Mindfulness Meditation Training and Cognitive Functions in Older Adults

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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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Table of Contents

List of Tables and Figures

Abstract

This study investigated the effect of a 10-week mindfulness meditation (MM) group program on older adults' performance on neuropsychological (CogState) tests of cognitive functions that typically decline with age. A sample of 44 meditation-naive adults (13 males, 31 females) aged 60-85 years (*M* = 69.07, *SD* = 6.53) completed neuropsychological tests of sustained attention, working memory, visuospatial memory, executive functions and processing speed. Following baseline testing, 22 of the participants attended a 10-week MM (Vipassana-based) training program involving weekly group meetings and daily individual MM practice, while 22 participants were part of an inactive (no intervention) control group. Both groups completed the same neuropsychological tests at the completion of the MM training program (3 months post-baseline-testing). The hypothesis that MM participants would show significant pre- to post-test improvements on all tests of cognitive functions, relative to the control group, was not supported by the results. Unexpectedly, both groups demonstrated significantly improved performance on visuospatial memory and executive functions tasks, while neither group improved significantly on tests of sustained attention, working memory or processing speed. However, the findings of this study are inconclusive due to a number of methodological limitations, and it is suggested that further research be conducted to determine whether differences in MM program characteristics (e.g., length of training, emphasis of techniques) and cognitive outcome measures produce MM-training-specific improvements in older adults' cognitive abilities.

The link between cognitive decline and ageing is well established, with numerous cross-sectional and longitudinal studies showing that memory and executive functions deteriorate with age (Buckner, 2004; Hedden & Gabrieli, 2004). The degree of cognitive impairment between individuals varies considerably, ranging from normal age-related decline, which typically involves decreases in processing speed and working memory capacity, to pathological memory impairment (i.e., dementia) (Buckner). While deleterious effects of dementia on quality of life are to be expected, research shows that even mild (normal) decline in the domains of memory and executive functions are associated with reduced quality of life, decreased independence, and poorer psychological health (Bunce, Tzur, Ramchurn, Gain, & Bond, 2008; Reppermund et al., 2011; Wolinsky et al., 2006). There is also a considerable financial burden of cognitive decline, with the financial cost of dementia to Australians expected to reach $8.2 billion by 2023 (Low, Gomes, & Brodaty, 2008).

Age-related cognitive decline is of particular relevance in Australia, where the proportion of people aged 65 years and above is expected to almost double by 2056 (25% of the population compared with 13% in 2007; Australian Bureau of Statistics [ABS], 2008). Furthermore, the number of people with dementia is estimated to more than triple during this time, from 220,050 in 2007 to 731,030 in 2050 (Low et al., 2008). Given the increasing size of Australia's aged population and the psychological, social and financial costs associated with (both normal and severe) cognitive decline, it is important to try to find ways to reduce or delay the onset of age-related cognitive decline.

Neuroplasticity and Mental Training Programs

Hope for improving the stability of cognitive functions in later life comes from cognitive neuroplasticity research, which shows that the adult brain is capable of structural and functional change as a result of training and experience (Slagter, Davidson, & Lutz, 2011). For example, practicing a simple five-finger piano exercise on five consecutive days (for two hours per day) has been shown to enlarge neural representations of those fingers in the motor cortex and to increase performance accuracy (Pascual-Leone, Amedi, Fregni, & Merabet, 2005).

Such evidence of neural plasticity has formed the basis for the implementation of mental training programs designed to enhance older adults' cognitive abilities through the repetitive practice of a specific skill or activity (Rabipour & Raz, 2012). There is evidence to show that such programs are effective in improving abilities such as attention, working memory and processing speed in older adults. For example, a randomised controlled trial (RCT) involving 2802 healthy older adults (mean age 77 years) demonstrated that 10 training sessions of either memory, reasoning or speed of processing skills (60-75 minutes each conducted over 6 weeks) resulted in significant improvement on measures of the trained cognitive ability, and that these improvements were maintained for five years post-intervention (Ball et al., 2002; Willis et al., 2006). Note, however, that these improvements were specific to the task on which individuals received training; that is, improvements did not generalise to other cognitive functions.

Clearly, mental training programs that target multiple abilities rather than one specific ability would be of greater value to older adults seeking to maintain their cognitive functions with age. Slagter et al. (2011) propose that the most effective mental training programs for enhancing multiple cognitive skills are those that produce process-specific, as opposed to task-specific, learning. Such learning involves developing core cognitive processes (such as sustained attention) that result in generalised improvements on cognitive tasks, rather than improvements that are limited to the task on which the person was trained (Rabipour & Raz, 2012). Components of process-specific mental training programs (as proposed by Slagter et al.) include: a complex training context (multiple processes are trained in parallel); high stimulus and task variability; moderate task difficulty; maintenance of optimum arousal and motivation; and long training duration (> 10,000 hours is most effective). Mindfulness meditation (MM) is a form of mental training that has been proposed to produce generalised improvements on tasks involving attention via its utilisation of some of these process-specific learning components.

Mindfulness Meditation: a Process-specific Form of Mental Training

Mindfulness refers to a mental state in which each sensory and internal experience is deliberately attended to as it occurs, and is perceived in a non-judgmental, non-reactive way (Kabat-Zinn, 1994; Cayoun, 2011). Specifically, MM appears to enhance attentional control, a core cognitive skill associated with three neurologically distinct yet interactive attention networks. These are described in Posner and Rothbart's (2007) neurocognitive model of attention as the alerting, orienting and executive attention networks. Alerting (also referred to as sustained attention) is defined as achieving and maintaining a high state of vigilance, and is associated with activity in the frontal, parietal and thalamic regions of the brain. Orienting (also referred to as selective attention) involves focusing on a selection of possible sensory inputs, and implicates sections of the parietal cortex and superior colliculus. Executive attention (also known as divided attention or conflict monitoring) monitors and manages conflict between thoughts, feelings and responses, and is represented by activity in the anterior cingulate cortex, prefrontal cortex and basal ganglia (Posner & Rothbart). Given the extensive role of attention in cognitive functioning (Buckner, 2004) it is logical to expect that training these subcomponents of attention would lead to improvement in many of the cognitive functions that typically decline with age, including processing speed, working memory and other executive functions.

Mindfulness meditation is based on Vipassana meditation practice as taught by Theravada Buddhist traditions, and involves two broad MM styles: concentrative (or focused and sustained attention) meditation, and open-monitoring (experiential acceptance) meditation (Slagter et al., 2011). These two forms of meditation involve processes that develop the three attention subcomponents described in Posner and Rothbart's (2007) attention network theory (Bishop et al., 2004; Holzel et al., 2011). For instance, MM training typically begins with concentrative meditation techniques, which involve developing sustained attention by focusing on a target, usually one's own breath, while remaining aware of internal and external stimuli (e.g., thoughts, sounds, sensations; Bishop et al., 2004). Selective attention is cultivated by learning not to react (even automatically) to thoughts and body sensations, but to accept them (Cayoun, 2011). Executive attention is developed when attention is switched from distracting stimuli back to the target (e.g., breath), requiring the use of attention-switching, or response re-engagement skills (Holzel et al., 2011).

The second stage of MM training consists of open-monitoring meditation techniques (Chiesa, Calati, & Serretti, 2010). This involves moving attention systematically through the entire body ("body-scanning") and noticing sensations that arise while preventing the usual (emotional, judgement-based) response to pleasant and unpleasant sensory experiences. Executive attention skills are also necessary to inhibit one's response to thoughts and sensory cues that emerge recurrently throughout the concentration process (Bishop et al., 2004; Holzel et al., 2011). Moreover, body-scanning has been proposed to enhance emotion regulation skills through reducing elaborative processing of thoughts and events associated with the development of negative emotions (Cayoun, 2011; Chambers, Gullone, & Allen, 2009; Rabipour & Raz, 2012).

While most MM programs include both concentrative and open-monitoring meditation components, some differences exist with regard to the emphasis of technique and the inclusion of other training. For instance, some programs focus primarily on open-monitoring meditation techniques (e.g., Vipassana retreats), while others (such as Mindfulness-based Stress Reduction [MBSR] and Mindfulness-Based Cognitive Therapy [MBCT]) include additional components such as cognitive therapy (Chambers, Lo & Allen, 2007). The length and delivery of training also varies between MM programs, for example, MBSR and MBCT are typically delivered to small groups by an experienced MM practitioner for 1-2 hours per week over a period of eight weeks, with 45-60 minutes individual practice daily (Chiesa et al., 2011). In contrast, other programs, such as intensive Vipassana meditation retreats, involve 10 or more hours daily practice for between 10 and 30 days (Chiesa et al.). It is possible that differences in length and type of MM programs have differential effects on cognitive functions, however this question has not been systematically examined by previous researchers. A thorough review of the effect of different types of MM on cognitive functions is beyond the scope of the current study, especially as many research articles do not contain sufficient detail to enable clear classification of their adopted MM training method. However, it is clear from the research described below that the key component of successful MM training programs is regular (daily) practice of at least one aspect of Vipassana-based MM techniques (concentrative and/or open-monitoring meditation), usually for a minimum of eight weeks (Chiesa et al., 2011). Such programs have been associated with improved cognitive function in the areas of attention, working memory and other executive functions.

Mindfulness Meditation and Cognitive Functions

Due to the paucity of prospective, controlled-trial studies investigating the effect of MM training on cognitive functions in older adults, most of the research findings presented hereafter relate to healthy younger adults.

Attention

To our knowledge, only one study has been conducted to examine the association between MM and attention skills in older adults. Prakash et al.'s (2011) cross-sectional study compared 20 male concentrative meditators (> 10 years Vihangam Yoga experience) with age-matched control participants (mean age = 60 years) on various tests of attention. They found that meditation practitioners performed significantly better on all attention tasks, indicating an association between MM experience and better attentional control.

Substantially more research has been conducted with younger adults, for whom there is some evidence that as little as eight weeks of MM can improve sustained, selective and executive attention (see Chiesa et al. (2011) for a recent review of 23 neuropsychological studies). For example, Jha, Krompinge and Baime (2007) conducted a non-randomised controlled trial to compare the effect of an eight week MBSR course provided to meditation-naive participants (N = 17; mean age = 24 years), an intensive one-month residential MM retreat provided to experienced concentrative meditation practitioners (mean age = 35 years), and no intervention (for meditation-naive participants (mean age = 22 years) on attention skills (as measured by the Attention Network Test [ANT]). They found that 1) at pre-test, experienced meditators were significantly better at conflict monitoring than meditation-naive participants; and 2) following MM training, selective attention was significantly better among MBSR group participants (but not control or retreat participants), and sustained attention was significantly better among experienced meditators only. These results suggest that an eight-week MM course can improve selective attention, while long-term meditation may enhance sustained and executive attention skills.

In contrast to the above findings, Anderson, Lau, Segal, and Bishop (2007) found no pre- to post-test improvement in sustained attention or inhibition of elaborative processing (executive attention) for healthy adults randomly assigned to either an eight-week MBSR course (N = 39, mean age = 37 years) or wait-list control group (N = 33, mean age = 33). However, shorter MM programs have been shown to enhance aspects of attention. For example, Chambers, Lo and Allen (2007) found that participants (N = 20, mean age = 33 years) assigned to attend a 10-day Vipassana meditation retreat improved significantly from pre- to post-test on an internal switching (sustained attention) task, while control group participants (N = 20, mean age = 31 years) did not improve significantly. Tang et al. (2007) found a superior effect of five days (20 minutes practice per day) of Integrative Body-mind Training (IBMT) on executive attention compared to relaxation training. However, no improvement on sustained or selective attention measures was observed in either group.

While mindfulness-meditation-induced neuroplasticity is not the focus of the present study, it is worth considering the link between long-term MM and stability of brain structures related to sustaining attention. For example, Lazar et al. (2005) conducted a magnetic resonance imaging (MRI) study to compare the cortical thickness of long-term (Insight) mindfulness meditators with that of non-meditators. While age-related cortical thinning of prefrontal cortical structures related to sustained attention was observed in the control group, older meditation practitioners (aged 40-50 years compared with 20- 30-year-olds) did not show expected decreases in cortical thickness. Furthermore, as little as 11 hours of mindfulness based IBMT training can produce white matter changes in the anterior cingulate (Tang et al., 2010) - an area of the brain that is heavily involved in executive attention processes (Posner & Rothbart, 2007). Such findings provide additional support for the theory that MM practice may protect against age-related decline in cognitive abilities related to attention. Given the central role of attention in many cognitive functions (Baddeley, 1998; Chiesa et al., 2011), it is not surprising that an attention training program such as MM training should also lead to improvements in areas such as memory and executive functions.

Memory and Executive Functions

A brief summary of working memory and executive functions is provided before addressing evidence of the efficacy of MM training for enhancing cognitive functioning in these domains. Working memory refers to the ability to hold information in memory and use it to perform complex cognitive tasks such as reasoning, comprehension and learning (Baddeley, 2010). A popular theoretical conceptualisation of working memory includes two components that involve processing and storing phonological and spatial information, respectively, and a system that governs allocation of attentional resources (Baddeley, 1998). Executive functions refer to higher order cognitive abilities such as information updating and monitoring, inhibitory control, and cognitive flexibility (attention shifting) that are required to effectively problem solve, plan, and make decisions, among other things (Chiesa et al., 2011).

Only one known study has investigated the link between MM training and enhanced working memory and executive functions in older adults. Prakash et al. (2012) found that long-term concentrative meditators (aged 55 years and over) performed significantly better than age-matched meditation-naive participants on a set-shifting task designed to measure cognitive flexibility. There was also a trend toward significantly higher scores on a measure of working memory (Digit Span Backward task) for meditators compared with non-meditators. While a causal relationship cannot be inferred from these (cross-sectional) findings, they suggest that MM may have a role to play in the prevention of cognitive decline in these areas.

Prospective studies of younger, healthy adults provide stronger support for the efficacy of MM training for improving working memory and executive functions (Chiesa et al., 2011). For example, in a study by Chambers, Lo, & Allen (2007), participants assigned to attend a 10-day Vipassana meditation retreat improved significantly from pre- to post-test on a measure of working memory (Digit Span Backward task), while control participants did not improve. Similarly, Jha, Stanley, Kiyonaga, Wong, and Gelfand (2010) found a trend towards significant improvement on working memory abilities (measured using an operation span task) following an eight-week mindfulness based program for (high meditation practice) military participants during high-stress pre-deployment training. In contrast, working memory performance decreased from pre- to post-test for the control group and low-practice MBSR training group. These findings suggest that adequate MM practice (in this case, 1.5 hours per week) can protect against stress-induced decline in working memory.

Evidence that MM training programs improve executive functions among healthy younger adults comes from findings by researchers such as Heeren, Van Broeck and Philippot (2009), who conducted a controlled-trial to examine changes in verbal fluency task performance following an eight-week MBCT program. They found that the MM group, which performed similarly to the control group at baseline, produced significantly more correct responses after receiving MM training.

There is little evidence that MM training has any effect on general measures of memory as assessed by popular learning and memory batteries (Chiesa et al., 2011). However, the scope of research to date has been limited to very brief mindfulness training intervention (two days) or involved traumatic brain injured participants (McMillan, Robertson, Brock, & Chorlton, 2002). To our knowledge, no researchers have examined the effect of MM training on general memory abilities in older adults. Another important area of cognitive function that has the potential to be enhanced by MM training is processing speed.

Processing Speed

Deterioration of the ability to efficiently attend to and process information (known as processing speed) is one of the most well-documented cognitive changes to occur with age (Buckner, 2004; Bunce et al., 2008). While no previous studies appear to have specifically examined the effect of MM training on processing speed, there is some evidence that processing speed is enhanced by other meditation techniques. Part of Cahn & Polich's (2006) review of the relationship between meditation experience and event-related potentials described a study in which meditators (trained for 5 weeks in Zen meditation) showed greater accuracy and reduced reaction times for a simple choice task following meditation (compared with no meditation). Furthermore, Prakash et al.'s (2011) cross-section study of older adults (mean age = 59 years) showed that experienced concentrative meditators had significantly faster processing speed performance (as measured by the Digit Symbol Substitution Test) compared with age-matched non-meditators.

The Present Study

While numerous studies have demonstrated a positive effect of MM training on a range of cognitive functions for young and middle-aged adults (Chiesa et al., 2011), there is a paucity of research investigating the benefits of MM for older adults. This is surprising, given the link between MM and the prevention of age-related cortical thinning of areas of the brain associated with attention (e.g., Lazar et al., 2005), and the potential for MM training to delay the onset of age-related cognitive decline by enhancing or maintaining attention, memory, and other cognitive functions that typically decline with age. A broad range of MM program lengths and formats have previously been found to be effective for enhancing various cognitive functions. One of the most widely used MM training formats involves a minimum of eight weekly sessions of group training (1-2 hours) in (Vispassana-based) concentrative and open-monitoring meditation techniques, combined with daily individual meditation practice (45-60 minutes) (Chiesa et al.). This form of MM practice is a more accessible, sustainable format for non-meditators to adopt than intensive (10-30 day) retreats.

The aim of the current study was therefore to examine the effect of a 10-week MM group program, in the Vipassana tradition, on older adults' performance on neuropsychological tests of attention, working memory, visuospatial learning and memory, executive functions and processing speed, relative to participants receiving no intervention (inactive control group). The study was designed to assess whether MM training, which has been proposed to induce process-specific learning (Slagter et al., 2011), would produce generalised improvement in a range of cognitive functions when delivered in a 10-week non-intensive group format.

Previous research has shown that MM training programs of various lengths (e.g., five days; eight weeks; 1-3 months) and delivery modes (e.g., weekly 2 hour group meetings; intensive live-in retreats) can enhance performance on neuropsychological tests of sustained attention (Chambers et al., 2007; Jha et al., 2007), working memory (Chambers et al.; Jha et al., 2010) and executive function (Heeren et al., 2009). On the basis of these findings it was hypothesised that mindfulness meditation (MM) participants' scores on neuropsychological tests of sustained attention, working memory and executive function (as measured by the CogState battery) would improve significantly from pre- to post-test, while the control group's scores would not vary significantly over this time. Based on evidence that MM improves a range of attention abilities that are required for learning and general memory (Chiesa et al.; Rabipour & Raz, 2012) it was expected in the current study that MM participants' scores on tests of visuospatial learning and memory would improve significantly from pre- to post-test, while the control group's scores would not vary significantly over this time.

To our knowledge, no previous researchers have examined the relationship between MM meditation and processing speed. However, on the basis of findings of a positive relationship between (non-MM) meditation and processing speed in younger adults (described by Cahn & Polich,2006), and faster processing speed among long-term meditators than among age-matched non-meditators in older adults (Prakash et al., 2011), it was tentatively hypothesised that MM participants in the current study would perform significantly better on a measure of processing speed after MM training, while control group participants' speed would not change significantly.

Method

Participants

The sample comprised 44 healthy adults (13 males, 31 females) aged 60-85 years (*M* = 69.07, *SD* = 6.53) living in urban and rural areas of Southern Tasmania. Participants for the Mindfulness Meditation (MM; experimental) condition were recruited through media advertisements for volunteers to participate in research examining factors associated with age-related memory decline. Eighty-nine respondents were contacted by telephone and informed of the study's procedure and inclusion criteria. Twenty-eight participants completed the initial neuropsychological testing/screening session, 25 of whom were deemed eligible to proceed with the mindfulness training component of the study. One participant dropped out of the training sessions due to family reasons, and two were excluded from the analyses due to previously undetected breaches of inclusion criteria. The final MM sample for analysis therefore comprised 22 participants (7 males, 15 females), with a mean age of 69.41 years (*SD* = 6.67), a mean education of 13.64 years (*SD* = 2.68), and a mean estimated premorbid Full Scale Intelligence Quotient (FSIQ) score of 111.82 (*SD* = 4.23).

Twenty-two inactive control group participants were drawn from a pool of participants who had acted as control participants in a study examining the effect of a short-term cognitive training program (Active Cognitive Enhancement [ACE]) on cognitive function. Control participants were selected on the basis of matching MM participants on age (*M* = 68.73, *SD* = 6.38), sex (6 male, 16 female), years of education (M = 14.28, SD = 3.86), and estimated premorbid FSIQ (M = 113.77, SD = 6.71).

Exclusion criteria for participation included: a history of recent or frequent meditation practice (see Appendix A for specific criteria); pronounced cognitive impairment; neurological disorders; unmanaged depression, anxiety, or other psychiatric disorders; non-corrected visual or hearing problems; medications known to affect cognitive functions; and a history of alcohol or illicit drug abuse.

Materials

This study administered the same battery of tests used in the ACE training study being conducted by the University of Tasmania for two reasons: 1) to allow results to be directly compared to those of the pre-collected control group data, and 2) for future studies to compare the effect of MM on cognitive functioning with that of ACE mental training.

Screening tests. An initial Telephone Screening Questionnaire (see Appendix B) was developed to assess participants' eligibility for the study with regard to meditation experience, physical and psychological health, dementia, and drug use. The Mattis Dementia Rating Scale-Second Edition (DRS-2; Mattis, 2001) assesses five cognitive domains (Attention, Initiation/Perseveration, Construction, Conceptualisation, and Memory) and produces a total score that is used to screen for cognitive impairment. Total raw scores were converted to age- and education-corrected MOANS scaled scores, with scores of eight ('Mildly impaired' cognitive functions) and below used as the exclusion criteria for cognitive functioning. As suggested in the DRS-2 manual (Mattis), scores above eight were classified as indicative of intact cognitive functions and were used to mark inclusion in the study (9-10 = 'Below average – intact'; 11-17 = 'Average – intact'; 18 = 'Above average –

intact'). This measure has been shown to have reasonable sensitivity (0.83), specificity (0.90), and high convergent validity (with the Mini-Mental State Examination; Fernandez & Scheffel, 2003).

The short version of the Depression, Anxiety and Stress Scale (DASS-21; Lovibond & Lovibond, 1995) is a brief self-report measure that was used to assess current levels of depression and anxiety. This measure has good internal validity for each of the three subscales (Depression = .94, Anxiety = 0.87 and Stress = 0.91), as well as reasonable concurrent validity (relevant subscales accord well with well-established measures of anxiety and depression, e.g., Beck Anxiety Iventory & Beck Depression Inventory) – see Antony, Beiling, Cox, Enns, and Swinson (1998). It requires each participant to rate 21 items (7 measuring Anxiety, 7 Depression, and 7 Stress) on a 4-point scale according to how much each item has applied to him/her over the past week. Scores greater than 1 standard deviation from the normative sample mean (categorised as 'moderate' symptoms) on Depression and Anxiety subscales were used as a basis for exclusion from the study.

The Wechsler Test of Adult Reading (WTAR; Wechsler, 2001) is composed of a list of 50 words of increasing difficulty that participants were asked to read aloud. Scores on this test were used to provide an estimation of premorbid intellectual functioning (predicted FSIQ scores; see Wechsler). The Brain Health Questionnaire (BHQ) is a customised, self-report measure that requires participants to list medication taken, as well as the number of hours spent engaged in physical exercise, mental stimulation (e.g., reading, crosswords, Sudoku), focused relaxation (e.g., meditation) and social activity in an average week (see Appendix C).

Cognitive functions assessment. Eight tests from the CogState battery were used to measure attention, working memory, processing speed and other executive function skills. This computerised test battery was selected because of its brief, standardised method of administration, as well as its good construct validity (Maruff et al., 2009), test-retest reliability (Collie, Maruff, Darby, & McStephen, 2003) and sensitivity to change (Jager et al., 2006). Participants responded to stimuli presented on desk-top computers using a standard mouse, and keyboard with the 'K' key covered by a 'Y' sticker to denote a "yes" response, and the 'D' key covered by an 'N' sticker to denote a "no" response. Audio feedback was provided to participants to indicate incorrect responses, and headphones were provided to maximise task focus.

At the beginning of each task, written instructions appeared on the computer screen which participants were directed to read before completing a short practice trial. The real test then commenced, which they were instructed to complete "as accurately and as fast as possible". Task stimuli were in the form of playing cards, a maze grid, and simple shapes, which were presented on a green background. The eight tasks administered and the cognitive functions they measure are described below, in order of presentation:

Groton Maze Learning Test (GML). This test provided a measure of executive function abilities (involving error monitoring, spatial problem solving and visuomotor processing). It consists of a 10 x 10 grid of tiles containing a 28-step hidden pathway that participants were required to find by using the computer mouse to click on each tile. A correct move (tile) was indicated by the appearance of a green tick, an incorrect move by a red cross. Rules included not moving diagonally or backwards along the pathway. A total of five learning trials were presented (each one containing the same hidden pathway). Twenty well-matched alternate forms of this test were pseudo-randomly administered to participants.

Detection Task (DET). This card task was used to measure processing speed. A single card was presented in the centre of the screen and participants were required to press the 'K' key to indicate "yes" as soon as the face of the card appeared (following the on-screen pre-task instruction "Has the card turned over?"). The task contained 35 trials.

Identification Task (IDN). This task was used to provide a measure of sustained attention. A single card was presented in the middle of the screen. As soon as it turned over (revealing a red or black 'Joker' face) participants were required to press the 'K' ('yes') or 'D' ('no') key following the pre-task instruction "Is the card red?". The task contained 30 trials.

One Card Learning Task (OCL). This task was administered to measure visual learning and memory. Pre-task on-screen instructions included "Have you seen this card before in this task? If yes, press the 'K' key, if no, press the 'D' key." Three sets of 14-card groups were presented (42 trials in total) that contained six repeating and eight distracter cards.

One-back Memory Task (ONB). This task provided a measure of simple working memory. A series of single playing cards were presented and participants were required to press the 'K' ('yes') or 'D' ('no') key according to the pre-task instruction "Is the card the same as the previous card?". The task contained 31 trials.

Two-back Memory Task (TWOB). This task was used to measure complex working memory. It followed the same format as the One-back Memory task, except that participants were required to respond to card stimuli according to whether "the card [is] the same as that shown two cards ago?". The task contained 32 trials.

Continuous Paired Associate Learning Task (CPAL). This two-stage task was used to provide a measure of visuospatial learning and memory. The first stage required participants to learn the location of eight shapes concealed beneath blue circles on the screen. In the second stage, previously learned shapes were presented sequentially in the centre of the screen and the participant was required to click (using the computer mouse) the hidden location (blue ball) where the shape previously appeared. This task consists of six rounds, and each round is classified as complete when the participant has found the correct location for each shape.

Groton Maze Learning Test – Delayed Recall (GMR). This test of delayed memory recall involved presentation of the GML test grid and required participants to reproduce the (28-step) pathway learned in the GML test (at the beginning of the session). It consisted of one trial only.

Performance measures for each CogState task were recorded automatically under each participant's code as either speed of response (mean reaction time in milliseconds), accuracy of response (proportion of correct responses), or number of errors (possible range of values is 0 to infinity). A logarithmic base 10 transformation was automatically applied to mean reaction time for correct responses by the CogState program in order to normalise data distributions, resulting in a possible score range of 2 to 5 (a lower score indicates better performance). Similarly, an arcsine transformation of the square root of the proportion of correct responses was applied to normalise accuracy data, leading to a possible score range of 0 to 1.57 (a higher score indicates better performance). The following primary outcome measures for tasks were selected in accordance with CogState guidelines (CogState, 2008): speed of performance for DET and IDN; accuracy of performance for OCL, ONB, TWOB, and CPAL; mean number of errors for GML and GMR.

Self-report measures. The Five Facet Mindfulness Questionnaire (FFMQ; Baer, Smith, Hopkins, Krietemeyer, & Toney, 2006) was used to measure level of perceived ability to use mindfulness skills in everyday life. It consists of 39 items designed to measure five facets of mindfulness, including Observing (e.g., "I pay attention to sensations, such as the wind in my hair or sun on my face."), Describing (e.g., "I am good at finding words to describe my feelings"), Acting with Awareness (e.g., "I find myself doing things without paying attention."), Nonjudging of inner experiences (e.g., "I criticize myself for having irrational or inappropriate emotions"), Nonreactivity to inner experiences (e.g., I perceive my feelings and emotions without having to react to them"). Participants rated each statement on how often it applied to them using a scale from 1 ('never') through to 5 ('always'). In accordance with scoring guidelines (see Baer et al., 2006), scores for each of the five facets were summed to produce a total mindfulness score (the primary measure used in the current study). The possible score range was 39 to 195, with a higher score indicating a higher subjective rating of facets of mindfulness.

The FFMQ has been shown to have reasonable internal consistency (alpha coefficients for each subscale range from 0.75 to 0.91; Baer et al.), although recent findings question its construct validity, suggesting that the FFMQ subscales do not measure all aspects of mindfulness (e.g., Van Dam, Hobkirk, Danoff-Burg, & Earleywine, 2012). However, similar criticisms have been made of other well-known mindfulness questionnaires (e.g., Mindfulness Attention Awareness Scale [MAAS], Brown and Ryan, 2003; Freiburg Mindfulness Inventory [FMI], Buchheld, Grossman and Walach, 2001), and there is no gold standard mindfulness questionnaire (Grossman & van Dam, 2011). We therefore chose to use the FFMQ because of its popularity, ease of administration, and relative comprehensiveness.

Mindfulness meditation training materials. MM participants were provided with two Mindfulness training CDs with audio instructions to guide them in daily practice of mindfulness meditation techniques introduced during each weekly training session. CD 1 (Cayoun, 2004) includes Rationale for Mindfulness Training, Progressive Muscle Relaxation, Mindfulness of Breath, and Basic Body Scan. CD 2 (Cayoun, 2005) covers more advanced body-scanning techniques (Symmetrical Scanning, Partial Sweeping, Sweeping en Masse and Transversal Scanning).

A weekly practice log sheet (see Appendix D) was also provided to MM participants to record mindfulness practice dates, times, duration and difficulty (rating out of 100).

Procedure

Pre-training neuropsychological testing. Upon obtaining permission from the Human Research Ethics Committee (see Appendix E), participants in the MM group attended individual pre-intervention testing sessions at the University of Tasmania Psychology Research Centre. Information and consent forms were provided to each participant (see Apendices F & G), and upon acquisition of consent, screening and self-report questionnaires were administered. Following a 10-15 minute tea/coffee break, participants received verbal instructions from the experimenter about the nature of the CogState tasks (based on the pre-task on-screen CogState instructions). Participants were then seated at a computer to complete the CogState battery, which was administered according to the format described in the *Materials* section, above. Participants were informed that they might ask for assistance during the 'practice' trials, but would receive no assistance during the 'real test' trials. Testing took place in a quiet, well-lit room, and total testing time was 2-3 hours.

In light of previous findings that using CogState data from a second testing session as a baseline measure virtually eliminates practice effects (e.g., Collie et al., 2003; Falleti, Maruff, Collie, & Darby, 2006), participants returned within a week to repeat the CogState battery. The test battery was administered to groups of four in a large, quiet room containing four desk-top computers with headphones. Testing time for the CogState battery was approximately 20 minutes.

Mindfulness meditation training. Following completion of neuropsychological testing and screening, eligible participants attended a 10-week mindfulness meditation course conducted by a clinical psychologist with extensive experience in mindfulness meditation training. Training consisted of two parts: 1) weekly two-hour group meetings, where mindfulness meditation techniques were explained and delivered hierarchically, and 2) individual home meditation practice (audio-guided via a CD) for 30 minutes twice daily (morning and evening). The first week of the program specifically taught Progressive Muscle Relaxation to assist participants in establishing a daily practice routine before commencing MM. In the second and third weeks, participants learned mindfulness of the breath (concentrative/focused attention MM techniques), and the remaining seven weeks involved the development of open-monitoring (body-scanning) MM techniques.

Post-training testing. Following the mindfulness meditation training course, participants attended an individual session (approx 2 hours) where they completed all pre-training test measures aside from the DRS-2 and WTAR (screening tests).

Control Group. Consent was obtained to use previously collected data from (inactive) ACE control group participants who had completed the same neuropsychological assessment procedure (baseline and three-month follow-up) 14-17 months previously. Upon obtaining written consent, participants were screened for previous meditation experience (they had previously demonstrated eligibility according to all other exclusion criteria) and completed the FFMQ. Note that the

FFMQ was only completed once by the control group (24 months after they had completed the other tests), as it was not part of the ACE project test battery.

Design and Analysis

A 2 [Group: Mindfulness Meditation, Control] x 2 (Time: Pre-training, Post-training) mixed factorial design was employed. A series of 2[Group: Mindfulness Meditation, Control] x 2 (Time: pre-, post-training) mixed factorial ANOVAs were conducted to analyse group differences in cognitive function scores (one for each CogState primary outcome variable, described above) and other cognitively stimulating activities (BHQ scores). Within- and between-group differences in mindfulness (FFMQ total raw scores) were also examined. Partial eta squared (ηp^2) effect sizes were calculated for each main effect and interaction, with the magnitude of effect size interpreted as ≥ 0.01 = small, ≥ 0.06 = medium, and ≥ 0.14 = large (Sink & Stroh, 2006).

Prior to running these analyses, data were visually inspected for outliers in order to assess the normality of data distribution, with points outside of Boxplot whiskers being removed (i.e., > 1.5 x Interquartile range). Analyses were then conducted on both cleaned and uncleaned data and the results were compared: for variables where removal of outliers made no difference to the significance of the *p* value, results based on the full data set are reported; for variables whose significance level varied with the removal of outliers, results from cleaned data sets are reported. Note that transformations (arcsine or logarithmic base 10) had been applied to most cognitive function (CogState) data in order to optimise normal data distribution.

All significant main effects and interactions were followed up using multiple comparison paired- and independent-samples *t*-tests, with False Discovery Rate corrections (Curran-Everett, 2000) being applied to control for Type I error rates.

Alpha was set at .05. Cohen's *d* was used as a measure of *t*-test effect size, and was interpreted as ≥ 0.2 = small, ≥ 0.5 = medium, ≥ 0.8 = large (Cohen, 1988). Morris and DeShon's (2002) equation 8 correction for dependence between means was applied to Cohen's *d* values based on paired-samples *t*-tests.

Results

Baseline Group Equivalence on Demographic, Cognitive, and Psychological variables

Preliminary examinations revealed minimal Group (MM; Control) differences at pre-test on demographic variables (age, sex, education, estimated FSIQ (WTAR)), as well as measures of cognitive function (DRS-2), and psychological wellbeing (DASS-21) (see Table 1). Independent-sample *t*-test analyses revealed these differences to be non-significant, indicating Group equivalence on demographic features and basic measures of cognitive and psychological functioning.

Table 1

Group Means and Standard Deviations (in brackets) for Demographic Variables, and DASS Scores at Pre-test

Variable	MM Group	Control Group	Independent-samples *t*-test
Age (yrs)	69.41 (6.67)	68.73 (6.38)	$t\,(42) = 0.35, p = .731$
Education (yrs)	13.64 (2.68)	14.28 (3.86)	$t\,(42) = -0.65, p = .522$
WTAR	111.82 (4.23)	113.77 (6.71)	$t\,(42) = -1.16, p = .254$
DRS-2 score	11.91 (2.39)	12.68 (2.19)	$t\,(42) = -1.12, p = .270$
Days between pre-& post-test	94.41 (7.77)	100.23 (13.19)	$t\,(42) = -1.78, p = .082$
DASS z-scores			
Depression	-0.44 (0.58)	-0.43 (0.53)	$t\,(42) = -0.05, p = .957$
Anxiety	-0.52 (0.51)	-0.61 (0.34)	$t\,(36.66) = 0.66, p=.512$†
Stress	-0.56 (0.66)	-0.34 (0.65)	$t\,(41) = -1.10, p = .277$

† Values computed based on unequal variance due to significant violation of Levene's test of homogeneity of variance.

Mindfulness Meditation Practice and Mindfulness Skills

In order to attribute any post-test differences in cognitive function measures to the effect of the intervention, an increase in MM practice and the development of mindfulness skills needed to be demonstrated. This was achieved by examining MM practice logs kept by MM Group participants during the intervention, as well as Group differences and changes in FFMQ scores.

Practice log scores. Overall, participants who received the MM training (n = 22) adhered closely to the recommended weekly number of home MM practice sessions (14 – two per day), completing a total weekly mean of 13.13 sessions (SD = 1.35; range = 6-14) across the nine weeks (data were not collected for the tenth week). Per individual, mean number of practice sessions per week ranged from 11 (SD = 3.25) to 14 (SD = 0).

Mindfulness levels (FFMQ). Since Control Group participants completed the FFMQ on only one occasion, a 2 [Group] x 2 (Time) ANOVA could not be performed on Group differences at pre- and post-test. Two t-tests were instead conducted. A paired-samples t-test revealed that the MM Group's mean FFMQ total score increased significantly from pre- to post-test, t (21) = -4.46, $p < .001$ ($M_{pre\text{-}test}$ = 132.64, SD = 14.42, compared with $M_{post\text{-}test}$ = 142.73, SD = 13.46). The effect size was large (d = -0.954), indicating that the MM Group's self-reported level of mindfulness improved to a meaningful extent following the MM intervention. Control Group participants obtained a mean total of 138.36 (SD = 16.11). An independent-samples t-test revealed that the MM Group's mean at pre-training did not differ significantly to that of the Control group, t (42) = -1.24, p = .22, d = -0.375.

BHQ Scores

Group means and standard deviations for healthy lifestyle activities are displayed in Table 2.

Table 2

Means and Standard Deviations (in brackets) for Average Number of Hours Per Week Spent Engaged in Physical Exercise, Social Activity, and Mental Stimulation, as Reported by MM and Control Group Participants

	Pre-test		Post-test	
BHQ measure	MM	Control	MM	Control
Physical exercise	10.62 (7.13)	11.76 (13.36)	11.95 (7.60)	10.66 (7.71)
Social activity	13.86 (9.65)	11.98 (9.49)	14.32 (10.09)	11.57 (6.43)
Mental stimulation	14.97 (7.17)	18.60 (11.85)	16.0 (6.27)	22.20 (11.82)
Focused relaxation	0.09 (0.33)	0.92 (1.77)	5.98 (2.18)	1.40 (3.22)

Physical exercise. The average number of hours per week spent engaged in physical exercise was similar for both Groups at pre-test, and at post-test it had increased slightly for the MM Group and decreased slightly for the Control Group (see Table 2). A mixed factorial ANOVA revealed these differences to be non-significant, with no main effects (Time: F (1, 42) = 0.01, p = .918, $\eta p^2 < .001$; Group: F (1, 42) = 0.001, p = .976, $\eta p^2 < .001$) and no significant Group x Time interaction (F(1, 42) = 1.20, p = .279, $\eta p^2 = .028$).

Social activity. The average number of hours per week that participants reported being engaged in social activity at pre-test was slightly higher within the MM Group compared with the Control Group. At post-test, the MM Group's social activity level had increased slightly, while the Control Group's had decreased slightly (see Table 2). However, a mixed factorial ANOVA revealed these differences to be non-significant, with no main effects (Time: $F(1, 42) < 0.001$, $p = .983$, $\eta p^2 < .001$; Group: $F(1, 42) = 0.86$, $p = .358$, $\eta p^2 = .02$) and a non-significant Group x Time interaction ($F(1, 42) = 0.16$, $p = .695$, $\eta p^2 = .004$).

Mental stimulation. The reported average number of hours per week spent engaged in mentally stimulating activities at pre-test was lower in the MM Group compared with the Control Group, and both Groups' reported mental activity levels increased between pre- and post-test (see Table 2). A mixed factorial ANOVA revealed a main effect of Group, $F(1, 37) = 3.84$, $p = .058$, $\eta p^2 = .09$, such that overall, the Control Group reported significantly higher levels of mental stimulation than the MM Group, regardless of Time. There was no main effect of Time ($F(1, 37) = 1.59$, $p = .215$, $\eta p^2 = .041$), nor was the Group x Time interaction significant ($F(1, 37) = 0.49$, $p = .487$, $\eta p^2 = .013$).

Focused relaxation. Participants' ratings at pre-test of the number of hours per week spent engaged in focused relaxation (including MM) were low for both the MM and Control Groups. As expected, reported levels of focused relaxation were substantially higher for the MM Group following the intervention, with only a slight increase observed in the Control Group at post-testing. A mixed factorial ANOVA was conducted to examine differences in focused relaxation. It revealed main effects of Group ($F(1, 42) = 11.29$, $p = .002$, $\eta p^2 = .21$) and Time ($F(1, 42) = 96.34$, $p < .001$, $\eta p^2 = .70$), which were subsumed by a significant Group x Time interaction ($F(1, 42) = 69.60$, $p < .001$, $\eta p^2 = .62$), shown in Figure 1.

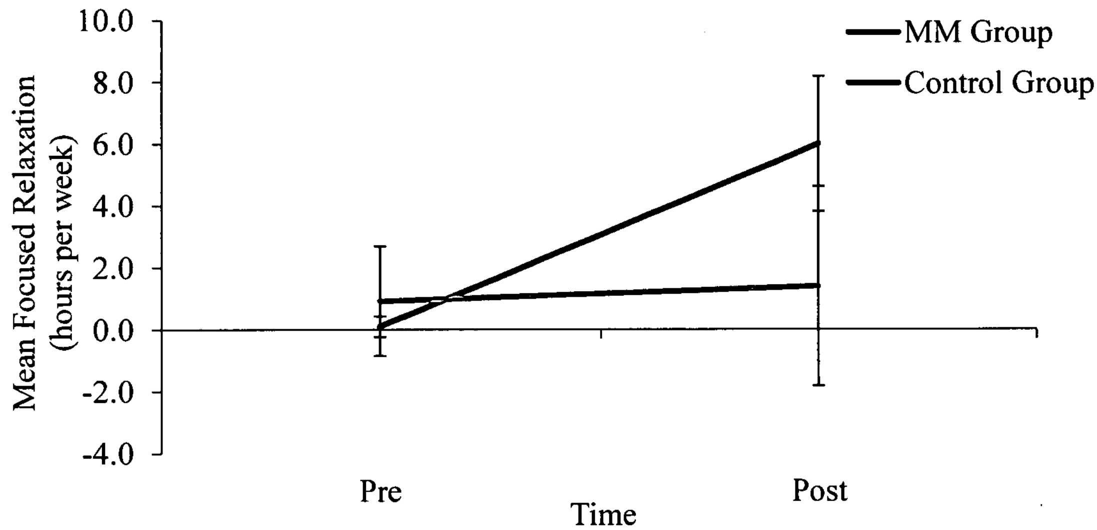

Figure 1. Mean amount of time spent engaged in focused relaxation (hours per week) for each Group at Pre- and Post-test. Vertical bars represent standard deviations.

Paired- and independent-samples *t*-tests were conducted to clarify the Group x Time interaction. Between-subject *t*-tests revealed that at pre-test, the Control Group spent significantly more time engaged in focused relaxation than the MM Group (t (22.49) = -2.17, p = .036, d = -0.709), but that following the intervention, the MM Group spent significantly more time engaged in focused relaxation (predominantly MM) than the Control Group (t (42) = 5.53, p < .001, d = 1.696). The increase in amount of time spent engaged in focused relaxation at post-test compared to pre-test was significant for the MM Group (t (21) = -12.59, p < .001, d = -3.380) but not for the Control Group (t (21) = -1.06, p = .300, d = -0.300).

CogState Cognitive Function Tasks

Pre-test and Post-test differences between MM and Control Groups' performance on CogState tasks measuring attention, working memory, executive function, processing speed/psychomotor function, and visual-spatial learning and memory are presented in Table 3.

Table 3

Group (MM; Control) Means and Standard Deviations (in brackets) for Performance on Tests of Cognitive Functions according to Time (Pre-test, 3 months Post-test)

	Pre-test		Post-test	
CogState test	MM	Control	MM	Control
IDN (speed)	2.71 (0.05)	2.71 (0.05)	2.70 (0.05)	2.71 (0.05)
ONB (accuracy)	1.41 (0.11)	1.40 (0.17)	1.38 (0.15)	1.41 (0.17)
TWOB (accuracy)	1.25 (0.13)	1.22 (0.13)	1.27 (0.14)	1.26 (0.14)
GML (total errors)	58.73 (23.44)	52.68 (18.58)	50.64 (15.70)	48.55 (13.51)
GMR (total errors)	10.68 (4.83)	8.73 (4.51)	8.64 (4.37)	7.05 (4.25)
CPAL (accuracy)	0.74 (0.20)	0.78 (0.21)	0.85 (0.24)	0.90 (0.26)
OCL (accuracy)	0.99 (0.09)	1.03 (0.12)	1.38 (0.15)	1.41 (0.17)
DET (speed)	2.52 (0.10)	2.57 (0.11)	2.55 (0.10)	2.54 (0.11)

Note. Speed = $\log_{10}$ transformed reaction time (milliseconds) for correct responses; a lower score indicates better performance. Accuracy = accuracy of performance (arcsine transformation of the square root of the proportion of correct responses); a higher score = better performance. Total errors = total number of errors (no data transformation applied); a lower score = better performance.

Table 4

Group and Time Main Effects and Interactions for Cognitive Function Variables

CogState test	Time main effect	Group main effect	Group x Time Interaction
IDN	F (1, 42) = 0.089, p = .767, ηp^2 = .002	F (1, 42) = 0.234, p = .631, ηp^2 = .006	F (1, 42) = 0.32, p = .577, ηp^2 = .007
ONB	F (1, 42) = 0.188, p = .667, ηp^2 = .004	F (1, 42) = 0.111, p = .741, ηp^2 = .003	F (1, 42) = 0.44, p = .512, ηp^2 = .01
TWOB	F (1, 42) = 2.10, p = .155, ηp^2 = .048	F (1, 42) = 0.364, p = .550, ηp^2 = .009	F (1,42) = 0.09, p = .766, ηp^2 = .002
GML	F (1, 42) = 6.96, p = .012, ηp^2 = .142*	F (1, 42) = 0.669, p = .418, ηp^2 = .016	F (1,42) = 0.73, p = .398, ηp^2 = .017
GMR	F (1, 42) = 6.72, p = .013, ηp^2 = .138*	F (1, 42) = 2.38, p = .130, ηp^2 = .054	F (1,42) = 0.06, p = .802, ηp^2 = .002
CPAL	F (1, 42) = 8.66, p = .005, ηp^2 = .171**	F (1, 42) = 0.675, p = .416, ηp^2 = .016	F (1,42) = 0.06, p = .807, ηp^2 = .001
OCL	F (1, 42) = 147.35, p < .001, ηp^2 = .778***	F (1, 42) = 2.23, p = .143, ηp^2 = .050	F (1,42) = 0.04, p = .838, ηp^2 = .001
DET	F (1, 41) = 0.01, p = .920, ηp^2< .001	F (1, 41) = 0.52, p = .474, ηp^2= .013	F (1,41) = 3.57, p = .066, ηp^2= .08

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

Attention and working memory. As seen in Table 3, there was little difference in either the MM or Control Group's performance on measures of attention (Identification task [IDN]) or working memory (One-back [ONB] and Two-back [TWOB] Memory tasks) at pre- or post-test. The results of three separate 2 [Group: MM, Control] x 2 (Time: Pre-test, post-test) mixed factorial ANOVAs (see Table 4) revealed no significant interactions or main effects for any of the three tasks, confirming that there was no significant change across Time or between Groups on measures of attention and working memory.

Executive function and visuospatial learning/memory. As seen in Table 3, the Control Group performed slightly better than the MM Group at pre-test on measures of executive function (Groton Maze Learning Test [GML]) and visuospatial learning/memory (One Card Learning Task [OCL], Continuous Paired Associate Learning [CPAL] Task), including delayed visuospatial memory (Groton Maze Learning Test – Delayed Recall [GMR]). Both Groups' performance on these measures improved from pre- to post-test. These improvements over time were significant, with mixed factorial ANOVAs revealing significant main effects of Time for all four measures: overall, participants made significantly fewer errors at post-training compared with pre-test on GMLT (F (1, 42) = 6.96, p = .012, ηp^2 = .14) and GMLT Delayed Recall (F (1, 42) = 6.72, p = .013, ηp^2 = .14), and obtained significantly higher proportions of correct responses for OCL (F (1, 42) = 147.35, p < .001, ηp^2 = .78) and CPAL (F (1, 42) = 8.66, p = .005, ηp^2 = .17) tasks. These findings indicate that all participants (irrespective of whether they had received MM training or no intervention) performed more accurately on measures of executive function and visual learning/memory at post- compared to pre-testing. There were no main effects of Group or significant Time by Group interactions for any of these measures (see Table 4).

Processing speed. As seen in Table 3, at pre-test the MM Group's reaction time on the Detection (DET) task was slightly faster than the Control Group's reaction time, but at post-test the MM Group's reaction time had increased slightly, while the Control Group's reaction time had decreased slightly. A mixed factorial ANOVA revealed a trend for a Group x Time interaction (F (1, 41) = 3.57, p = .066, ηp^2 = .08) (see Figure 2), but no main effects (see Table 4). Given the presence of a moderate effect size, we chose to explore the trend by conducting independent- and within-samples t-tests. However, the results of t-tests were non-significant for both between-Group comparisons (t(41) = -1.48, p = .147, d = -0.286 at pre-test; t(42) = -0.28, p = .783, d = 0.095 at post-test) and within-Time comparisons (t(20) = 1.50, p = .149, d = -0.240 for MM Group; t(21) = 1.20, p = .243, d = 0.263 for Control Group). Overall, these results indicate that participants' performance on this test of processing speed/psychomotor function did not vary significantly as a function of Group or Time.

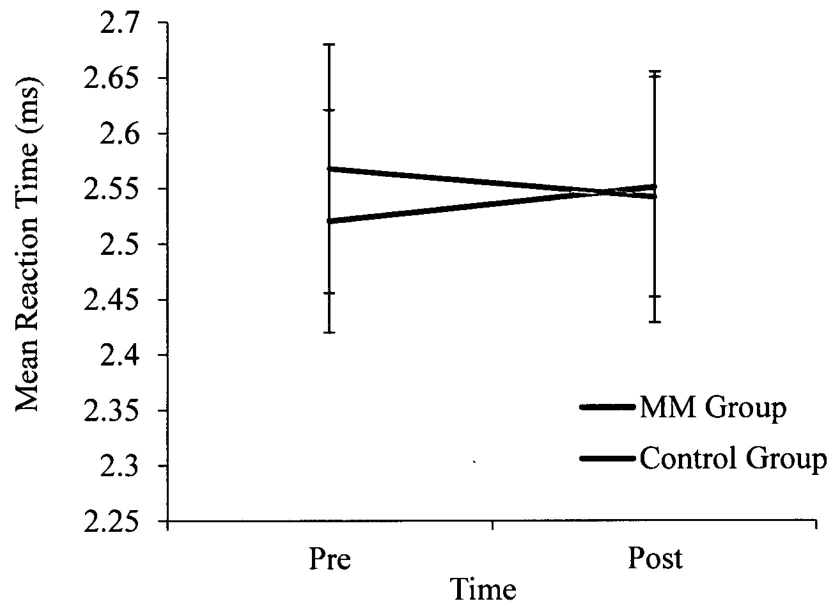

Figure 2. Mean Detection task $\log_{10}$ transformed reaction time (milliseconds) for MM and Control Groups at pre- and post-testing.

Reliable Change Index (RCI) scores for cognitive function variables. In the absence of significant Group x Time interactions for cognitive measures, another method of change analysis was conducted. This involved calculating Reliable Change Indices (RCI) scores for each cognitive function measure, which were obtained by dividing individuals' test-retest difference scores by the standard error of that difference score. RCIs higher than 1.96 and lower than -1.96 were classified as significant positive and negative change, respectively (Collie, Darby, Falleti, Silbert, & Maruff, 2002). Chi-square tests were then conducted to compare Groups on a number of significant (positive and negative) RCI scores for each cognitive function variable (see Table 5). None of the Chi-square tests on the number of RCIs for each cognitive function test were significant, indicating that the number of participants who performed significantly better on tests of cognitive function from pre- to post-test did not vary significantly according to Group allocation.

Table 5

Frequency of Significant Change (Positive, Negative and No Change) for each Group on CogState Test Variables

	MM Group			Control Group			
Test variable	+ change	- Change	No change	+ change	- Change	No change	χ^2 test result
IDN (speed)	8	8	6	7	6	9	$\chi^2(2) = 0.95, p = .747$
ONB (accuracy)	6	7	9	10	6	6	$\chi^2(2) = 1.68, p = .483$
TWOB (accuracy)	8	4	10	10	7	5	$\chi^2(2) = 2.71, p = .302$
GML (total errors)	2	11	9	4	6	12	$\chi^2(2) = 2.57, p = .350$
GMR (total errors)	4	10	8	5	11	6	$\chi^2(2) = 0.44, p = .800$
CPAL (accuracy)	10	3	9	12	3	7	$\chi^2(2) = 0.43, p = .914$
OCL (accuracy)	9	5	8	10	6	6	$\chi^2(2) = 0.43, p = .861$
DET (speed)	8	4	10	4	7	11	$\chi^2(2) = 2.20, p = .395$

Notes. + change = RCI > 1.96; - change = RCI < 1.96; *p* values were derived from Pearson's Chi-square exact probability (two-tailed). For accuracy measures, + change indicates improved performance; for total errors and speed measures, - change indicates improved performance.

Discussion

The aim of the current study was to investigate the potential for a 10-week mindfulness meditation (MM) training program to produce process-specific learning in older adults, as measured by enhanced performance on neuropsychological tests of attention, working memory, visuospatial learning and memory, executive functions and processing speed following MM training. Overall, the results provide scant support for the hypotheses that MM participants would show significant improvements on neuropsychological tests of cognitive functions, relative to an inactive control group.

Contrary to the hypothesis, MM participants did not obtain significantly faster reaction time scores on the test of sustained attention (Identification task) at post-training compared with pre-training. This result provides mixed support for previous findings using a young adult sample. It does not support findings of significant improvements on tests of sustained attention among meditation-naive participants following a 10-day Vipassana MM retreat (Chambers et al., 2007) and among experienced meditators following a one-month concentrative MM retreat (Jha et al., 2007). However, this result is consistent with findings of other studies showing no change in measures of attentional control in meditation-naive participants following non-intensive eight-week MBSR programs (Jha et al.; Anderson et al., 2007). Therefore, a possible explanation for the lack of improvement on a test of sustained attention observed in the current study is that the MM training program was not sufficiently long or intense enough to produce significant changes in sustained attention skills.

Against expectation, MM participants did not exhibit significantly faster reaction times in the processing speed (Detection) test at post-test compared with pre-test. This result is not consistent with previous findings that meditation (mostly concentrative styles, e.g., Transcendental Meditation) improves processing speed in young adults (Cahn & Polich, 2006), nor does it support cross-sectional data showing that older adult concentrative meditators performed significantly better than age-matched non-meditators on tests of processing speed (Prakash et al., 2011).

One possible explanation for this difference in processing speed findings relates to differences in emphasis on MM techniques. Holzel et al. (2011) reported that different MM techniques have varying effects on attention. The current study emphasised open-monitoring (body-scanning) techniques (concentrative techniques were taught for two weeks only), while previous studies of processing speed have mainly involved concentrative techniques. It may be that the open-monitoring techniques emphasised in the current study are less closely related to the development of attention skills used in processing speed tasks than are concentrative meditation techniques examined by Prakash et al. and reviewed by Cahn and Polich. A second possible explanation for the difference between findings of the current study and those of previous studies relates to the choice of task. The current study examined reaction time to the detection of visual stimuli (involving a simple motor response), whereas Prakash et al. measured the number of correct written responses within a timed (90 second) interval for a digit-symbol coding task. It may be that MM training enhances processing efficiency of visual information but not reaction-time for psychomotor performance-based tasks. Support for this explanation comes from recent findings by Jensen, Vangkilde, Frokjaer, and Hasselbalch (2012) that suggest that reaction-time-based tests of attention are unsuitable for testing the effect of MM training programs, as they are susceptible to significant improvement through attentional effort alone.

Mindfulness meditation participants' accuracy on working memory (One-back- and Two-back Memory) tests also did not improve significantly at post-test compared with pre-test. These results do not support the hypotheses, and are inconsistent with previous research which shows improved performance for young adults on tests of working memory following 10 days of intensive (Vipassana) MM training (Chambers et al., 2007) or eight weeks of less intensive (MBSR-based) MM training (Jha et al., 2010). A possible explanation for these differences relates to MM training methodology. The present study used a Vipassana methodology and approximately the same number of hours of MM practice (80-90) as the intensive traditional 10-day retreat studied by Chambers et al. (about 100 hours), but spread over nine weeks. MBSR, used by Jha et al. (2010), is an adapted version of Vipassana meditation (Kabat-Zinn, 1982), including yoga practice and implementation differences, such as predominance of orally-guided practice of concentrative practice, versus the Vipassana emphasis is on silent practice of open-monitoring. These methodological differences may have differential effects on cognitive performance.

Differences in choice of task should also be considered as an explanation for the lack of expected improvements in working memory tasks, as the (CogState) task measures used in the current study have not (to our knowledge) been previously used to examine the effect of MM training on working memory. However, there is no reason to suggest that they are not comparable to previously used (Digit Span and Ospan) tasks. The ONB and TWOB tasks have demonstrated good construct and test-retest reliability (Collie et al., 2003; Maruff et al., 2009) and involve visual presentation of stimuli as does the Ospan task used by Jha et al. (2010) Nevertheless, it is possible that some task differences (such as the motor responses required in the current study versus verbal recall of information in the Ospan task) may have contributed to the lack of significant improvement in working memory performance found in the current study. An alternative explanation is that MM training may simply be less effective in enhancing working memory performance for older adults (as studied in the current project) than it is for younger adults (as studied by Chambers et al., (2007) and Jha et al.).

Partial support was gained for the hypothesis regarding changes in visuospatial learning/memory task performance following MM training. As predicted, MM group participants obtained significantly higher accuracy/lower error scores on tests of visuospatial learning/memory (One Card Learning Task, Continuous Paired Associate Learning, Groton Maze Learning Test – Delayed Recall) at post-test, compared with pre-test. Unexpectedly, the control group's performance on these tests also improved significantly from pre- to post-test, and the two groups' scores did not differ significantly at post-test. The observed improvements for the MM group were expected on the basis of previous findings that MM training enhances a range of attention skills that are necessary for many learning and memory tasks (Chiesa et al.; Rabipour & Raz, 2012). Possible explanations for the control group's unexpected improvement on these tasks are discussed in the following section.

Partial support was also gained for the hypothesis regarding changes in performance on an executive function test involving error monitoring/spatial problem-solving. As expected, MM group participants made significantly fewer errors at post-test compared with pre-test on the Groton Maze Learning Test. However, the control group's performance on this test also improved significantly from pre- to post-test, and the two groups' scores did not differ significantly at post-test. Overall, these results differ from Heeren et al.'s (2009) findings of a significant pre- to post-test improvement on executive function (verbal fluency) tests for the MM-trained group alone (the control group's performance did not change significantly).

A possible explanation for the difference in executive function results of the current study and those of Heeren et al. relates to the type of executive function tasks used. The term *executive functions* encompasses a wide range of cognitive skills (Salthouse, Atkinson & Berish, 2003) and while both verbal fluency and error monitoring/spatial problem-solving tasks belong to this cognitive category, they involve the use of different skills. Furthermore, Chiesa et al. have suggested that MM training may have a less powerful effect on executive functions that require a motor response, such as the Groton Maze Learning Test used in the current study, compared to ones that are purely cognitive, such as the verbal fluency tasks used by Heeren et al. Support for this explanation comes from Heeren et al.'s findings that MM training did not enhance performance on motor inhibition or motor flexibility tasks. These differences in task methodology and choice of task may explain why the MM group in the current study did not improve significantly more than the control group on the executive functions as measured in the current study. However, this explanation does not account for the control group's improved performance on this task.

Task Practice Effects versus Improved Attentional Control

Task practice effects are a seemingly obvious explanation for the equally significant increase in performance on executive function and visual-spatial learning/memory tasks for both the MM and control groups. That is, repeated experience with testing procedures and task instructions may have led to better task performance. The present study was designed to avoid practice effects by testing participants twice at pre-test and taking the second baseline measure as the point of comparison to three-month-post-test results. This methodology was recommended by researchers who have found that CogState task performance in young adults stabilises following a second testing session (Collie et al., 2003; Falleti et al., 2006) and that older adults demonstrate no improvement in CogState task performance between baseline and three-month-post testing (Fredrickson et al., 2009). However, previous practice-effect research did not include investigation of the GML, GMR, OCL and CPAL tasks used in the current study. These tasks involve a more complex memory component than the CogState tasks previously tested, and it is suggested that they may therefore be open to greater improvement with practice through the application of more effective cognitive strategies (e.g., visualisation memory techniques) than simpler CogState tasks such as IDN, ONB and DET tasks (which, it may be argued, are less susceptible to the use of cognitive strategies).

An alternative explanation for the overall (non MM-training-specific) improvement on executive function and visual-spatial learning/memory tasks is that the MM training enhanced the MM group's performance, while an extraneous factor (such as applied cognitive effort) was responsible for task improvements in the control group. The first step in assessing whether MM training may have produced the performance improvements evident in the MM group was to confirm that the program delivered to participants was of a comparable standard to previous interventions, and that it was well adhered to by participants. This was clearly the case, as the training was delivered by an experienced MM trainer and practitioner (with 20+ years personal Vipassana meditation experience), and participants attended a high proportion of the training sessions and closely adhered to the recommended number of individual practice sessions. Further evidence of the program's effectiveness comes from analysis of the MM group's FFMQ data, which showed significant and large improvements on subjective ratings of mindfulness in everyday life. However, a placebo effect on perceived mindfulness cannot be ruled out, as the control group only completed the FFMQ on one occasion, and it was therefore not possible to compare the changes in FFMQ ratings of both groups.

As it appears that the MM training program used in the current study was well-adhered to, it is necessary to consider the mechanism by which MM training may have improved performance in the areas of executive function and visuospatial learning/memory in the MM group. The theory underlying the efficacy of MM training to enhance these (and other) cognitive skills is that repetitive practice of concentrative and open-monitoring MM techniques results in the training of sustained-, selective- and executive attention skills (Holzel et al., 2011). The development of these core attentional skills has been proposed to result in process-specific learning (Slagter et al., 2011), leading to enhanced performance on a range of cognitive functions that require these skills, including memory and executive function abilities (Baddeley, 1998; Chiesa et al., 2011). As other studies (e.g., Chambers et al., 2007; Jha et al., 2007) have shown that MM training enhances these core attentional skills in younger adults, it is plausible that improved attentional control among MM group participants in the current study was responsible for their improved visuospatial memory and executive function skills. However, as a test of sustained attention was the only form of attention measured in the current study (on which the MM group did not show pre- to post-test improvements), it is not possible to confirm the mechanism by which MM training may have improved performance on tests of executive function and visuospatial learning/memory.

There is some support for the theory that control participants' improved performance on these tests was due to a confounding factor related to recruitment method. Participants were recruited as part of a control group in a research study into a new memory and thinking improvement program (ACE), and are likely to have been cognisant of the benefits of brain training exercises (e.g., Ball et al., 2002) taught to the ACE-trained group. Some of these participants initially applied to be part of the ACE-trained group (suggesting an interest in improving their memory), and ACE researchers reported that control group members in general seemed highly motivated to improve their performance on cognitive tests at each subsequent testing session (the control group were part of a longitudinal study and received feedback on their individual results at the end of each testing session). Considering the control group's seemingly high level of motivation to perform well on the cognitive tests and their likely awareness of brain training techniques, it is possible that they may have self-engaged in additional brain training skills (e.g., extra crosswords, practice of memory word lists etc) between pre- and post-test.

To test this theory, participants' self-reported average hours/week of physical exercise, mental activity, social activity, and focused relaxation activities (BHQ data) were examined. However, this revealed no significant pre- to post-test increases for the control group, relative to the MM group, on any of these variables (although, overall, the control group was significantly more mentally active than the MM group). This suggests that the control group's improved performance on executive function and visuospatial learning/memory measures is unlikely to be due to increased engagement in brain training exercises (or any of the other healthy lifestyle activities measured by the BHQ).

A more plausible explanation for the control group's improved performance on these tasks relates to their higher level of engagement in mentally stimulating activities (as measured by the BHQ) relative to the MM group. This (pre-existing) greater engagement in such activities may translate to a higher accumulation of cognitive strategies by the control group, which they may have been able to utilise more effectively with repeated CogState test administrations to improve their performance on the more complex (visuospatial learning/memory and executive function) tasks. That is, the control group's greater (baseline) experience of mentally stimulating activities may have predisposed them to exhibit larger practice effects than the MM group on complex cognitive tasks open to the use of cognitive strategies (and therefore more susceptible to practice effects). As previously discussed, the MM group's improved performance on these tasks may instead be related to increased attentional control. However, the absence of objective evidence of either increased attentional control in MM participants or greater access to cognitive strategies in control participants means that this theory cannot be regarded as a confirmed explanation of both group's pre- to post-test improvements in visuospatial learning/memory and executive function tasks.

Limitations and Future Research

There are a number of limitations to the current study that make it difficult to draw firm, generalisable, conclusions about the efficacy of MM training for enhancing cognitive functions in healthy older adults. First, the small sample of high-average intelligence older adults on which the results are based necessitates caution in generalising the results to the wider older adult population. Second, the non-random allocation of participants to groups resulted in some inter-group differences, such as higher engagement in mentally stimulating activities in the control group.

Third, there was no comparison intervention group (such as relaxation training or exercise), meaning that placebo effects, or cognitive benefits related to the structure of the intervention (e.g., meeting socially once a week) cannot be discounted for the MM group. Fourth, the two groups were assessed by different assessors, who were not blinded to the participants' group allocation; however, standardisation of test administration and scoring procedures limits the effect that this is likely to have had on results. Fifth, the length and intensity of MM training may not have been sufficient to improve performance on tests of cognitive function (especially sustained attention); greater benefits may have been observed following 6-12 months of MM practice or following an intensive retreat (e.g., Chambers et al., 2007). Sixth, the choice of task measures was not broad enough to assess all three of the three types of attention that form the basis of MM's claim to enhance process-specific learning; other limitations related to task measures are the use of reaction-time- and motor-response-based instead of purely cognitive measures (which have been shown to be less sensitive to MM benefits; Heeren et al., 2009; Jensen et al., 2012), as well as the use of only one test of executive function (not representative of all executive functions; Salthouse et al., 2003). Finally, although it was not a limitation per se, the emphasis on open-monitoring MM techniques employed in the current study's intervention is a factor that when combined with insufficient practice time, may account for the lack of MM-specific improvement on a cognitive tasks.

The present study is the first known prospective study to have compared the effect of a short MM training program with no intervention on performance on neuropsychological tests of cognitive function in older adults. Given the methodological limitations outlined above, there is therefore a strong need for further research to be conducted in this area. Specifically, future studies could examine the effect of MM skills practiced over a longer period of time (6-12 months) on low-, middle- and high-functioning older adults. Large numbers of participants might also be randomised to receive training in different aspects of MM training (concentrative alone, open-monitoring alone, combined techniques) and comparison interventions (e.g., relaxation training; exercise group). The choice of task measures should also comprise non-reaction-time-based measures of sustained, selective and executive attention, and utilise non-motor-response-based measures of other cognitive functions.

In conclusion, the current study has provided no evidence that a 10-week MM training program for older adults produces generalised improvements in a range of cognitive functions, relative to no formal mental training program. On the basis of these findings, this type of MM program cannot be recommended as an effective strategy to counter the increasing prevalence of age-related cognitive decline (ABS, 2008). However, in light of the methodological limitations of the present study, and considering the existing body of literature in support of the cognitive benefits of MM training for younger adults, further research must continue the investigation into the potential for using MM training to reduce the onset of age-related cognitive decline.

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Appendix A

Meditation Exclusion Criteria

Exclude the person if s/he practised mindfulness (MF) or concentrative type (e.g., Transcendental Meditation):

1. for more than 1 week in the past 6 months
2. daily for more than 3 months up to 2 years ago,
3. for more than 2 years up to 5 years ago

Exclude the person if s/he practised any kind of yoga:

1. for more than 1 week in the past 3 months
2. daily for more than 3 months up to 1 years ago
3. for more than 2 years up to 3 years ago

Appendix B

Telephone 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. You left a message expressing interest in the mindfulness meditation project that we're conducting...	
"How did you find out about the mindfulness research we are conducting?"	
"What makes you want to participate in the mindfulness research project?"	
"Before I tell you about this project, I just need to ask whether you ever been involved in other psychology studies, such as the Active Cognitive Enhancement (ACE) program? – even as a member of a control group?" (If YES, do not proceed with qs)	

- "In order to determine if you are eligible to participate in this research, I need to know some important information, and will be asking you a number of questions, some of which will be about personal habits. I 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
- Explain mindfulness meditation (briefly): mindfulness is a form of meditation that involves learning to focus your attention on your breath and body sensations. It has been shown to be particularly useful for managing distracting thoughts and unpleasant body sensations, such as pain.
- 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 the Clinical School, at the RHH, on Friday mornings from 10am-12pm. 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 tenweek 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 three sessions, and will take approximately seven hours in total. 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 (learn meditation skills) free of charge (normally $38-155 per session = $380-1550 total)
    - Receive feedback on your level of cognitive functioning free of charge as well.
- **Assuming that you meet our eligibility criteria, 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: **(Must fall between 9/9/1926 and 9/9/1951)**	
Postal 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,	**No** ☐ **Yes** ☐ *Provide details:*

anxiety disorder or other mental illness <u>that is not currently well-managed</u>?" *(with medication and/or psychotherapy):*	
"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>current</u> <u>average</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?" If yes, "How often?"	**No** ❑ **Yes** ❑
"Do you currently use illicit drugs?"	**No** ❑ **Yes** ❑ *Provide details:*
"What over-the-counter and prescribed medications do you currently take?" If they take various medications, ask participants to bring a list to their first session, including name of medication, and dosage frequency.	
"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., <u>full-time equivalent</u>, 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? 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, assessment times will be arranged with you when you are telephoned." **If caller appears to be eligible to participate, make a note of what days/times they are available for testing.** *Following interview, assign a code and insert at top of each page.*	

Appendix C
Brain Health Questionnaire (BHQ)

Brain Health Questionnaire

Name:______________________ Date: ______________________

What medications/supplements (prescription and over-the-counter) are you CURRENTLY taking?

Medication/Supplement Name	Dosage	Frequency

On average, how many hours, and what type(s) of exercise do you undertake per week?

Type of exercise	Hours per week (average)
Total number of hours per week (average)	

On average, how many hours of MENTAL STIMULATION (e.g., crosswords, sudoku, U3A, reading etc.) do you undertake per week?

Type of mental stimulation	Hours per week (average)
Total number of hours per week (average)	

On average, how much time do you spend engaging in FOCUSED RELAXATION (e.g., meditation, mindfulness, etc.) per week?

On average, how many hours time did you spend engaging in SOCIAL ACTIVITY per week?

Type of social activity	Hours per week (average)
Total number of hours per week (average)	

Appendix D

Weekly Mindfulness Meditation Practice Log

DAILY SCHEDULE OF MINDFULNESS PRACTICE

Your Name:	Date	a.m. (circle)	Duration	Rating % (How satisfied were you with your practise?)	p.m. (circle)	Duration	Rating % (How satisfied were you with your practise?)
Monday		Yes / No			Yes / No		
Tuesday		Yes / No			Yes / No		
Wednesday		Yes / No			Yes / No		
Thursday		Yes / No			Yes / No		
Friday		Yes / No			Yes / No		
Saturday		Yes / No			Yes / No		
Sunday		Yes / No			Yes / No		

Appendix E

Human Research Ethics Committee Research Approval Letter

Social Science Ethics Officer
Private Bag 01 Hobart
Tasmania 7001 Australia
Tel: (03) 6226 2763
Fax: (03) 6226 7148
Katherine.Shaw@utas.edu.au

HUMAN RESEARCH ETHICS COMMITTEE (TASMANIA) NETWORK

UTAS

10 August 2011

Professor Jeffery Summers
School of Psychology
University of Tasmania
Private Bag 30
Hobart Tasmania

Student Researchers: Catherine Bushnell
Caroline Bertrand

Dear Professor Summers

Re: FULL ETHICS APPLICATION APPROVAL
Ethics Ref: H0011939 - The effect of mindfulness meditation on cognitive functioning in older adults

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We are pleased to advise that the Tasmania Social Sciences Human Research Ethics Committee approved the above project on 29 July 2011.

Please note that this approval is for four years and is conditional upon receipt of an annual Progress Report. Ethics approval for this project will lapse if a Progress Report is not submitted.

The following conditions apply to this approval. Failure to abide by these conditions may result in suspension or discontinuation of approval.

1. It is the responsibility of the Chief Investigator to ensure that all investigators are aware of the terms of approval, to ensure the project is conducted as approved by the Ethics Committee, and to notify the Committee if any investigators are added to, or cease involvement with, the project.

2. Complaints: If any complaints are received or ethical issues arise during the course of the project, investigators should advise the Executive Officer of the Ethics Committee on 03 6226 7479 or human.ethics@utas.edu.au.

3. Incidents or adverse effects: Investigators should notify the Ethics Committee immediately of any serious or unexpected adverse effects on participants or unforeseen events affecting the ethical acceptability of the project.

4. Amendments to Project: Modifications to the project must not proceed until approval is obtained from the Ethics Committee. Please submit an Amendment Form (available on our website) to notify the Ethics Committee of the proposed modifications.

5. Annual Report: Continued approval for this project is dependent on the submission of a Progress Report by the anniversary date of your approval. You will be sent a courtesy reminder closer to this date. **Failure to submit a Progress Report will mean that ethics approval for this project will lapse.**

6. Final Report: A Final Report and a copy of any published material arising from the project, either in full or abstract, must be provided at the end of the project.

Yours sincerely

Katherine Shaw
Acting Executive Officer

Appendix F

Information Sheet for Participants

UTAS

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 three testing sessions in which you will complete tests of attention and memory skills.

Session One (3 hours)

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.

Session Two (1 hour)

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.

Session Three (3 hours)

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 3 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 7458. 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 G

Consent Forms for Participants

UTAS

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 detect a 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 tł 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 tł participating, the following must be ticked.

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

Name of investigator ______________________

Signature of investigator ______________________ Date ____________