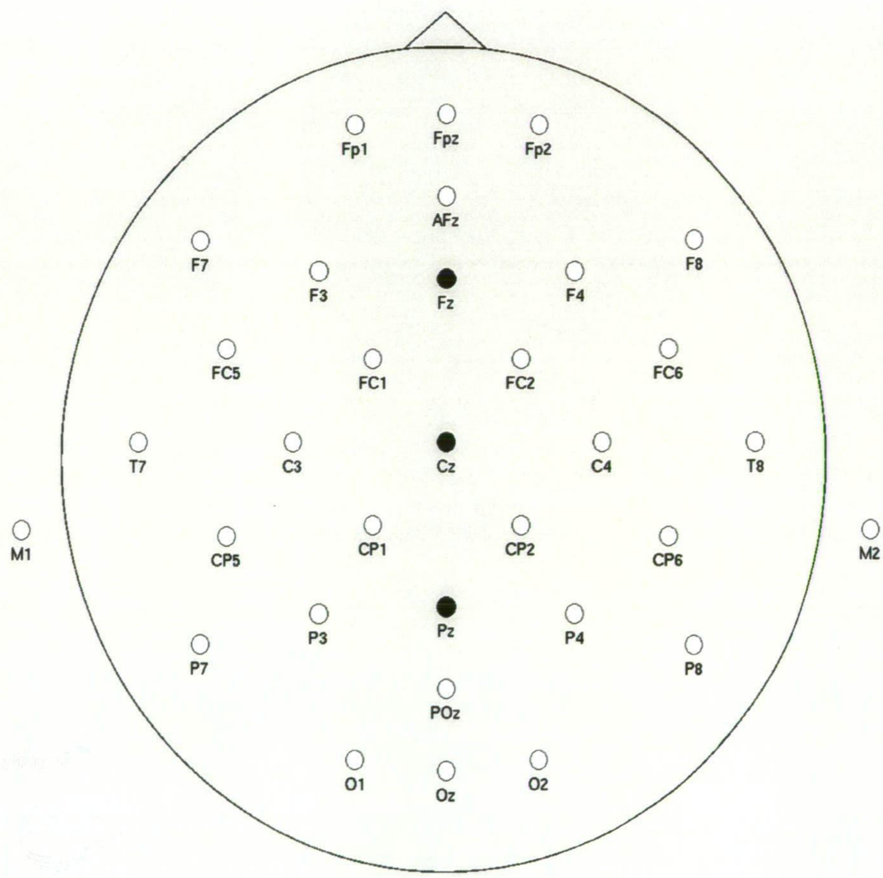

Figure 2. Schematic of electrode placement

The ground electrode was positioned on the forehead. The ANT-system uses an averaged reference for all the electrodes. Skin–electrode impedance was maintained below 10 kΩ. The data and event triggers were simultaneously and continuously sampled at 1024 Hz with a 276 Hz low-pass filter. Vertical and horizontal EOG were recorded from electrodes placed above and below the left eye and at the outer canthi of both eyes, respectively.

EEG data were edited using ASA 4.7 software. Continuous EEG files were band-pass filtered at 24 dB per octave, with a high band pass of 0.10 Hz and a low pass of 30 Hz (Butterworth (causal) filtering). Ocular artefact reduction was performed using a Principal Component Analysis (PCA) method that models the brain signal and artefact subspaces (Ille, Berg, & Scherg, 2002). High and low voltage cut-offs for artefact rejection were set at ±75 μV.

For the oddball task analysis, EEG activity was averaged offline for a 900 ms epoch commencing 100 ms prior to stimulus onset. Correct responses were baseline corrected at the pre-stimulus interval. ERPs were averaged for novel and target stimuli individually and ERP peaks were checked manually. P3a peak amplitude and latency were determined from grand mean averages and individually derived from within the intervals of 250ms – 650ms post (novel) stimulus whilst P3b amplitude and latency were similarly individually derived from within the intervals of 250ms – 800ms post (target) stimulus. Statistical analyses were confined to Fz, Cz and Pz, since the components in the oddball paradigm have been shown to be most pronounced at these sites. In particular, P3a in response to the distracter stimuli is most pronounced at the fronto-central region (particularly Fz and Cz), whilst P3b in response to the target stimuli is most pronounced parietally, at Pz (Fjell et al., 2009).

Visual three-stimulus oddball task. A visual three-stimulus oddball task involved the presentation of Common (blue circle, 10.18 cm^2), Target (larger blue circle, 15.20cm^2), and Novel (large blue square, 20 cm^2) stimuli which were randomly delivered with probabilities of .70, .15, and .15, respectively. An example of the three shapes (not to scale) is depicted in Figure 3 below. This paradigm utilising the small difference between the target and common stimuli and the large difference between target and novel stimuli has been shown to maximise P3 amplitude (Fjell & Walhovd, 2004).

All stimuli were presented for 75 ms with a stimulus-onset asynchrony (time between the onset of one stimuli and the onset of the next) of 1500ms. Participants were instructed to respond quickly and accurately to the target stimuli by pressing a response button with their right index finger and not to respond to common and novel stimuli. The response window was 1000 ms. An approximately five minute block of 200 trials was run with the block consisting of 30 target, 30 novel, and 140 standard stimuli (as per Fjell & Walhovd, 2004).

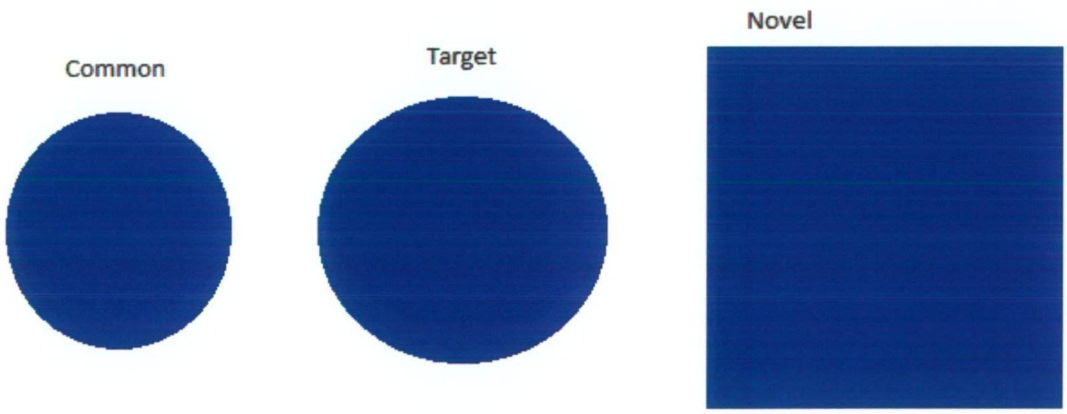

Figure 3. Schematic of oddball stimuli

Procedure

Participants attended an initial session in which they provided written informed consent to participate in the study and completed the screening and baseline assessment measures. Following this, they attended the initial EEG session. Participants were seated in front of a computer in a well-lit, sound-attenuated room and the EEG procedure was explained to them. An electrode cap was fitted and connected to the recording computer. The task was explained thoroughly to the participant, before a practice trial was administered. Following successful completion of the practice trial, the oddball task was implemented.

Participants then attended a 10-week mindfulness meditation course in the Vipassana tradition, delivered as per the of MiCBT approach (Cayoun, 2011). Participants attended the group training once a week for two hours and were asked to practice the skills they learned for one hour (twice 30 minutes) each day, assisted byaudio instructions on CDs provided by the course facilitator. The course was conducted by an experienced mindfulness meditation practitioner and trainer, aided by two assistants. In the first week, participants were first introduced to progressive muscle relaxation, which they were asked to practise for 17 minutes twice daily. In the second week, participants were introduced to the mindfulness of breath technique, which they practiced for two weeks. They learned to focus attention on a specific target (the breath), to inhibit responses to spontaneously emerging stimuli such as thoughts and body sensations, and to switch attention back to the breath as soon as possible. From the fourth week, participants were introduced to various body scanning techniques, during which attention is passed through the entire body, first in a discrete manner with 6- to 10-cm spots of attention. In later weeks, participants are gradually trained to survey progressively larger areas of the body simultaneously to, eventually, be able to feel the entire body simultaneously with a simple vertical movement of attention from the top of the head to the tip of the toes (see Cayoun, 2011, for more detail on the Vipassana methods). During the training, the rationale for each aspect of the training was clearly explained and participants were encouraged to become more aware of their present moment experience, whilst remaining non-judgemental and accepting of the nature of the experience.

Following the completion of the mindfulness training course, participants attended a follow-up EEG testing session in which they repeated the visual oddball task completed in the initial testing session.

Design and data analysis

Ethics approval for the study was obtained from the *Human Research Ethics (Tasmania) Network* (H0011939). All statistical analyses were conducted using SPSS version 20.0. Analyses were considered significant at the .05 level.

The electrode sites used in the analyses were selected in line with previous research and accepted conventions (e.g., Fjell & Walhovd, 2004; Polich, 2007) and based on visual inspection of the grand mean average waveforms.

As a result, analyses of the amplitude and latency of the P3a component of the waveform elicited in response to the novel stimuli were restricted to electrode sites Fz and Cz. Therefore, for analysis of P3a amplitude and latency, a 2[Time] x 2[Site] repeated measures design was employed. Time consisted of pre mindfulness training and post mindfulness training, whereas site comprised electrode sites Fz and Cz. For the repeated measures ANOVAs, Bonferroni adjustments were made for multiple pairwise comparisons. The partial eta square statistic (ηp^2) indexing the proportion between variance explained by one experimental factor and the total variance was calculated and reported as appropriate, with the magnitude of effect size interpreted as ≥ 0.01 = small, ≥ 0.06 = medium, and ≥ 0.14 = large (Sink & Stroh, 2006).

Analysis of the amplitude and latency of the P3b component of the waveform elicited in response to the target stimuli was restricted to electrode site Pz. Repeated measures t-tests were conducted to compare the P3b amplitude and latency at Pz before and after mindfulness training. For the t-tests, Cohen's *d* statistic was calculated, with the magnitude of effect size interpreted as 0.2 = small, 0.5 = medium and 0.8 = large.

Results

Behavioural results

Preliminary analyses were conducted on reaction times for correct responses and the number of targets correctly responded to at each time point. A summary of these behavioural results is described below in Table 1[1].

Table 1

Mean Reaction Times for Identification of Targets and Mean Number of Correct Identification of Targets

Time	Correct RT* M*(SD)*	Target % M*(SD)*
PreMT	448.35*(57.46)*	93.96*(8.45)*
PostMT	455.12*(58.21)*	95.21*(6.32)*

**RT measured in milliseconds*
Note. N = 16; M(SD) = Mean(Standard Deviation); MT = Mindfulness Training; RT = Reaction Time; Target % = Percentage (/30) of the number of targets correctly responded to

There was no significant difference between the participants' reaction time taken to respond to target shapes, $t(15) = 1.12$, $p = .281$, $d = 0.12$, before and after

[1] Analysis of the number of targets correctly responded to was made using arcsine root transformed percentage data whilst the analysis of reaction time at each time point was conducted using untransformed data. Table 1 contains untransformed data.

the mindfulness training. There was also no significant difference in the number of targets correctly identified, $t(15) = .302$, $p= .767$, $d = 0.17$, before and after the mindfulness training.

Electrophysiological data analyses

P3a in response to the novel stimuli. Visual inspection of the grand mean average waveforms in response to the novel stimuli indicates P3a activity was most pronounced in the fronto-central regions (see Figure 4). Some early widespread negativity and some earlier parietal and occipital positivity was also evident.

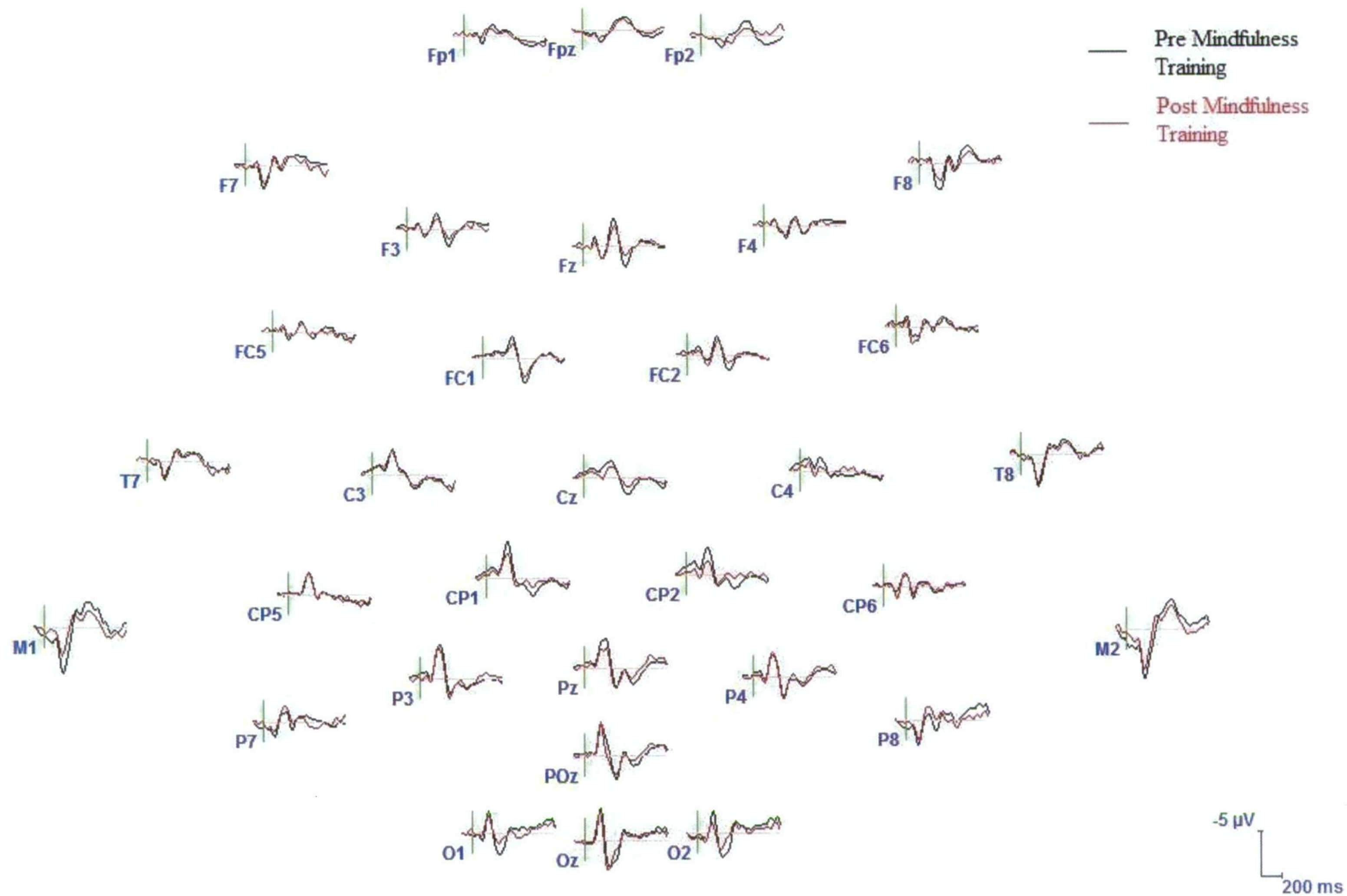

Figure 4. Grand mean average waveforms in response to novel stimuli

Given this pattern of activity over the 30 electrode sites, and line with previous research (e.g., Fjell & Walhovd, 2004; Polich, 2007), statistical analyses were restricted to P3a activity at electrode sites Fz and Cz. Figure 5 highlights this positive going waveform elicited in response to the novel stimuli (P3a) more clearly.

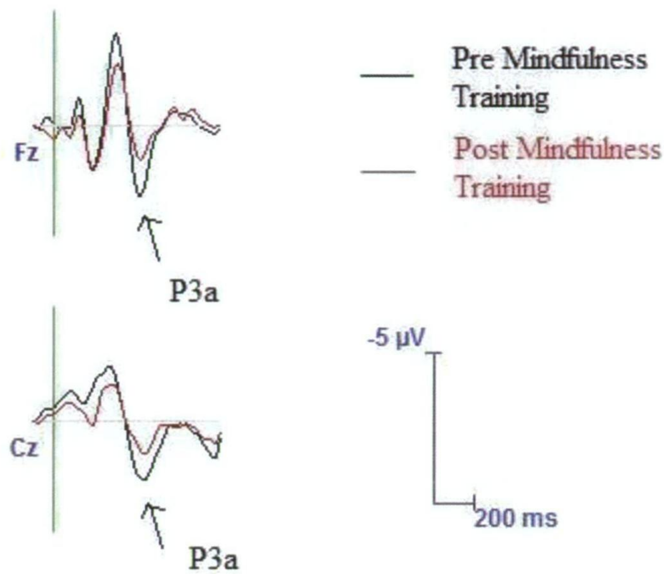

Figure 5. Grand mean average waveforms in response to novel stimuli at selected electrode sites

P3a amplitude. P3a mean peak amplitude (measured in microvaults; µV) values in response to the novel stimuli at electrode sites Fz and Cz are shown in Table 2 below.

Table 2

P3a Mean Peak Amplitude (µV) to Novel Stimuli at Selected Electrode Sites

Time	Fz	Cz
Pre Mindfulness training	3.07*(2.83)*	3.08*(2.97)*
Post Mindfulness training	2.17*(1.39)*	2.06*(1.11)*

Note. Standard deviations in parentheses.

Analyses indicated that the difference in P3a amplitude across time at each of the two electrode sites was not statistically significant. A 2[Time] x 2[Site] repeated measures ANOVA revealed no significant main effect of time, $F(1,15) = 1.37, p = .260, \eta p^2 = .084$, nor any significant main effect of site, $F(1,15) = 0.03, p = .860, \eta p^2 = .002$. There was also no significant time x site interaction, $F(1,15) = 0.06, p = .815, \eta p^2 = .004$.

P3a latency. Mean latencies of the P3a peak in response to novel stimuli (measured in milliseconds; ms) at electrode sites Fz and Cz are presented below in Table 3.

Table 3

P3a Mean Peak Latency (ms) to Novel Stimuli at Selected Electrode Sites

Time	Fz	Cz
Pre Mindfulness training	370.67 *(76.41)*	476.07*(134.30)*
Post Mindfulness training	399.47*(114.90)*	486.21*(137.94)*

Note. Standard deviations in parentheses.

A 2[Time] x 2[Site] repeated measures ANOVA revealed no significant main effect of time, $F(1,15) = 0.89, p = .361, \eta p^2 = .056$, on P3a latency. There was, however, a significant main effect of site, $F(1,15) = 7.03, p = .018, \eta p^2 = .319$, 95% CI [18.86, 173.28]. There was no significant time x site interaction, $F(1,15) = 0.06, p = .815, \eta p^2 = .004$.

P3b in response to the target stimuli. Visual inspection of the grand mean average waveforms in response to the target stimuli indicated P3b activity was most pronounced in the parietal regions (see Figure 6). Apart from some early parietal-occipital negativity and some later, more frontal negativity, little other distinct activity is evident.

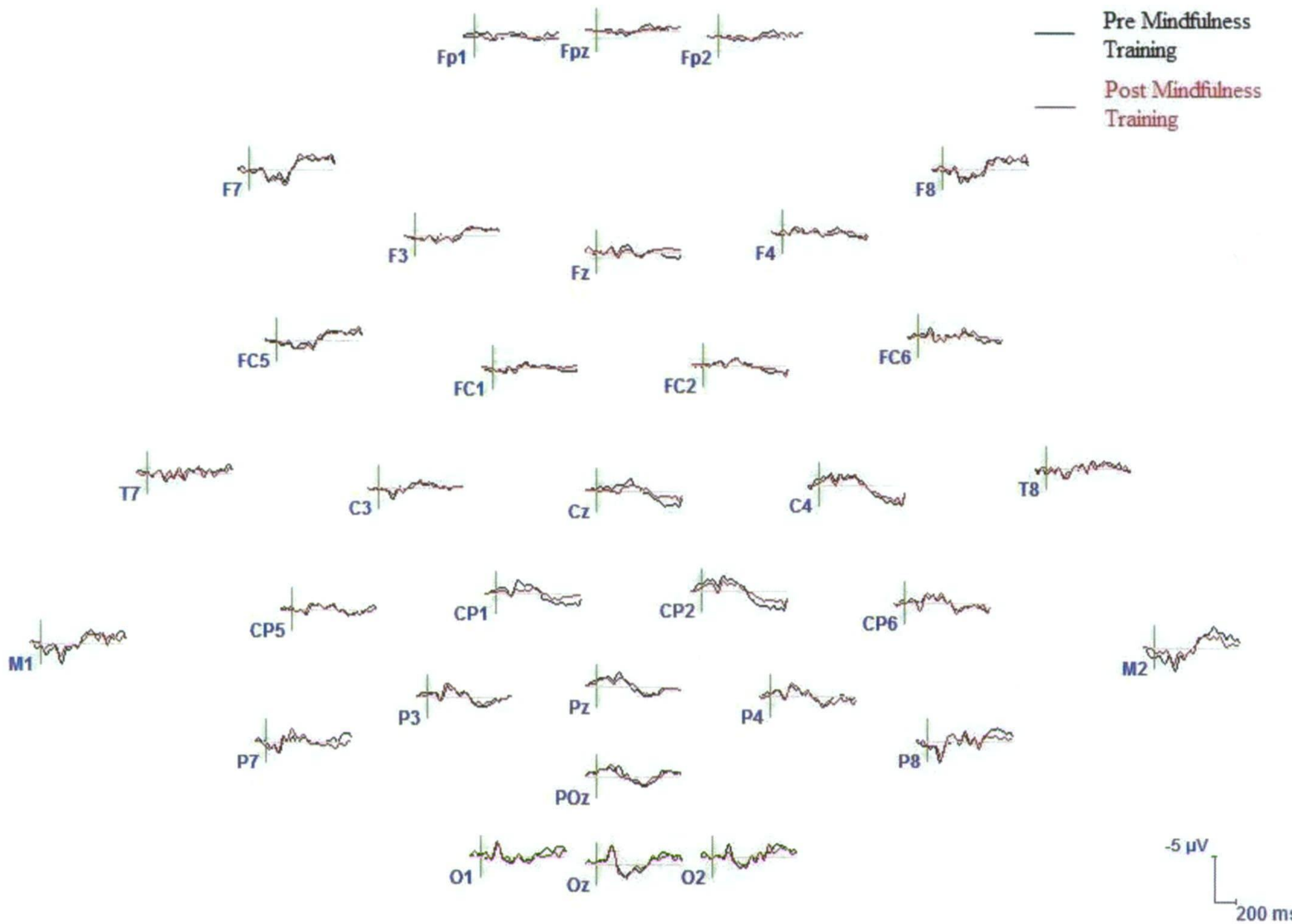

Figure 6. Grand mean average waveforms in response to target stimuli

Given this pattern of activity over the 30 electrode sites, and line with previous research (e.g., Fjell & Walhovd, 2004; Polich, 2007), statistical analyses were restricted to P3b activity at Pz. It should be noted that there is some emerging research which points to a more widespread pattern of P3b activity in older adults compared to younger adults, resulting in a posterior to anterior shift in activity (Fujiyama, Garry, Martin & Summers, 2010). However, inspection of the waveforms elicited by the presentation of target stimuli in the current study fail to show any clear P3b peak or distinct activity in the more anterior regions. As such, the decision was made to restrict analyses in the current study to P3b activity at Pz. Figure 7 below highlights this positive going waveform elicited in response to the novel stimuli (P3b) more clearly.

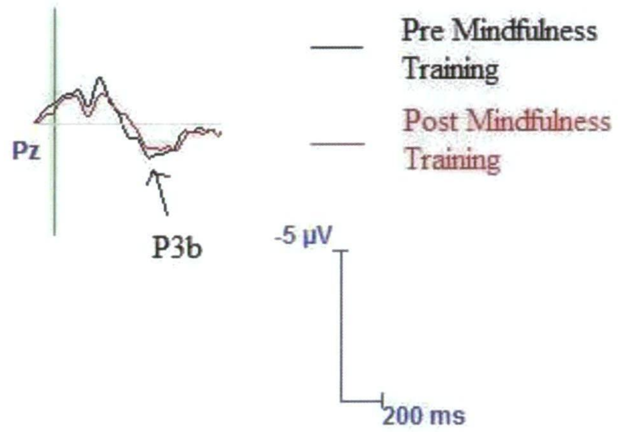

Figure 7. Grand mean average waveforms in response to target stimuli at electrode site Pz

P3b amplitude. P3b mean peak amplitude (µV) values in response to the target stimuli at electrode site Pz are shown in Table 4 on the following page.

Table 4

P3b Mean Peak Amplitude (μV)to Target Stimuli as Measured at Electrode Site Pz

Time	Mean amplitude
Pre Mindfulness training	2.52*(0.97)*
Post Mindfulness training	2.38*(1.03)*

Note. Standard deviations in parentheses.

Subsequent analyses revealed no significant difference in P3b amplitude at Pz in response to the target stimuli after mindfulness training when compared to pre mindfulness training, $t(15) = 0.39, p = .71, d = .14$, 95% CI [-.63, .91].

P3b latency. Mean latency of the P3b peak amplitude in response to the target stimuli (ms) at electrode site Pz are outlined below in Table 5.

Table 5

P3b Mean Peak Latency (ms)to Target Stimuli as Measured at Electrode Site Pz

Time	Mean latency
Pre Mindfulness training	498.11*(134.99)*
Post Mindfulness training	447.04*(110.67)*

Note. Standard deviations in parentheses.

Analyses revealed no significant difference in P3b latency after mindfulness training compared to before mindfulness training at Pz in response to the target stimuli, $t(15) = 1.36, p = .19, d = .41$, 95% CI [-28.87, 131.01].

Discussion

The present study aimed to explore the neurophysiological correlates of attention before and after mindfulness training in the Vipassana tradition. EEG activity was measured during a visual three-stimulus oddball paradigm to investigate attentional processes in a group of meditation naïve, healthy older adults before and after a 10-week mindfulness meditation course. ERP components P3a and P3b elicited in response to the novel and target stimuli of the oddball task respectively were measured as a means of investigating various neurophysiological aspects of attention allocation to stimuli.

The hypothesis that participants would show improved accuracy and shorter reaction time on the behavioural measures of the oddball task following mindfulness training was not supported. There was no significant difference between pre- and post-mindfulness training in either the number of targets correctly identified or in the time taken to respond to target stimuli.

The mean accuracy rate of above 93% at both time points accuracy rate is quite high and it is possible that a performance ceiling might have been reached; particularly given the above average mean FSIQ of participants in the current study was 111.82. However, this is, of course, speculative.

Furthermore, whilst some studies have suggested a link between mindfulness meditation experience and improved performance on behavioural measures of attentional processes, a recent study by Moore et al. (2012) showed no significant improvement on behavioural measures in a standard Stroop task following 16 weeks of mindfulness training. This is despite neurophysiological results of the study showing a significant reduction in P3 amplitude in response to incongruent stimuli in the Stroop task (Moore et al., 2012). Particularly in the Stoop task, behavioural performance is said to correlate more strongly with later ERP components. In the Moore et al., (2012) study, however, a significant difference was found in P3 latency between meditation and control groups, but not in later ERP components. Therefore, there is an alteration of the earlier, stimulus-driven ERP components rather than the later, voluntary decision-making process resulting in behavioural performance. However, whilst this is consistent with the results of the current study in terms of the behavioural performance, it does not explain the failure of the results to support the hypothesis that there would be a significant difference in stimulus-driven ERP (particularly P3a in response to the novel stimuli, which demands no behavioural response).

The hypothesis that participants would show a greater ability to allocate attentional resources more rapidly following mindfulness training was also not supported. Analyses revealed no significant difference in mean P3a peak latency at Fz and Cz in response to the novel stimuli, nor in mean P3b peak latency at Pz in response to the target stimuli. In addition, the hypothesis that participants would show a reduction in elaborate cognitive processing of stimuli was also not supported. Analyses indicated no significant reduction in mean P3a amplitude in response to the novel stimuli or mean P3b amplitude in response to the target stimuli following mindfulness training.

These results are in contrast to a number of studies showing reduced P3 amplitude and latency in experienced mindfulness meditation practitioners or in meditation naïve participants following short- to medium-term meditation training. Slagter et al. (2007) found a reduction in P3b amplitude in response to the first of two target stimuli in an attentional blink task following intensive meditation training. Reduced P3 latencies were also observed in response to a visual oddball task in experienced meditators compared with controls (Goddard, 1992). Also, as previously mentioned, a recent study by Moore et al. (2012) found a reduction in P3 amplitude in response to incongruent stimuli in a Stroop task following 16 weeks of mindfulness training.

There are, however, a number of noteworthy differences between these studies and the present study. The present study explored the neurophysiological correlates of attention in meditation naïve participants who completed a 10-week mindfulness meditation course. The reduction in elaborate stimuli processing observed in the study by Slagter et al. (2007) followed an intensive 3-month meditation retreat; whereas the study by Goddard (1992) was cross-sectional in design and compared experienced meditation practitioners with a meditation naïve control group. Whilst improvements in cognitive performance on a range of tasks, including measures of attentional processing have been shown after as little as 8-weeks of mindfulness meditation (e.g., Jha et al., 2007), much of the research to date has investigated cognitive processes in experienced meditators (Moore & Malinowski, 2009; Wenk-Sormaz, 2005). Furthermore, the age difference between participants in many of these studies described and the current study is substantial and numerous studies have shown distinct neurophysiological patterns in older compared to younger adults.

However, the results of the present study are consistent with the study by Anderson et al. (2007), which failed to find an improvement in attentional functions after participation in an 8-week MBSR program compared with a wait-listed control group as assessed by various measures of Stroop interference, attention and attention switching. They are also somewhat consistent with the study by Semple (2010), which found a reduction in errors of omission on a vigilance task following one month of mindfulness meditation practice, but no group differences in reaction time or other behavioural measures on a vigilance task, nor on digit symbol substitution or Stroop tasks when comparing meditation, relaxation and wait list controls.

The current results are in line with other studies that failed to support the notion of a causal relationship between meditation training and neurocognitive attentional improvement (see Chiesa et al., 2011; Chiesa & Serretti, 2010 for review). Certainly, support for a role of meditation in improving cognitive processes, particularly attention, is growing; however, as mentioned, the limitations of many of the studies of this relationship to date are substantial. Many of the studies examined attentional processes during or immediately after meditation. Therefore, it is difficult to ascertain whether the improvements reported were sustained beyond the immediate context of meditation. Moreover, a large proportion of the studies have been cross-sectional in design, comparing cognitive performance and neurophysiology of experienced meditators with meditation naïve control groups. The potential confounds of pre-existing between group differences in these studies make it difficult to draw a causal link between any improvements in cognitive performance or neuroanatomical or neurophysiological differences and mindfulness meditation practices. Further, the lack of non-active (that is, non-meditating) control groups in a number of these studies make it impossible to infer any role of meditation in any group differences that may have been observed.

Mention has also been made in the mindfulness literature of the potential confounding effects of motivation, demand characteristics and outcome expectations on study outcomes given it is often difficult to blind participants to the nature of the study (Slagter et al., 2011). Interestingly, and in support of this position, a recent study that compared MBSR to non-active controls measured and manipulated attentional effort in performance on a range of attentional tasks, including Stroop, found effort to significantly influence performance. Control participants were randomised before the post-testing stage to either a non-incentive or incentive control group. Both control groups were paid $250 for their participation; however, the incentive controls were offered a financial bonus of $50 if they could improve their performance on the tasks, although improvement was not defined to them. The study found an overall absence of unique attentional effects from MBSR, and the authors argued that the combined results suggested that previous investigations of short-term meditation related improvements in attentional performance should be regarded with caution due to the potential confound of attentional effort (Jensen, Vangkilde, Frokjaer, & Hasselbalch, 2012). However, despite the participants in the current study not being blind to the nature of the study and the study design not controlling for attentional effort, no improvement in attentional processing was observed.

As mentioned, the current study was exploratory in nature, designed to contribute to the limited research into neurophysiological correlates of attention in older adults following mindfulness meditation training and designed to address some of the limitations of previous studies of mindfulness meditation. Whilst the results of the current study fail to support the hypothesis that regular brief mindfulness meditation would improve attentional processes in older adults, as measured by a visual oddball paradigm, there are a number of limitations that must be considered when interpreting these results.

The visual three-stimulus oddball paradigm employed in the current study is widely utilised and shown to reliably elicit P3a in response to the novel stimuli and P3b in response to the target stimuli. However, there may be other effective paradigms for investigating the effect of short-term mindfulness meditation practice on attentional processes. Performance on the oddball task largely involves sustained attention or vigilance. Whilst voluntary, top-down processing of target stimuli is required, presentation of the novel stimuli activates the largely stimulus-driven alerting or sustained attentional processes. Moreover, it is widely posited that concentrative attention skills (such as orienting and conflict monitoring) are developed earlier in mindfulness meditation training than receptive attention skills (such as those that influence altering or sustained attention) (Jha et al., 2009). As such, research paradigms aimed at measuring selective and executive attentional processes may be more effective at assessing any attentional improvements that may result from shorter-term meditation training.

Importantly, there are number of significant limitations of the present study that must be considered when considering the results. Most significantly, due to methodological limitations outside of the scope of the current study, the current study comprises only an experimental group for which participants were recruited specifically. Therefore, broader age-related comparisons of intra-individual variability in behavioural or neurophysiological correlates of performance are not possible. Obviously, this is a significant limitation and significantly confounds the results.

As mentioned, the current study formed part of a larger study of cognition and aging and, as such, due to methodological limitations outside of the scope of the present study, only one block of the oddball task was completed by participants. Multiple test trials are understood to increase the reliability of the total score by reducing the potential for error (Fjell et al., 2009). Moreover, intra-individual variability in scores, defined as non-permanent, short-term changes in cognitive performance, has been shown to be large in older adults (MacDonald, Nyberg, &

Bäckman, 2006). This age-related variability in cognitive performance has been shown at both a behavioural levels and in variability in P3a and P3b latency (known as latency jitter; Fjell et al., 2009). Given the potential for intra-individual variability in performance, it is difficult to draw too broad a conclusion about the influence of mindfulness meditation on behavioural and neurophysiological correlates of attention in older adults based on this single task.

Whilst the current exploratory study goes some way to contributing to the current research into the role of mindfulness meditation in influencing attentional processes, further, more rigorous research is still required. Future research should endeavour to address the limitations of this, and other studies assessing the role of mindfulness meditation in improving the efficiency of attentional processing. In particular, longitudinal, randomised controlled trials comparing performance on and neurophysiological correlates of a range of cognitive tasks are still required to further investigate the relationship between attentional processes and mindfulness meditation. There is also a need to investigate and compare this relationship in older and younger adults.

Non-active and active control groups should be included in any future study designs and experimental groups should include individuals with no previous meditation experience. Comparison of previously mediation-naive participants with those who have extensive mediation experience will assist in elucidating the extent of any attentional benefits that may result from regular short- and long-term meditation practice.

Moreover, future studies will need to control for differences in operational definitions and mindfulness meditation practices (MBSR, Vipassana, etc), which tend to apply attention mechanisms in different ways. Inclusion of active control groups in such research will enable further conclusions to be drawn about the active components of mindfulness meditation that may be involved in the relationship with cognition and attention. Moreover, such clarification will allow for a more targeted assessment of the specific aspects of cognitive functioning, particularly attention, thought to be influenced by mindfulness meditation training (Cahn & Polich, 2006; Chiesa &Serretti, 2011). Such targeted assessment will also require the careful selection of appropriate attentional tasks in order to further clarify the specific aspects of attention that may be influenced by meditation practice.

In conclusion, the results of the current study failed to show that regular, brief training in mindfulness meditation improved older adults' performance on a measure of visual sustained attention. Moreover, mindfulness meditation did not result in changes in neurophysiological measures associated withattentional processes and speed of information processing in older adults. Whilst these results are in line with other studies, more rigorous research is required to clarify the relationship between mindfulness and cognitive performance, particularly in older adults.

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Appendix A: Print advertisement

School of Psychology

UTAS

Are you aged between 60 and 85 years?

Interested in Mindfulness?

We are currently seeking **volunteers, aged 60-85 yrs** to participate in a research project investigating the changes in brain activity that take place with age. This research aims to investigate factors that may protect against age-related reductions in memory and other mental functions in older adults.

Mindfulness meditation is a specific kind of attention training that has been shown to improve attention and memory skills in younger adults. This project will offer you the opportunity to participate in a 10-week mindfulness meditation course with a highly qualified and experienced mindfulness meditation practitioner and trainer. The course will be provided **free-of-charge** and consists of **2-hour weekly meetings** held in **Hobart**.

Before and after the mindfulness course, we will ask you toundertake a series of neuropsychological and neurophysiological assessments of memory and attention at the Sandy Bay campus, University of Tasmania.

People with dementia, extensive meditation experience or those who have previously participated in the Active Cognitive Enhancement (ACE) project are not eligible to participate.

If you are interested in taking part in this research project, or would like more information, please contact Cathy or Caroline on **(03)6226 6657** or by email **research.mindfulness@gmail.com**

Appendix B: Screening questionnaire

Mindfulness research project – Screening Questionnaire

Participant's name:	
Date of screening:	
Time of screening:	
Duration of screening:	
Name of person conducting screening:	
"My name is ...., I am a post graduate psychology student at the university of Tasmania.	
"How did you find out about the mindfulness research we are conducting?"	
"What makes you want to participate in the mindfulness research project?"	

- "In order to determine if you are eligible to participate in this research, we will be asking you a number of questions. Many of these questions will be of a personal nature. We will be asking you some questions about your medical history, any medications you may be taking, and your use of alcohol and tobacco and illicit drugs. You are free to choose not to answer any questions and you are also free to decide that you no longer wish to continue with the interview. **Is that OK?**
- Explain purpose of research project (briefly): looking at the possible beneficial effects of mindfulness on attention and memory in older adults
- What will this require of you?
  - Participation in 10-week mindfulness training course offered free of charge
  - Tests of attention and memory, before and after course (explain later)
- As I mentioned, the mindfulness meditation course will run over 10 weeks, from... Each week there will be a two hour group meeting held at... on ....If you decide to participate, it is really important that you are able to commit to attending these sessions. You will also be asked to practice the techniques you learn in the meditation group at home for one hour each day, preferably in two 30 minute blocks, once in the morning and once in the evening. Research has shown that people who practise regularly benefit most. It is important for you to know what's expected in the course and to enrol only if you think a daily commitment for 10 weeks is possible for you. **Are you willing to commit to this daily practice and weekly meetings?...that's wonderful!**
- You will be tested on a range of memory and attention tasks both before and after the ten-week mindfulness course. Some of these tests will involve using a computer, and others will be pencil-and-paper questionnaires. During some of the tasks we will be measuring your brain activity using what is known as an EEG. An EEG is a non-invasive way of measuring brain activity on the surface of the scalp using a cap that goes on your head. These tests before the mindfulness course will be run over two sessions, and each will take about three-hours. After the course, you will complete some of these same tests over two sessions, this time they'll only go for about two hours each.
- Whilst this might sound like a large time commitment, there is a number of advantages for you as a participant:
  - Receive mindfulness meditation course free of charge
  - Receive highly professional feedback on your level of cognitive functioning free of charge as well.

- **Would you be you happy to participate in this research?** - If YES, proceed with screening questions	
"In order to determine whether you are eligible to participate in the research, I need to ask you a few questions. Some of these questions are a little personal, but please remember that what you say will remain confidential."	
Preferred name:	
Contact numbers:	
Date of birth:	
Address:	
Email address:	
Place of birth:	
"Are you currently in employment or are you retired?"	
"Are you married or in a de facto relationship?" *If not married:* "**Do you live alone?"**	**Married❑De facto❑ Unmarried❑** **Lives alone❑ Lives with others❑**
Exclusion criteria *(if any of these apply, participants may be excluded from study):*	
"Have you ever been diagnosed with Alzheimer's disease or another form of dementia?" (e.g., vascular dementia, Pick's disease, dementia with Lewy-bodies, fronto-temporal dementia, alcohol-related dementia/Korsakoff's syndrome)	**No❑Yes❑***Provide details:*
"Have you suffered a stroke in the past year?"	**No❑Yes❑***Provide details:*
"Have you ever had a stroke that resulted in language difficulties?"	**No❑Yes❑***Provide details:*
"Have you ever been diagnosed with a neurological disorder?"*(e.g., Parkinson's disease; epilepsy that is not controlled by medication; Huntington's disease, Pick's disease, HIV/AIDS, Korsakoff's syndrome):*	**No❑Yes❑***Provide details:*
"Have you had a head injury in the past year?"	**No❑Yes❑***Provide details:*
"Have you ever had a head injury that resulted in a significant loss of consciousness?" *(i.e., not just momentary)*	**No❑Yes❑***Provide details:*
"Have you been diagnosed with depression, anxiety disorder or other mental illness <u>that is not currently well-managed</u>?"*(with medication and/or psychotherapy):*	**No❑Yes❑***Provide details:*
"Have you any sensory impairment that would impact on your ability to complete computer testing or to participate in a large group?" *(where there are often times when participants are working in small groups – i.e., quite noisy):*	**No❑Yes❑***Provide details:*
"Do you have any other health conditions not already mentioned?"	**No❑Yes❑***Provide details:*
"Is your <u>currentaverage</u> alcohol consumption <u>greater than</u> 4 standard drinks per day on 4 or more days of the week?"	**No❑Yes❑***Provide details:*
If no to above question: **"Have you ever consumed alcohol at this level?"**	**No❑Yes❑***Provide details: (ask when they last consumed alcohol at that level).*
"Do you currently smoke?"	**No❑Yes❑**
"Do you currently use illicit drugs?"	**No❑Yes❑***Provide details:*
"What over-the-counter and prescribed medications do you currently take?"	

"Do you have a family history of Alzheimer's disease or other form of dementia?"	
Highest level of education and total number of years completed formal education *(i.e., full-time equivalent, university degree/diploma, TAFE certificate, high school)*	**Highest level:** **Total number of years:**
"Would you consider your reading and writing ability to be of at least an average level?" *I.e., able to read a newspaper)*	**Yes❑No❑***Provide details:*
Have you ever done any form of meditation practice?	Yes ❑ No ❑ If YES: Can you please describe what sort of practice this was? When? For how long?
Have you ever done any formal relaxation training or practice?	Yes ❑ No ❑ If Yes: Can you please describe this? When? For how long?
Have you ever practiced yoga?	Yes ❑ No ❑ If YES: What type? When? For how long?
Do you regularly do any brain training exercises such as crosswords or Sudoku etc?	Yes ❑ No ❑ If YES: What? How often?
"Is there any other information you think we need to know?"	
"Thank you for your time. You will be contacted advised whether you are eligible to participate in the mindfulness research, and if so, whether you have been assigned to the mindfulness group being conducted in 2011 or early 2012, assessment times will be arranged with you when you are telephoned." *Following interview, assign a codeand insert at top of each page. Code = ACE 5 003 **00** M (Then ACE 5 003 01 M etc)*	

Appendix C: Information sheet

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PARTICIPANT INFORMATION SHEET

The Effect of Mindfulness Meditation Training on Cognitive Functioning in Older Adults

Invitation

You are invited to participate in a research study into the effect of mindfulness meditation training on attention and memory skills in healthy older adults.

This study is being conducted as partial fulfillment of Masters in Clinical Psychology degrees being undertaken by Caroline Bertrand and Catherine Bushnell. They will be supervised by:
Professor Jeff Summers (School of Psychology, University of Tasmania)
Dr Bruno Cayoun (School of Psychology, University of Tasmania)
Dr Hakuei Fujiyama (School of Psychology, University of Tasmania)

1. 'What is the purpose of this study?'

The purpose is to investigate whether a 10-week course of mindfulness meditation affects healthy older adults' performance on attention and memory tasks as measured by neuropsychological tests, personal reports, and electroencephalograph measures.

2. 'Why have I been invited to participate in this study?'

You are eligible to participate in this study because you are aged 60 to 85 years old and do not have significant meditation experience or cognitive impairment (including dementia).

3. 'What does this study involve?'

You will be asked to participate in a 10-week mindfulness meditation course, which will be conducted by an experienced mindfulness meditation practitioner. The course will involve meeting for 2 hours each week (in a group setting), where you will learn to focus and control your attention, and to regulate your emotions. Individual daily practice is also an important requirement of the course, and you will be asked to practice the mindfulness techniques at home for 30 minutes twice a day (morning and evening).

Before and after participating in the mindfulness meditation course, you will be asked to come to two testing sessions in which you will complete tests of attention and memory skills. In the first session, you will be asked to:

- undertake an assessment of your thinking and memory
  answer questions pencil-and-paper questions indicating how much a given statement applies to you over the past week, for example "I found it hard to wind down" , or "when I do things, my mind wanders off and I'm easily distracted".
- asked to recall and recite a number of words within a time limit
- read and say a series of unfamiliar and uncommon words
- complete a number of short questionnaires about your daily activities (social, mental, physical), medication used, and your feelings about your memory.
- take home and complete a questionnaire about your level of mental activity, both currently and throughout your life.
- Undertake training for some attention and memory tests that involve using a computer (you will complete the tests at the next session).

It is expected that this first session will take around 3 hours. Providing that your results fall within the normal range, you will be invited to continue with the remainder of the study.

In the second session you will be asked to complete some testing on a computer. Recording your answers will be simple and will require you to either use two buttons on the keyboard or mouse clicks. It is expected that this second session will run with 4 other participants (although your results will not be shared with the others) and will take around 1 hour.

In the third session you will be asked to complete some tests of memory and attention while your brain activity is measured using an electroencephalograph (EEG). It is expected that this session will take approximately 2 hours. To measure brain activity, an elasticized cap is fitted to your head and a small amount of conductive gel applied to your scalp. Electrodes will also be attached above and below one of your eyes and on both temples in order to record your eye movements during the tests. Both the conductive EEG gel and the adhesive on the electrodes are safe to be used on your skin. Individuals with sensitive skin should let the experimenters know as alternative options are available. During the EEG session you will:

- Be asked to remember a number of words and the colour that they are displayed in
- Respond to shapes presented on the computer screen whilst ignoring other shapes

- Ignore distracter arrows and indicate whether the target arrows are pointing to the left or the right
- Use a modified computer game controller to give your answers in the tasks

It is important that you understand that your involvement is this study is voluntary. While we would be pleased to have you participate, we respect your right to decline. There will be no consequences to you if you decide not to participate. If you decide to discontinue participation at any time, you may do so without providing an explanation. If you wish, you are also able to request that any data you have provided to the study be destroyed and, therefore, no longer included in the study. All information will be treated in a confidential manner, and your name will not be used in any publication arising out of the research. All of the research will be kept in a locked cabinet in School of Psychology CAMAL Research Assistants' Office, where it will be kept for a minimum of five years, after which time it will be destroyed.

4. Are there any possible benefits from participation in this study?

It is possible that you will notice an improvement in your attention, memory, and ability to regulate your emotions from the mindfulness meditation course after a certain period of time. This may lead to an improvement in your day-to-day life. It may also result in improved wellbeing and lessened anxiety about your memory. We will be interested to see if you experience any other benefits from the mindfulness course.

On a larger scale, the results of this study may provide valuable information that will contribute to a better understanding of the ageing brain and the benefit of mindfulness meditation training programs for older adults.

5. Are there any possible risks from participation in this study?

It is possible that that the neuropsychological tests you complete during this study may reveal signs of clinical anxiety, depression or dementia. Should this occur, you will be contacted by a qualified clinical psychologist who will discuss your results with you. You are also encouraged to contact the University Psychology School Clinic for free counseling if you are distressed by any of the testing or study procedures (phone (03) 6226 2805), or the Dementia Helpline (24 hours) on 1800 100 500 if you are concerned about your cognitive functioning. Alternatively, you may prefer to contact your general practitioner.

6. What if I have questions about this research?

If you would like to discuss any aspect of this study please feel free to contact Dr Hakuei Fujiyama on ph (03) 6226 2243. Alternatively, you may email Caroline Bertrand (email: Caroline.Bertrand@utas.edu.au) or Cathy Bushnell (email: Catherine.Bushnell@utas.edu.au). Any one of us would be happy to discuss any aspect of the research with you. Once we have analysed the information we will be mailing / emailing you a summary of our findings. You are welcome to contact us at that time to discuss any issue relating to the research study.

This study has been approved by the Tasmanian Social Science Human Research Ethics Committee. If you have concerns or complaints about the conduct of this study should contact the Executive Officer of the HREC (Tasmania) Network on (03) 6226 7479 or email human.ethics@utas.edu.au. The Executive Officer is the person nominated to receive complaints from research participants. You will need to quote [*HREC project number: H11939*].

Thank you for taking the time to consider this study.
If you wish to take part in it, please sign the attached consent form.
This information sheet is for you to keep.

Appendix D: Consent form

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CONSENT FORM

The Effect of Mindfulness Meditation Training on Cognitive Functioning in Older Adults

1. I have read and understood the 'Information Sheet' for this project.
2. The nature and possible effects of the study have been explained to me.
3. I understand that the study involves:
    - Participating in a mindfulness meditation course for 10 weeks. This will consist of a two hour group session conducted once a week, and individual practice at home of one hour (2 x 30 minutes) per day.
    - Attending five testing sessions of 1-3 hours each in which I will:
        - undertake neuropsychological tests;
        - be fitted with an electroencephalograph cap and have my brain activity measured whilst completing tests of attention and memory;
        - complete questionnaires about my memory, thinking and feelings
4. I understand that participation involves the possibility that the researchers may detecta decline in my thinking and memory.
5. I would like to be told if a decline is detected. ☐ YES ☐ NO

If I ticked yes: I would like to be contacted by a counsellor from Alzheimer's Australia. ☐ YES ☐ NO

6. I may also experience stress or anxiety from the challenges of the testing. While this is expected to be minimal, if this occurs, the facilitator will offer me support or alternatively, arrange for me to see a counsellor.
7. I understand that all raw data will be held within locked rooms in locked filing cabinets and password secured computers on University of Tasmania premises, in the School of Psychology for a period of at least 5 years. Computer files will be erased and confidential documents shredded after this 5 year period.

8. Any questions that I have asked have been answered to my satisfaction.
9. I agree that research data gathered from me for the study may be published provided that I cannot be identified as a participant.
10. I understand that the researchers will maintain my identity confidential and that any information I supply to the researchers will be used only for the purposes of the research.
11. I agree to participate in this investigation and understand that I may withdraw at any time without any effect, and if I so wish, may request that any data I have supplied to date be withdrawn from the research.

Name of Participant: ______________________

Signature: ______________ Date: ______________

Statement by Investigator

☐ I have explained the project & the implications of participation in it to this volunteer and I believe that the consent is informed and that he/she understands the implications of participation

If the Investigator has not had an opportunity to talk to participants prior to them participating, the following must be ticked.

☐ The participant has received the Information Sheet where my details have been provided so participants have the opportunity to contact me prior to consenting to participate in this project.

Name of investigator ______________________

Signature of investigator ______________________

Date ______________