The Impact of Intensive Mindfulness Training on Attentional Control, Cognitive Style, and Affect

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ORIGINAL ARTICLE

The Impact of Intensive Mindfulness Training on Attentional Control, Cognitive Style, and Affect

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Abstract To evaluate the impact of an intensive period of mindfulness meditation training on cognitive and affective function, a non-clinical group of 20 novice meditators were tested before and after participation in a 10-day intensive mindfulness meditation retreat. They were evaluated with self-report scales measuring mindfulness, rumination and affect, as well as performance tasks assessing working memory, sustained attention, and attention switching. Results indicated that those completing the mindfulness training demonstrated significant improvements in self-reported mindfulness, depressive symptoms, rumination, and performance measures of working memory and sustained attention, relative to a comparison group who did not undergo any meditation training. This study suggests future directions for the elucidation of the critical processes that underlie the therapeutic benefits of mindfulness-based interventions.

Keywords Mindfulness · Meditation · Executive cognition · Attention · Rumination · Working memory · Depression

Introduction

Mindfulness meditation practice, commonly referred to in the literature simply as mindfulness, has recently has recently proven clinically effective, both incorporated into existing psychological treatment approaches such as cognitive behavioral therapy, and as an intervention in its own right (c.f. Allen et al., 2006; Bach & Hayes, 2002; Baer, 2003; Carlson, Speca, Patel, & Goodey, 2003; Grossman, Niemann, Schmidt, & Walach, 2004; Lowenstein, 2002; Roth & Stanley, 2002; Segal, Williams, & Teasdale, 2002;

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Smith, Compton, & West, 1995). However, the processes underlying these clinical effects are presently not well understood.

Despite difficulties operationalizing mindfulness (e.g. Baer, 2003; Bishop, 2002; Bishop et al., 2004; Brown & Ryan, 2003; Hayes, 2003; Hayes & Feldman, 2004; Kabat-Zinn, 1990, 2003; Roemer & Orsillo, 2003), most definitions emphasize two points. The first is that a mindful state is characterized by full attention to, and awareness of, the internal and external experience of the present moment. Second, this awareness is employed equanimously, in that whatever arises is acknowledged and examined without judgment, elaboration, or reaction. Mindfulness therefore incorporates elements of both attention-regulation and an open, accepting orientation to experience (Bishop et al., 2004; Brown & Ryan, 2004; Hayes & Shenk, 2004; Bishop, 2002). It is important to note that mindfulness refers to a particular quality of attentional focus, mindful awareness, rather than to any particular practice or technique.

Mindfulness-based therapies often integrate this quality of awareness or attention with other cognitive and/or behavioral interventions. For instance, combining mindful awareness with cognitive behavioral therapy (CBT) yields an intervention characterized by a focus on the present moment (as with CBT) but with an emphasis on accepting thoughts, emotions, and behaviors, rather than actively trying to change them. This forms the underpinning of Mindfulness-Based Cognitive Therapy (MBCT), which has been shown to prevent relapse in individuals who have suffered multiple previous episodes of depression (William, Segal, & Teasdale, 2000). Likewise, combining mindfulness with relaxation techniques and body awareness has yielded Mindfulness-Based Stress Reduction (MBSR), an intervention which has demonstrated numerous benefits in a number of clinical and non-clinical populations (Davidson et al., 2003; Kabat-Zinn, 1990).

Mindfulness-based psychological interventions have been drawn largely from Buddhist insight meditation techniques known as Vipassana.[1] These aim to foster the development of insight into the nature of mind, through developing mindful awareness of our present-moment psychological responses (see Goleman, 1977; Hart, 1987). Systematic practice gradually erodes patterns of habitual responding. The particular type of Vipassana meditation investigated in the present study emphasizes developing mindful awareness of bodily (kinesthetic) sensations (see Hart, 1987). This anchors the practitioner in the present moment, and helps them to recognize their emotional state through concomitant physiological arousal. Remaining equanimously aware of such arousal prevents any reaction to unhelpful or unpleasant moods, and facilitates problem solving.

This process remains to be operationalized in terms of established psychological processes. The principal aim of this study is therefore to begin to elucidate the role of one group of relevant processes, executive cognition (in particular attentional control), in mindfulness, and their relationship to psychological wellbeing.

It is conjectured here that mindfulness meditation practice aids the development of two facets of executive cognition. The first is sustained attention, the ability to focus attentional resources on specific stimuli in a sustained manner. The second is attention switching, the ability to volitionally switch the attentional focus between stimuli. We

[1] Throughout this paper, the term "mindfulness" is used interchangeably with the Sanskrit term "Vipassana". This type of practice is also referred to as Lhaktong (Tibetan). There are different forms of this practice found throughout different Buddhist lineages, although all have the common aim of fostering insight into the nature of the mind.

hypothesize that increases in these abilities will result in improved ability to monitor and self-regulate mental and emotional states—processes often referred to as metacognition and metaemotion—leading to greater psychological wellbeing.

There is disagreement as to whether mindfulness represents a distinct construct or merely a quality of consciousness that spans and incorporates other states. Brown and Ryan (2003) have developed a self-report measure of mindfulness, the Mindful Attention Awareness Scale (MAAS), which appears to tap a distinct construct. The scale differentiates mindfulness practitioners from others, and is associated with enhanced self-awareness and psychological wellbeing, unique from other psychological traits and characteristics. Alternatively, Bishop (2002) argues that construct validity for mindfulness necessitates further exploration of the relationship between mindfulness training and enhanced cognitive performance. This is one of the key objectives of the present study.

Processes underlying mindfulness training

A number of processes have been proposed to underlie training in mindfulness. The most commonly cited of these is *relaxation* (Dunn, Hartigan, & Mikulas, 1999), although it has been suggested that this is at most a beneficial side effect of mindfulness practice, rather than an inherent process (Baer, 2003). Another hypothesized process is a *reduction in overgeneral autobiographical memory* (Williams, Teasdale, Segal, & Soulsby, 2000). There may also be an *erosion of the use of literal, evaluative language* (Hayes, 2003; Hayes & Shenk, 2004). Acknowledging rather than evaluating thought processes circumvents the usual cognitive defenses which attempt to prolong or avoid such processes. This results in an increased range and flexibility of actions (Hayes, 2003) and has been termed *cognitive flexibility* (Roemer & Orsillo, 2003). Mindfulness training may also facilitate *metacognitive insight* (Bishop et al., 2004; Mason & Hargreaves, 2001; Teasdale, 1999; Teasdale, Segal, & Williams, 1995). This represents a transition toward viewing thoughts as ephemeral mental events, rather than as direct representations of reality. Such ‘‘decentering’’ somewhat distances us from our problematic thoughts and emotions, allowing us to address them consciously rather than merely reacting to them.

Resulting from these processes may be enhanced levels of *exposure* (Kabat-Zinn, 1982; Kabat-Zinn et al., 1992) and *acceptance* (Brown & Ryan, 2004; Hayes, 1994; Roemer & Orsillo, 2002; Teasdale et al., 1995). Reduced reactivity to negative emotional states such as anxiety allows exposure to thoughts and emotions that would otherwise engender cognitive defenses (Baer, 2003). Such non-reactive awareness provides the opportunity for all thought processes to be examined in a less biased manner, and for concomitant emotional responses to diffuse. Relatedly, there may be a shift away from goal-based processing, a quality referred to as ‘‘non-striving’’ in the Buddhist literature. This results in reduced rumination and increased openness to current experience (Teasdale, Segal, & Williams, 2003).

It is possible that some of these processes depend, at least initially, on the development of attentional control and other executive cognitive functions (Baer, 2003). The emphasis of mindfulness practice on the present moment potentially enhances the capacity for sustained attention, attention switching, and inhibition of elaborative processing (Bishop et al., 2004). Working together with the processes outlined above, this amplifies one’s potential for self-regulation (Shapiro & Schwarz, 2000) and allows attention to be redirected from depressive or anxious rumination back to the experience of the present moment (Teasdale, 1999; Teasdale et al., 1995, 2003). This may result in decreased negative affect and improved psychological health (Davidson et al., 2003; Shapiro, Schwartz, & Bonner, 1998). Recent research has suggested that mindfulness is a more effective remedy for coping with dysphoric mood than either rumination or distraction (Broderick, 2005).

Executive cognition and attentional control

The ''spotlight'' model of attention posits that information which is not focused upon remains in the background rather than being lost (Posner & Peterson, 1990). Such latent information may indirectly influence both automatic and controlled processing (Posner, 1995). As such, the extent to which we are able to skillfully manipulate the focus of our attention has significant implications for psychological wellbeing.

Indeed, attentional deficit or dysfunction has been implicated in rumination (Treynor, Gonzales, & Nolen-Hoeksema, 2003), depression (Depue & Collins, 1999; Strauman, 2002), and anxiety (Wells, 2002). Conversely, attentional control, which may be strengthened through training, has been demonstrated to have an ameliorating effect in these symptom domains (Rueda, Posner, & Rothbart, 2004). This relationship may be underpinned by increased capacity for self-regulation (Mischel & Ayduk, 2002; Rueda et al., 2004; Ruff & Rothbart, 1996), which includes the ability to control reactions to stress and maintain focused attention (Fonagy & Target, 2002). Stated differently, attentional control may lead to increased self-regulation, which has positive benefits for psychological wellbeing.

Sustained attention. Also called vigilance, sustained attention refers to the capacity to detect unpredictably occurring stimuli over prolonged periods of time (Sarter, Givens, & Bruno, 2001). It underlies higher-order attentional capacities such as selective and divided attention, as well as more general cognitive functions such as learning and memory (Posner, 1994). Deficits in this capacity have been implicated in a number of psychological disorders such as attention deficit hyperactivity disorder (ADHD), schizophrenia, Alzheimer's disease, and Parkinson's disease (Lawrence, Rossy, Hoffmann, Garavan, & Steiny, 2003). As outlined above, one of the critical changes during mindfulness training may be the enhancement of sustained attention capacities.

Attention switching. Research into attention switching, or *set-shifting*, has historically employed card-sorting (Davis & Nolen-Hoeksema, 2000; Moritz et al., 2002), trail-making (Paradisio, Lamberty, Garvey, & Robinson, 1997), dichotic listening (Hughdahl et al., 2003), Stroop (Schatzberg et al., 2000) and dot-probe (Bradley, Mogg, & Lee, 1997) tasks. These tasks, however, have only managed to assess the external domain—the capacity of individuals to shift the focus of their attention between various external stimuli.

By contrast, Garavan (1998) examined mental counting ability, and demonstrated that there is a chronometric cost involved in switching attention from one *internal* counter to another. Garavan termed this a *switching effect*. An example would be keeping count of blue and red cars that pass you as you drive home. The first few are blue (''one, two three...''), but then suddenly a red one drives past and you have to switch the internal focus of your attention to start counting in a new, second category (''three-one, three-two...''). Another example is intentionally switching attentional focus from unpleasant (e.g. angry) thoughts to more pleasant (e.g. compassionate) ones. These may be fundamentally different to, say, shifting one's attention away from a phobic stimulus such as a spider, which would be an example of external attention switching.

Garavan (1998) inferred from this that working memory, or executive cognition, is limited in capacity. Gehring, Bryck, Jonides, Albin, and Badre (2003) demonstrated that various top-down (e.g. subjective expectation and trial-position effects) and bottom-up (e.g. priming and inhibition) influences may have confounded Garavan's (1998) findings. Nonetheless, their data supported the notion of switching effects, which they also ascribed to the top-down attentional process of shifting attention between mental objects (internal representations).

Furthermore, Murphy et al. (1999) demonstrated that switching effects are even more pronounced when attention is switched between affective stimuli. Using a go/no-go task, they found manic and depressed patients demonstrated response biases for "happy" and "sad" words, respectively. They proposed that emotive or personally relevant information may pose an increased challenge to attentional control.

Set-shifting difficulties are commonly reported in psychiatric populations (Garavan, 1998; Gehring et al., 2003). These same populations also exhibit a tendency toward rumination (Treynor et al., 2003), raising the possibility that poor attentional control within the internal domain is a salient cognitive process that underlies the role of rumination in exacerbating and maintaining psychological distress. This may be fundamentally different to disorders pertaining to the control of attention in the external, environmental domain, such as attention-deficit disorder.

The present paradigm

As discussed above, mindfulness meditation practice provides systematic training in mindfulness of emotional reactivity, using the body as both an anchor and an early-warning indicator with which to recognize and monitor emotional and cognitive reactions. The type of mindfulness practice investigated here is initially learned on a course of 10 days duration, during which practitioners are encouraged to adhere to a strict timetable and code of discipline, refrain from any sort of communication or entertainment, and perform up to 110 h of actual meditation practice. Accordingly, this presents a model population for investigating the effects of an intensive period of mindfulness training, and for examining the effects of mindfulness training per se on psychological functioning, without the possible confounding influence of elements such as relaxation, yoga, and cognitive therapy that are utilized (for example) in MBSR and MBCT interventions.

In summary, mindfulness training may significantly enhance executive cognition, especially attentional control, which may have implications for psychological wellbeing. The present study investigated the changes associated with participation in a 10-day intensive Vipassana course using a repeated measures design. We utilized various self-report measures of mindfulness, rumination, and affect, a performance measure of working memory capacity, and a new experimental "Internal Switching" task (see the Method section) designed to directly tap into the ability to both maintain sustained attentional focus and shift attention between alternative internal mental representations (sets). These were assessed in a group of novice meditators prior to and after completing their first 10-day mindfulness meditation course, and a comparison group who did not undergo such training. It was hypothesized that the group who underwent the intensive mindfulness training would show improvements on measures of cognitive processes such as rumination, mindful awareness, affect, and executive cognition. This was predicted to include improvements in performance on the Internal Switching task, taken to be indicative of improved capacity for both sustained attention and internal attention switching, particularly when processing affective stimuli. We also predicted enhanced performance on a measure of working memory. Further it was hypothesized that these improvements would be greater than those observed in a comparison group who also repeated these assessments over a similar period, without undergoing mindfulness training.

Method

Participants

Twenty participants were recruited voluntarily as they applied for a place on their first 10-day meditation course at Dhamma Aloka Vipassana Meditation Centre in Woori Yallock, Victoria, Australia. They consisted of 11 men and 9 women, aged 21–57 years ($M = 33.70$, $SD = 12.34$). A further 20 participants were recruited from waiting lists for these same 10-day courses ($n = 5$) and drawn from undergraduate and post-graduate psychology courses at The University of Melbourne, Australia ($n = 15$). They consisted of 9 men and 11 women, aged 22–63 years ($M = 31.9$, $SD = 10.25$). There was no significant difference between the groups in terms of age, $t(38) = .50$, $p = .62$, gender, $X^2(1,1) = .40$, $p = .527$, or highest level of education, $t(38) = -1.21$, $p = .24$. All were native English speakers and had normal or corrected-to-normal eyesight.

Design

Participants in the mindfulness group were tested twice, immediately prior to commencement of the 10-day course (Time 1 (T1); $M = 1.58$ days prior, $SD = 1.16$) and then again 7–10 days after its conclusion (Time 2 (T2); $M = 9.25$ days after, $SD = 1.82$). It was decided to wait 7–10 days between the end of the course and post-testing in order to allow the participants to readjust to their daily routines and for more transient effects of the course to diffuse. Although somewhat arbitrary in length, waiting for this period before retesting was expected to provide a better measure of enduring changes resulting from the meditation course. Participants in the comparison group were likewise tested 21 days apart, despite not attending a meditation course in the interim nor having any formal ongoing meditation practice.

The experimental design was therefore a mixed within-between subjects design with time (T1 and T2) as a within-subjects factor and Group (Meditators versus Controls) as a between-subjects factor.

Stimulus materials

Five self-report inventories and two performance measures were administered at T1 and T2 in order to explore the potential relationship between measures of mindful awareness, rumination, affect, and executive cognition.

Self-report inventories. A range of self-report instruments were administered at T1 and T2, designed to assay cognitive processes and affect. The Mindful Attention Awareness Scale (MAAS; Brown & Ryan, 2003) was used to measure the individual's frequency and strength of mindfulness. The Ruminative Responses Scale (RRS), a subscale of the Response Styles Questionnaire, (RSQ; Nolen-Hoeksema & Morrow, 1991), was used to measure ruminative tendencies. This scale has been shown to distinguish between two dimensions of rumination, brooding and reflection (Treynor et al., 2003). Treynor et al.

(2003) found that while both brooding and reflection were associated with depression concurrently, only brooding predicted depressive symptoms longitudinally.

Symptoms of dysphoria were assessed using the Beck Depression Inventory (BDI; Beck, Rush, Shaw, & Emery, 1979; Beck & Steer, 1987). Symptoms of anxiety were assessed using the Beck Anxiety Inventory (BAI; Beck, Epstein, Brown, & Steer, 1988). Finally, current mood was assayed using the Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988), which independently measures both positive and negative affective arousal.

Performance measures. The Digit Span Backward (DSB) subscale of the Wechsler Adult Intelligence Scale, 3rd edition (WAIS III; The Psychological Corporation, 1997) was administered to provide a measure of working memory. In addition, a new experimental task, referred to as the Internal Switching Task (IST; Lo & Allen, submitted) was also used to provide a reaction time (RT) measure of the participants' capacity for sustained attention and switching effects. This task allows measurement of *internal* switching using affective stimuli, contrasting with the research performed by Murphy et al. (1999) outlined above, which restricted itself to the external domain.

In the *Neutral condition* of the IST, a total of 80 English words was used, belonging to two semantic categories, *food* and *household objects*. The frequency of use of these words was balanced based on the corpus by Leech, Rayson, and Wilson (2001), and the number of letters in each word was balanced between the two semantic groups.

Participants were instructed that they would be presented with words, one at a time, in the middle of the computer screen, and were asked to maintain a silent mental count of how many they saw from each of the two semantic categories, "food" and "household objects", during each trial (set of words). They were also instructed to press the spacebar when they had updated their mental count and were ready for the next word. They were requested to do this as quickly as possible, while maintaining accuracy. At the end of each trial, they were asked to report this count to the experimenter. Errors were not assessed as a dependent variable, but were used to ensure that the participants properly understood the task. On this basis, one case was identified as a multivariate outlier and removed from the analyses of the IST. The rate of errors was not significantly different between conditions, groups, or assessment times.

In the *Affective condition* a total of 80 English words were used, again belonging to two semantic categories, this time *positive* affective words and *negative* affective words. Selection was based on ratings in the Affective Norms for English Words (ANEW) by Bradley and Lang (1999). Again, the words were balanced across the positive and negative categories for both length and frequency.

Participants were asked to perform a task similar to the neutral condition, only this time with the affective words. They were asked to imagine being described by these words, and to decide whether they considered each word to be a positive or negative descriptor. They were asked to therefore maintain a silent mental count of how many "positive" and "negative" words they saw during each trial, reporting this count at the end of each trial. Again, they were instructed to press the spacebar when ready for the next word, and were asked to do this as quickly as possible, while maintaining accuracy. As before, errors were not recorded, but were used to assess understanding of the task.

Apparatus

Word stimuli for the ISTs were displayed in the center of a 15″ color monitor on an ASUS M2N notebook PC running *DMDX v.3.0.4* (Forster & Forster, 2003). Screen resolution was set manually at 800 × 600 px, 16 bit (65,536 colors). White words, each 7 mm high, were presented on a black background. The distance from the screen to the participants' eyes was 58 cm. The visual angle was calculated to be .69°.

Procedure

Active (opt-in) recruitment procedures were used, whereby people applying for a place on one of the four 10-day courses which ran during the data collection period were sent, on behalf of the investigators, a plain language statement outlining the current study, as well as a consent form which was to be returned should they wish to participate. Participants were tested individually in a quiet room in either their own homes, an experimental laboratory, or in a silent reading area of a public library. Each participant was tested in the same place, at approximately the same time of day at both T1 and T2. Participants were given a verbal description of the experimental procedure, and signed a consent form prior to the commencement of experimentation.

The participant was next administered the MAAS, RRS, BDI, BAI, PANAS, and DSB. The experimenter remained with the participant, readying the *DMDX* task for the next part of the procedure, while the participant filled in the questionnaires, clarifying any points of uncertainty which the participant raised concerning any of the items. Finally, the participant completed the neutral and affective versions of the IST. Because of the possible influence of affective arousal induced by the affective condition to affect performance during the neutral condition, the neutral condition was completed first by all participants.

Results

Data analysis

The impact of gender and age on measures of mindfulness, rumination, affect, and attentional control was evaluated with a series of independent-samples *t*-tests (for gender) and regression analyses (for age). Results indicated no significant effects or trends, so all subsequent analyses were collapsed across age and gender.

Comparison of groups at baseline

Independent samples *t*-tests were performed to detect significant T1 (before the 10-day meditation course) differences between the meditators' and controls' baseline scores on the MAAS, RRS (brooding and reflection dimensions), BDI, BAI, PANAS, and DSB, as well as their overall reaction times (RTs) and switching costs on the IST. There were only significant between-group differences in participants' scores on the MAAS and BDI at T1, with the mindfulness training group (i.e., those about to begin the course) demonstrating lower levels of trait mindfulness and more depressive symptoms (see Table 1).

Change on measures of mindfulness, rumination and affect

Differences between T1 and T2 mean scores on each of the self-report measures of mindfulness (MAAS), rumination (RRS Reflection and RRS Brooding) and affective symptoms (BDI, BAI, and PANAS) were calculated for each group using a series of

Table 1 Means, standard deviations and between-groups *t*-test scores for variable scores across groups at Time 1

Measure	Mindfulness (n = 20)		Control (n = 20)		*t*	Cohen's *d*
	Mean	SD	Mean	SD		
MAAS	54.35	14.27	63.20	10.32	–2.25*	.71
RRS Brood	10.30	4.30	9.70	3.04	.51	.16
RRS Reflection	13.40	3.36	11.75	3.87	1.44	.46
BDI	8.05	5.12	4.60	3.98	2.38*	.75
BAI	8.40	7.30	5.15	5.43	1.60	.51
PANAS+	31.90	5.99	31.20	11.12	.25	.08
PANAS–	13.25	3.11	11.80	3.47	1.39	.44
DSB	8.05	2.58	8.35	2.41	–.38	.12
IST Overall RT	2147.27	539.18	1991.33	471.87	.96	.31
IST Switch Cost	298.97	236.27	299.24	216.77	–.004	.001

*$p < .05$ (2-tailed). MAAS = Mindful Awareness Attention Scale; RRS = Ruminative Response Scale (RRS Brood = brooding dimension; RRS Reflection = reflection dimension); BDI = Beck Depression Inventory; BAI = Beck Anxiety Inventory; PANAS = Positive and Negative Affect Scale (+ and – refer to the positive and negative affect dimensions, respectively); DSB = Digit Span Backward (subscale of the Wechsler Adult Intelligence Scale, 3rd Edition; WAIS III); IST = Internal Switching Task (Overall RT = measure of mean RT in milliseconds on both switch and non-switch trials; IST Switch Cost = mean switching cost (difference in milliseconds between switch and non-switch trials)

repeated-measures *t*-test procedures. Then, in order to establish if the degree of change was statistically significant between the groups, a 2 (group) by 2 (time) ANOVA was conducted for each variable, with the interaction term reflecting the difference in the degree of change between the two groups. These results are presented in Table 2.

As shown in Table 2, it appears that the mindfulness training group demonstrated significant improvements in scores on the MAAS, RRS reflection, BDI, and PANAS Negative Affect scales. These improvements were specific to the mindfulness group, as

Table 2 Means, standard deviations, and *F* statistics for variable scores, for each group, at T1 and T2

Measure	Mindfulness (n = 20)		Control (n = 20)		Time	Group	Time × group
	T1	T2	T1	T2			
MAAS	54.35 (14.27)	64.50 (12.37)^{T}	63.20 (10.32)	61.55 (11.24)	11.28**	.66	21.75***
RRS Brood	10.30 (4.31)	9.7 (3.05)	9.00 (3.97)	9.35 (4.31)	3.46	.01	1.15
RRS Reflection	13.40 (3.36)	11.75 (3.88)^{T}	11.25 (2.88)	12.35 (3.98)	2.72	.07	8.57**
BDI	8.05 (5.12)	3.15 (3.34)^{T}	4.60 (3.98)	4.15 (3.88)	27.14***	1.04	18.78***
BAI	8.40 (7.30)	4.35 (3.70)^{T}	5.15 (5.43)	3.65 (3.07)	10.96**	2.00	2.31
PANAS+	31.90 (5.99)	34.55 (8.81)	31.20 (11.12)	33.70 (8.24)	4.47*	.09	.004
PANAS–	13.25 (3.11)	11.40 (2.16)^{T}	11.80 (3.47)	12.05 (3.72)	3.89	.19	6.69**
DSB	8.05 (2.58)	9.80 (2.33)^{T}	8.35 (2.41)	8.40 (3.03)	8.75**	.52	7.81**

Note: Standard deviations are in parentheses. *$p < .05$, **$p < .01$, ***$p < .001$. MAAS = Mindful Awareness Attention Scale; RRS = Ruminative Response Scale (RRS Brood = brooding dimension; RRS Reflection = reflection dimension); BDI = Beck Depression Inventory; BAI = Beck Anxiety Inventory; PANAS = Positive and Negative Affect Scale (+ and – refer to the positive and negative affect dimensions, respectively); DSB = Digit Span Backward (subscale of the Wechsler Adult Intelligence Scale, 3rd Edition; WAIS III). Note: ^{T}T2 measure significantly different to T1 measure within that group indicated by significant group by time interactions combined with the fact that each of these measures displayed a significant within-group repeated measures change for the mindfulness training group, but not the controls.

As noted above, the initial analysis revealed significant T1 differences between the groups on the BDI and MAAS at baseline. This raises the possibility that the differential change across time between the two groups on these variables might be attributable to these differences in their initial scores. One solution to this issue is to statistically control these differences in initial scores using Analysis of Covariance (ANCOVA) or related procedures. However, despite the widespread use of ANCOVA for this purpose, there have been strong criticisms made of this approach (Miller & Chapman, 2001). In sum, these critiques point out that using analysis of covariance to control for between-group differences violates the statistical assumption of independence of covariates and independent variables.

One alternative solution that is statistically defensible is to stratify the between-group analyses by various levels of the covariate (Miller & Chapman, 2001). In order to achieve this we examined a subset of the current cases who were selected in order to establish two groups who were comparable in terms of their initial scores on the MAAS and BDI. In order to achieve this, the six lowest T1 MAAS scores were removed from the mindfulness training group, resulting in two groups who were comparable in terms of their initial MAAS scores [$t(32) < 1$]. The interaction between the groups and changes in MAAS scores from T1 to T2 remained significant, $F(1,32) = 12.23$, $p = .001$, $\eta^2 = .27$. Similarly, we removed the cases with the five highest T1 BDI scores (BDI > 13) from the mindfulness training group, and the lowest scoring case (BDI = 0) from the control group. This resulted in groups that were comparable in terms of initial BDI scores [$t(32) < 1$]. However, the interaction between the groups and changes in BDI scores from T1 to T2 remained significant, $F(1,32) = 9.45$, $p = .004$, $\eta^2 = .23$. These analyses suggest that the effects described in Table 2 for the BDI and MAAS variables cannot be attributed to those participants in the mindfulness training group who had initial scores outside the range of the comparison group (or visa versa).

There was weaker evidence of mindfulness training-related improvement on the BAI. Despite there being significant improvement on this measure in the mindfulness group only, the group by time interaction did not reach significance.

Changes on performance measures of executive cognition

To determine whether mindfulness training successfully enhanced participants' executive cognition capacities in the predicted directions, participants' scores at T1 and T2 on the DSB and the IST were analyzed.

Digit Span Backward subscale. The mean DSB scores, for each group, at T1 and T2 are presented in Table 2. The mindfulness training group demonstrated a significant increase across the two time points, while the control group demonstrated no significant change. This was underscored by a significant time by group interaction for DSB scores.

Switching task data were screened with *DMDX*'s *Analyse* application prior to statistical analysis. Consistent with previous research, in order to control for the effect of outliers, RTs faster than 200 ms were discarded as outliers, based on the assumption that they are outside the typical and acceptable range of processing of word-stimuli (e.g. Kessler, Treiman, & Mullennix, 2002). No upper limit was set for rejection of slow RTs. Rather, the *DMDX* program was set to automatically update words after 15 s, in which case the item that was not responded to was summarily scored as an error. No cases

Table 3 Mean RTs (ms) for each group, on each condition (neutral versus affective), for each trial-type (switch versus non-switch), at T1 and T2

Measure	Mindfulness (n = 20)		Control (n = 19)	
	Mean	SD	Mean	SD
Time 1				
Neutral				
Switch	2,022.12	458.64	2,075.77	533.22
Non-switch	1,750.65	423.65	1,728.65	357.27
Affective				
Switch	2,571.39	735.85	2,316.53	651.12
Non-switch	2,244.92	685.15	1,992.8	621.39
Time 2				
Neutral				
Switch	1,717.2	383.32	1,962.18	436.76
Non-switch	1,467.71	363.7	1,618.86	301.22
Affective				
Switch	2,057.84	334.32	2,072.26	523.43
Non-switch	1,756.76	359.12	1,758.75	436.8

were discarded due to this criterion. RTs were windzorized to 2 standard deviations (SDs), meaning that any RTs more than 2 SDs from the overall mean RT for each participant were set nominally at 2 SDs using the analysis functions associated with *DMDX* (Forster & Forster, 2003). About 4.69% of RTs were windzorized overall.

A 2 (task: neutral versus affective) by 2 (condition: switch versus non-switch) by 2 (time) by 2 (group) omnibus ANOVA was initially computed to examine participants' RT measures across tasks.

Internal switching task. One case was discovered to be a multivariate outlier and removed from the analyses of the IST. An omnibus ANOVA comparing participant's reaction times across time (T1 versus T2), condition (neutral versus affective), and trial-type (switch versus non-switch), with a between-group factor of group (mindfulness intervention versus control), revealed significant main effects of time, $F(1,38) = 18.83$, $p < .001$, $\eta^2 = .34$, condition, $F(1,38) = 37.44$, $p < .001$, $\eta^2 = .50$, trial-type, $F(1,38) = 115.82$, $p < .001$, $\eta^2 = .76$, and significant interaction effects of condition by group, $F(1,38) = 4.68$, $p = .04$, $\eta^2 = .11$, condition by time, $F(1,38) = 8.89$, $p = .005$, $\eta^2 = .19$, and time by group, $F(1,38) = 4.80$, $p = .04$, $\eta^2 = .11$. Table 3 summarizes the mean reaction times for each group, on each trial-type, for each condition, at T1 and T2.

Analysis of means associated with the group by condition interaction effect indicated that the mindfulness training group demonstrated significantly longer RTs in the affective condition, relative to the neutral condition, than did the controls, irrespective of time and trial type. Figure 1 represents the group by time interaction effect (i.e. collapsed across condition and trial-type), indicating that the mindfulness training group's overall RTs significantly improved from T1 to T2, whereas the controls' did not.

Correlation between change in mindfulness and other measures

In order to further explore the association between changes in self-rated mindfulness and changes in other measures of affect and executive cognition from T1 to T2, we

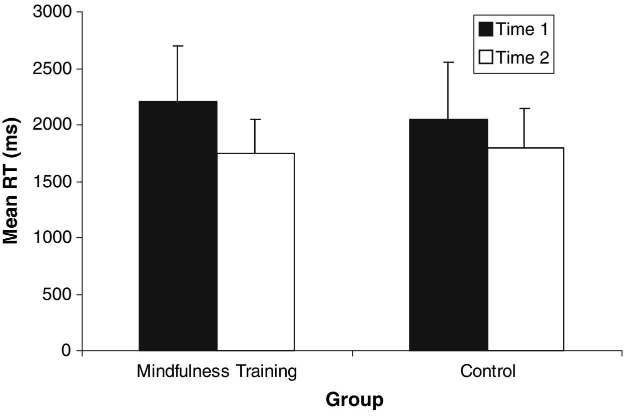

Fig. 1 Mean reaction times on Internal Switching Task for Mindfulness Training and Control groups at T1 and T2, collapsed across conditions (neutral and affective) and trial-type (switch versus non-switch). Error bars represent one standard error

examined the correlation between change scores[2] on these measures. Of the nine correlations explored, six were found to be significant. Across all cases increases in mindfulness (as assessed by the MAAS) between the two time points were found to significantly correlate with decreased scores on the BDI (r = .49), BAI (r = .28), RRS reflection (r = .36), and increased scores in DSB (r = .31) and PANAS positive affect (r = .37). Furthermore there was a non-significant trend for increased MAAS scores to be associated with decreases in measures of switching costs during the affective condition of the IST (r = .24, $p < 0.1$), suggesting that those who rated themselves as becoming more mindful show a trend towards being able to switch more easily between sets in the affective condition (i.e. demonstrate smaller switching costs).

Correlations between changes in executive cognition and affect

Finally, in order to further explore the relationship between changes in executive cognition and changes in self-reported affect, a series of correlational analyses were performed on change scores for these indices. Reduction in the average RT on the IST was found to significantly correlate with improved BDI scores, $r(39) = .39$, $p = .015$. Improved switching costs in the neutral condition of the IST were likewise found to correlate with improved BDI scores, $r(39) = .43$, $p = .007$.

[2] There are a number of ways to calculate change scores from pre- and post-intervention scores. The most basic method is to subtract pre-scores from post-scores, to provide difference scores. However, where such change scores are correlated, this is akin to part/whole correlations, which tend to produce misleading results, typically an over-correction of the post-score (Cohen, Cohen, West, & Aiken, 2002). Consequently, a linear regression analysis was used here, with the pre-score (T1) used to predict the post-score (T2). This analysis was used to derive a standardized residual score for each dependent variable to represent the change in that variable over the intervention period. These standardized scores were then analyzed for correlation with change residuals from other variables in order to evaluate which changes covaried over the intervention period.

Discussion

The principal aim of this investigation was to assess the impact of intensive mindfulness practice on cognitive processes, executive cognition, and affect. This was achieved by comparing inexperienced meditators undergoing their first 10-day mindfulness meditation course with a sample who did not complete any mindfulness training, over two time points. The results suggest that mindfulness training has benefits for psychological functioning, although the initial hypotheses were only partially supported. The benefits of the mindfulness training were reflected in significantly enhanced self-reported levels of mindfulness, significantly reduced self-reported depressive symptoms, reflective rumination, and negative affect, and improvement on some indices of executive cognitive function. There was also weaker evidence of reductions in anxiety.

There was partial support for the hypothesis that the mindfulness training group's scores on self-report measures of cognitive processes such as mindful awareness and rumination would be significantly more improved than those of the control group. As predicted, the mindfulness training group demonstrated a significant increase in self-reported mindfulness relative to the control group, with a medium to large effect size for the time by group interaction. This suggests that the course resulted in enhanced mindfulness skills, as expected, and consistent with previous literature (Baer, 2003; Grossman et al., 2004).

There was mixed evidence of a reduction in rumination. The mindfulness training group showed a significant reduction on the reflection dimension of the RRS, but not the brooding dimension. The same pattern was recently noted by Ramel, Goldin, Carmona, and McQuade (2004), who found that scores on the reflection dimension significantly declined in a group undergoing an 8-week MBSR course, but not in a waitlist control group. Furthermore, they found that the amount of meditation practice a person had completed significantly predicted decreased RRS reflection scores. Neither of these relationships were observed for the brooding dimension. Ramel et al. (2004) suggested that although reflection is thought to be less clearly linked with depressive and anxious symptoms than is brooding (c.f. Treynor et al., 2003), it does describe a tendency to ruminate on the meaning of one's actions and feelings. Such rumination is particularly inconsistent with the focus on here-and-now bodily sensations that is at the core of the Vipassana practice examined here (a practice which has significantly influenced MBSR). This reduced reflection appears to be more characteristic of the kind of cognitive change brought about by mindfulness training than is a change in self-derogatory brooding. This effect might indicate that in a non-clinical population, reflection phenomena may be a more salient form of rumination than brooding, the latter being more strongly associated with depressive symptoms.

As hypothesized, the mindfulness training group's working memory capacity was significantly enhanced. This is a novel finding, and is particularly noteworthy as it suggests that mindfulness practice may increase working memory capacity. It may thus have widespread application as an intervention in a broad range of psychological conditions that are characterized by working memory deficits, such as Attention Deficit Hyperactivity Disorder (ADHD; Koschack, Kunert, Derichs, Weniger, & Irle, 2003), borderline personality disorder (Stevens, Burkhardt, Hautzinger, Schwarz, & Unckel, 2004), post-traumatic stress disorder (PTSD; Clark et al., 2003), and schizophrenia (Silver, Feldman, Bilker, & Gur, 2003). With respect to the Internal Switching Task (IST), the significant main effect of trial type (i.e., switch versus non-switch) supports the notion of switching costs hypothesized in previous research (Garavan, 1998; Gehring et al., 2003; Murphy et al., 1999). The considerable effect size indicates that the IST is a useful tool for measuring the cost of switching between cognitive representations in working memory. However, there was no indication that the switching costs were differentially affected by the mindfulness training, suggesting that attention switching capacities were not enhanced by the intervention. Indeed, switching costs were invariant across group, time and condition (affective versus neutral), implying that switching costs are relatively insensitive to variations in the stimulus materials and the type of manipulations represented by mindfulness training. Further research into the psychological correlates of these switching costs will elucidate their relationship with other aspects of executive cognition, and their responsiveness to training and intervention.

The significant main effect of condition, again with a very large effect size, indicates that both groups exhibited slower reaction times (RTs) in the affective condition relative to the neutral condition. This is consistent with previous research which has found affective material to generally slow RTs (Murphy et al., 1999), and supports the notion that emotive, personally relevant information initiates processing at a deeper semantic level and thus poses an increased challenge to information processing. This effect was particularly pronounced in the mindfulness training group, although was not differentially affected by the intervention, as might have been predicted on the basis of the hypothesis that mindfulness training would break the usual cognitive pattern of reacting defensively or appetitively to affective stimuli. Why the mindfulness training group demonstrated a greater difference in RTs between the neutral and affective switching tasks than did the control group is not clear, especially given that the psychological correlates of this phenomena have not been explored in the literature.

As hypothesized, there was a significant decrease in the mindfulness training group's overall RTs (irrespective of affective condition or switch/non-switch status), indicating an improved capacity for sustained attention during the task. This improvement was not evident in the control group, and therefore cannot be attributed to a practice effect. Like the results for the DSB task, this finding generally supports the notion that mindfulness training enhances aspects of executive cognition (Baer, 2003; Bishop et al., 2004). The overall pattern of results suggest that intensive mindfulness training may impact less significantly on attention switching than on sustained attention and working memory capacity. Further research is required to further explore exactly which aspects of executive cognition respond to mindfulness training.

An inverse relationship between executive cognition and depressive symptoms has been well established (c.f. Fossati, Ergis, & Allilaire, 2002). The present results support the notion that there may be a relationship between decreased depressive symptoms and improved executive cognition in a sample demonstrating changes within the non-clinical range of depressed mood. This is consistent with the few previous studies that have investigated the relationship in this population, which have found that depressive symptoms tend to impair executive cognition (Berndt & Berndt, 1980; Farrin, Hull, Unwin, Wykes, & David, 2003; Slife & Weaver, 1992). However, there is ongoing debate as to the extent and specific nature of this dysfunction. Furthermore, it is not clear whether depressive symptoms impair executive cognition, or impaired executive cognition underlies depressive symptoms, or whether each contributes to the other in a self-sustaining loop. In general, the pattern of findings presented here suggests that there may be a relationship between enhanced executive cognition, improved capacity for self-regulation, and improved affect (Mishel & Ayduk, 2002; Rueda et al., 2004; Ruff & Rothbart, 1996).

The relatively weak effects observed for anxiety symptoms runs contrary to previous research which has demonstrated significant decreases in anxiety following mindfulness training (for a review, see Grossman et al., 2004). One interpretation for this is that the intensive nature of the course may somehow produce different effects to the mindfulness-based interventions discussed in the literature, at least in the period immediately following the conclusion of the course. It should be reiterated here that this is the first study to investigate the psychological effects of such intensive mindfulness practice.

Also interesting was the failure to detect the predicted improvement in positive affect amongst the mindfulness group. It should be noted that the PANAS positive affect scale primarily measures a state of high arousal positive affect (i.e., excitement, joy) rather than the low arousal positive emotions that are often associated with the effects of meditation (i.e., contentment). This concurs with previous research which has suggested that mindfulness may not necessarily lead to increased positive affect, but may rather result in a more moderate, balanced emotional demeanor characterized by low levels of negative affect (Brown & Ryan, 2003).

As hypothesized, increased levels of self-reported mindfulness were found to correlate with decreased levels of self-reported rumination, particularly reflection, adding further weight to the argument that the reflection dimension of rumination was most strongly affected by the mindfulness training. These analyses were exploratory and preliminary, and a large number of correlations were conducted in order to uncover potentially important relationships. Therefore, they must be interpreted with caution until they are replicated. Increased self-reported mindfulness was found to significantly correlate with decreases in self-reported depressive symptoms and anxiety, and increased self-reported positive affect. This would be expected from the literature, which suggests an inverse relationship between rumination and psychopathology (Davidson et al., 2003; Shapiro et al., 1998). However, and perhaps more importantly, it indicates that a shift away from ruminative cognitive processing may be one of the underlying processes behind the observed benefits of mindfulness training for psychological wellbeing. Finally, a significant correlation was found between increased self-reported mindfulness and increased working memory capacity. Combined with the observed non-significant trend for correlation between self-reported mindfulness and decreased switching costs in the affective condition of the IST, this indicates a positive relationship between executive cognition and mindfulness, suggesting that training which improves levels of mindfulness may also engender enhanced cognitive functioning.

A number of methodological limitations of the present study should be considered. The 10-day course provided a unique natural population for the investigation of the psychological effects of intensive mindfulness meditation practice amongst inexperienced meditators. However, it was not possible to control or directly assess the amount of actual meditation practice engaged in during the course, the amount of application applied to mastering the technique, and any variables that may have affected how well this was achieved. Despite this, as previously discussed, these meditation courses are structured so as to be maximally free from distraction and conducive to performance of actual meditation practice. Therefore, it can be reasonably assumed that the meditators in this study performed approximately 110 h of actual meditation practice over the 10 days. Only meditators who completed the full course were included in the study. It may be valuable for future studies to attempt to measure the amount of actual practice performed both during and following the intervention, as well as investigate the characteristics of people who do not complete the course.

The results supported the validity of the IST as a tool for measuring internal attention switching, consistent with the literature outlined above. However, switching costs were found to be invariant across conditions (neutral and affective), group (mindfulness training and controls), and assessment times. The present results suggested that overall information processing speed during the task was relatively more plastic than switching costs, in that it was significantly affected by the intensive mindfulness practice, and thus may provide a more useful measure of executive cognition in this case.

Another important limitation was that while both groups were matched on age, gender, and years of education, this was not a truly randomized trial. The majority of the controls were drawn from a psychology course rather than from waitlisted applicants for the mindfulness training course. Furthermore, the two groups demonstrated statistically (although perhaps not clinically) significant baseline differences in their levels of depressive symptoms and trait mindfulness, which although statistically controlled for, suggests that the differential effects of mindfulness training on these measures should be interpreted with caution. However, the groups were matched on most measures at baseline, including a number of measures of mood and symptomatology (i.e., BAI, PANAS). Most significantly, the two groups did not show baseline differences on the performance tests of executive cognition, rendering the differential effects of mindfulness training on these tasks particularly noteworthy.

Although the current findings do have implications for understanding the impact of intensive mindfulness training on depressive symptoms within the normal range, the implications of these findings for understanding clinically depressed states is less clear. Impact of mindfulness training on psychological processes and symptomatology in those suffering from clinical depression may be very different from that observed here. As the participants in this study were not clinically depressed, future studies will need to more clearly ascertain whether mindfulness training can have an impact in that context (Kenny & Williams, in press).

A final caveat is that a number of potential complications arise from the use of self-report scales to assess changes in cognitive style and affect as there is an inherent risk of self-report biases confounding the data. This may be exacerbated by demand characteristics. Participants on Vipassana courses learn that one of the principal aims of mindfulness training is to reduce vulnerability to unpleasant emotional states such as depressive symptoms and anxiety. They were thus arguably more likely to under-report such symptoms at follow up. Conversely, as mindfulness meditation aims to increase sensitivity to thoughts, feelings, emotions, and kinesthetic sensations, scales which ask participants to rate their experiences of each of these could potentially produce apparently inflated scores, reflecting this increased awareness. This effect has been reported in previous literature (e.g., Bach & Hayes, 2002; Hayes & Feldman, 2004).

While bearing in mind these important caveats, it should also be recognized that this study has some unique strengths. While previous studies have indicated benefits of mindfulness training for psychological wellbeing, the present study is the first to systematically explore the cognitive and affective effects of an intensive period of mindfulness training. Furthermore, while previous research has tended to focus largely upon the *effects* of mindfulness meditation, the present study represents an attempt at elucidating some of the *cognitive processes* underlying these effects. While the results here must be interpreted with caution, they point the way toward potential areas of interest for future researchers.

The principal objective of the present study was to investigate the effects of an intensive period of mindfulness meditation training on cognitive processes, executive cognition, and affect. The results indicated that mindfulness training may not necessarily lead to enhanced internal attention switching capacity, but may significantly benefit working memory capacity and sustained attention. This change is also associated with some improvements in affective functioning. These results support further research into the efficacy and processes of mindfulness as an intervention with potential application in a wide range of areas of psychological research and practice. Further research is warranted to gain greater understanding of the complex processes underlying mindfulness, which the present study has begun to elucidate. There is a particular need for randomized controlled trials with larger sample sizes, as well as studies that evaluate the impact of mindfulness training on long term outcomes, so that the potential role of these interventions in both primary and relapse prevention can be evaluated.

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