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ORIGINAL RESEARCH

The Influence of a Short-Term Mindfulness Meditation Intervention on Emotion and Visual Attention

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Abstract

It has been suggested that mindfulness meditation (MM) improves psychological well-being via the focusing and broadening of attention. Whilst studies show that short-term MM interventions can improve focused attention, there is little evidence to support the broadening of attention. The current study investigated the influence of a short-term MM intervention on emotion and the scope of visual attention. Seventy participants completed a global-local processing task separated into three blocks of trials, with a 10-min break between each one. During the breaks, a MM group engaged in a breath-counting task and a control group engaged in a task of their choosing. Response times to global and local targets and a measure of self-reported emotional affect were recorded for each block. Mindfulness had no impact on attention; however, both positive and negative affect decreased for the MM group across the course of the experiment. The results suggest that MM can reduce the focus on negative (and positive) thoughts, indicating possible changes to focused attention, yet a short-term intervention is not sufficient to broaden attention.

Keywords Mindfulness meditation · Visual attention · Emotion · Mindfulness-to-meaning theory

Introduction

Mindfulness has been described as a conscious state of mind that is attained by attending non-judgementally to the current moment (Bishop et al. 2004). This involves a temporary quietening of both internal sensations (e.g. emotions) and external events (e.g. visual distractions) to promote an open and accepting approach towards the current environment (Kabat-Zinn 2003). This practice is often achieved through silent meditation and sustained present-moment focus (Olendzki 2010), with the idea that focus on a current physical sensation can prevent judgement of both mental and environmental activities (Kabat-Zinn and Hanh 1990).

The concept of mindfulness is rooted in the Buddhist tradition of meditation (Kabat-Zinn 2005), of which there are numerous techniques and styles. Lutz et al. (2008) outline two categories of meditative practice, focused attention and open monitoring (and mindfulness can incorporate both of these). Focused attention meditation consists of sustaining attention on a particular object, such as the sensation of breath, being aware of when the mind wanders to other objects, and disengaging attention from these distractions in order to move attention back to the object of focus. Open monitoring (such as the technique of adopting a wide field of awareness of the whole body, sensations, and thoughts without deliberately concentrating on any of these) builds on focused attention. With increased practice and expertise, focused attention will become automatic, allowing the individual to monitor and be aware of different thoughts and sensations but to move between these in an effortless manner, without stimuli explicitly "grabbing" attention. This then allows the individual to be aware of thoughts and experiences in such a way that they do not evoke the same level of attachment and emotional reaction.

Although meditation is used as a method to induce mindfulness, the practice itself is a universally accessible concept that does not necessarily require long-term training (Dane 2010). For example, research has found that mindfulness can either be a passing state, induced during short-term practice (state mindfulness), or a personality trait, present in everyday life (trait mindfulness) (Kiken et al. 2015). Despite its complexity, the ease of access to mindfulness and growing evidence for its beneficial impact on mental health and well-

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being (Brown and Ryan 2003) mean that it is fast becoming a leading therapeutic intervention (Hölzel et al. 2011). There is now a body of work that aims to explore the practice and understand the mechanisms that lead to such benefits.

Mindfulness research has predominantly used standardised mindfulness-based interventions (MBIs) to induce state mindfulness in participants (Gu et al. 2016). Such interventions typically incorporate the historical concepts of meditation, such as breath focus, into a short-term (less than 4 weeks) or long-term (beyond 4 weeks) course (Grossman et al. 2004). Previous studies have found MBIs to reduce the negative effects associated with physical ill health (Grossman et al. 2004), mental ill health (Shapiro et al. 2007), and impaired social functioning (Mersh et al. 2015). Furthermore, research has extensively shown that MBIs lead to an increase in both hedonic well-being (attainment of short-term pleasure) and eudaimonic well-being (related to self-realisation and long-term contentment) (Chang et al. 2015).

Whilst there is a substantial amount of research to suggest that mindfulness enhances well-being, there is little indication as to how this process occurs (Hölzel et al. 2011). One argument is that the practice of mindfulness alters brain activity (Gotink et al. 2016) and cognitive processing (Zeidan et al. 2010), which leads to improvements in psychological health. Another factor thought to be involved in the beneficial effects of mindfulness is emotion. Research has shown that MBIs can alter both positive and negative moods, and studies have provided different explanations for how these changes might lead to enhanced well-being (Corcoran et al. 2009). Keng et al. (2011) have argued that mindfulness influences emotion to ultimately improve health and happiness. Specifically, the focus on present-moment happenings during MBIs leads to a decentring from thoughts and feelings, and more control over which thoughts are attended to. On the basis of this, negative thoughts are quietened whilst positive thoughts are focused on. This then leads to a decrease in negative mood and an increase in positive mood.

In an attempt to explain the beneficial effects of mindfulness meditation (MM) Lindsay and Cresswell (2017) developed the Monitoring and Acceptance Theory (MAT), which outlines two distinct mechanisms. The first is *attention monitoring* whereby a practitioner will attempt to focus attention on a specific object (i.e. the breath), ignoring distracters and bringing attention back to the object when the mind wanders. The second mechanism is *acceptance* with practitioners encouraged to accept all momentary experiences, acknowledging them but not reacting to them in any way, then letting them pass. Lindsay and Creswell propose that monitoring and acceptance are two separate skills that can be influenced in different ways depending on the characteristics of the MM. In particular, they predict that training in attentional monitoring will impact on cognition (such as improving sustained attention and task switching), but training in both attentional monitoring and acceptance is required for benefits to psychological and physical health. Whilst training in attentional monitoring can improve the control of attention, allowing an individual to redirect attentional resources away from negative thoughts, acceptance is necessary to manage emotional reactivity.

Wolkin (2015) argued that the benefits of MM can be explained using an attention-based model. Due to limited cognitive resources, effective performance in a task is associated with selective attention whereby resources are allocated towards task-relevant information and away from task-irrelevant information (e.g. Johnston and Dark 1986; Schneider and Shiffrin 1977). The allocation of attention incorporates three processes: disengagement of resources from the current focus, a shift of attention to a new stimulus, and engagement of resources on the new stimulus (Posner and Petersen 1990). To support selective attention Posner and Petersen (1990) have theorised three separate attentional networks of alerting, orienting, and executive control. Alerting is associated with vigilance; the attentional system must remain alert for changes in task demands or the onset of new information (i.e. the onset of a distraction). Orienting is associated with prioritising specific stimuli for processing over others (i.e. focusing resources towards relevant information and away from distractions). Executive control supports the focus of attention by monitoring for conflict in task demands and updating attentional settings in accordance with task changes.

Wolkin (2015) proposes that MM enhances well-being as the practice incorporates the allocation of attention towards a specific stimulus (e.g. the movement of breath), therefore disengagement from negative thoughts and distractions. In particular, she proposes that the deliberate concentration of attention on the current experience shifts focus from ruminating on negative thoughts to the acceptance of other information (effectively viewing MM as a method of distraction that directs resources elsewhere). Rumination is a particular style of thinking that is characterised by the focus on negative thoughts. It has been grouped into two categories of reflective pondering (focusing on negative information in order to solve a problem and adapt to a situation) and depressive brooding (a focus on negative information in a passive manner with no attempt to try and alter the situation) (Koster et al. 2011; Treynor et al. 2003). Increased rumination (particularly depressive brooding) has been linked to poor well-being, depression, and anxiety (e.g. Koster et al. 2011; Nolen-Hoeksema 2000; Nolen-Hoeksema and Morrow 1993); therefore, a reduction in rumination would be associated with improved well-being.

In addition to the increased focus on negative information, rumination has also been related to poor executive control and difficulties switching attention, with an inability to monitor attention and update settings as task demands change (e.g. Bernstein et al. 2017; Treynor et al. 2003). Wolkin (2015) outlines that MM may enhance cognitive flexibility by

broadening the focus of attention through a process of decentering. This allows the reflection on negative thoughts but from a more adaptive perspective, linking to the concept of open monitoring or acceptance in the MAT (Lindsay and Cresswell 2017).

A similar argument regarding the importance of attentional processing in the association between MM and well-being comes from the mindfulness-to-meaning theory (MMT; Garland et al. 2015). This outlines that MM involves the control of attention to a specific stimulus together with the inhibition of distracting information. This would link to the orienting component of the attentional network theory (Posner and Petersen 1990). Following this, there is a "decentering" from negative thoughts and emotions allowing for broadened awareness and for new information to be processed. Prolonged negative affect leads to cognitive biases whereby resources are automatically directed towards negative information (e.g. Beck 1967; De Raedt and Koster 2010). Garland et al. (2017) argue that decentering enables attention to be disengaged from "habitual cognitive sets", providing space in working memory for new thoughts and appraisals. The new information enables positive reappraisals of the self and the world, enhancing positive affect and well-being. Again, the element of decentering proposed within the MMT links to the importance of executive control.

Garland et al. (2015) outline the key features of the MMT as attentional control, decentering, broadened awareness, reappraisal, and positive affect. To support the importance of attentional control, Garland et al. (2017) compared the effects of 12 weeks of cognitive behavioural therapy and 12 weeks of mindfulness-based stress reduction (MBSR) training on individuals with social anxiety disorder. Using a series of questionnaires to assess attentional control (the Attentional Control Scale; Derryberry and Reed 2002), decentering and broadening (the Five Facet Mindfulness Questionnaire; Baer et al. 2006), emotional regulation (the Emotion Regulation Questionnaire; Gross and John 2003), and emotional affect (the Positive and Negative Affect Schedule; Watson et al. 1988), they found that improved positive affect in the MBSR group was predicted by improvements in self-reported attentional control. Specifically, improvements in attentional control led to increased decentering, which then led to increased broadening, and increased broadening predicted enhanced positive affect and positive reappraisal.

Although evidence supports the impact of long-term MM on attention and well-being, Zeidan et al. (2010) have argued for the need to examine the effects of short-term mindfulness training. Not all individuals have the time or motivation to engage in lengthy training programmes, and if brief MM interventions can benefit performance, they may be used as methods of cognitive enhancement. Zeidan et al. (2010) measured the impact of a short-term MM intervention that involved participants focusing on the flow of breath. In groups of three to five, participants were given instruction in breath focus from a trained facilitator over four 20-min sessions. Zeidan et al. found improved accuracy on an *n*-back task, a symbol digit modalities test, and a test of verbal fluency (tasks they argue incorporate focused attention and executive control). Further support for the proposal that MM influences attentional control, Wenk-Sormaz (2005) found improvements in a Stroop test, but not in a word production task, following a 20-min breath-focusing intervention. Gorman and Green (2016) have also found that three 10-min sessions of a breath-counting intervention improved performance in tasks of visuospatial selective attention (e.g. the flanker task) but not in tasks of working memory or cognitive flexibility.

Research therefore shows that short-term MM can have a beneficial impact on attention; however, the work cited above concentrates on the early stages of the MMT (the control of attention and the focus of attention). In addition, they do not show whether improvements in attention are paired with changes in emotion (Zeidan et al. 2010 did include a measure of self-reported emotional affect but found that increases in positive affect did not vary between the MM group and the control group). The current study aimed to measure the effect of a short-term MM intervention on emotion and the broadening of attention using a self-report measure of emotional affect and a global-local processing task. The global-local task has been used to measure the influence of emotion on the scope of visual attention (e.g. Fredrickson and Branigan 2005) and Garland et al. (2017) advocate the use of such a paradigm to explore the broadening aspect of the MMT.

Emotional affect and performance on the global-local task was measured across three blocks of trials and between each block participants engaged in a breath-counting MM intervention or a task of their choosing. Based on studies showing that MM can improve well-being (e.g. Brown and Ryan 2003; Chang et al. 2015; Josefsson et al. 2014), it was predicted that the MM group would show increased positive affect across the experiment compared to the control group. Studies using the global-local task predominantly show a global precedence effect whereby participants focus on global features at the expense of local features (e.g. Fiske and Taylor 1991; Navon 1977). Findings have also shown that individuals in a more positive emotional state show increased focus towards global features than local features compared to those in a negative emotional state (Fredrickson and Branigan 2005). This supports the broaden-and-build theory (Fredrickson 2001) which posits that positive emotions will broaden attention. It was predicted that both groups would show the global bias in the first block, but the bias towards global processing would become more apparent for the MM group than the control group in the second and third blocks as positive affect increased.

Method

Design

The study used a mixed measures 3 × 2 × 2 design. The independent variables were *time*, with completion of tasks before (pre), mid-way through (mid), and after (post) the interventions, *group* (MM or control), and *target feature* (the target letter in the global-local processing task was presented as a global or local feature). There were three dependent variables: response times (RT; in milliseconds) to detect the targets in the global-local task, positive affect, and negative affect.

Participants

Participants were an opportunity sample of 70 staff and students (49 female) from the University of Salford, none of whom had previous experience of MM. An a priori sample size calculation using an alpha criterion of 0.05 and statistical power of 0.95 indicated that a minimum of 66 participants were required to detect a small to intermediate effect size of 0.2. The age range was 18–63 years, and the mean age was 26.76 years ($SD = 10.14$). Participants were randomly allocated to the MM group ($n = 35$; 28 females, $M = 28.34$ years) or the control group ($n = 35$; 18 females, $M = 25.25$ years). Participants received course credit or an inconvenience allowance for taking part.

Stimuli and Materials

A global-local processing task (Navon 1977) was designed using E-Prime software (Psychological Software Tools, Inc.). Eight images were created each consisting of a large letter (global feature) made up of smaller, different letters (local feature), with five smaller letters used to create each horizontal or vertical line of the larger letter. Every image contained a target letter (T or H), which could be presented as either the global or the local feature, and the other letter was always a non-target letter (L or F). Local letters measured 2.5 cm × 2.5 cm and were presented in black in Times New Roman font. All images were displayed on a white background. Participants completed this task on a Viglen Intel Quad Core 2.66 GHz computer with a 17-in. screen.

The Positive and Negative Affect Schedule (PANAS; Watson et al. 1988) was used to assess emotional affect. This is a self-report measure containing 20 words, 10 representing positive emotions and 10 representing negative emotions. The questionnaire asked participants to assess "the extent you feel this way right now, that is, at the present moment" and to respond to each emotion using a five-point scale from 1 (very slightly or not at all) to 5 (extremely). Positive and negative affect was measured separately with possible scores ranging from 10 (low affect) to 50 (high affect).

The MM group completed a breath-counting task (Levinson et al. 2014). This was an online exercise, which presented natural, moving, visual stimuli on the screen. Participants wore headphones during the intervention to obscure any external sounds.

Procedure

Participants completed the PANAS and were then seated approximately 50 cm from the computer display and given on-screen instructions for the global-local processing task. In each trial, an image appeared on the screen and participants were instructed to determine whether the letter T or the letter H was presented in the image and to respond by pressing "T" or "H" on the keyboard. Feedback was provided for 500 ms before the next trial began. Participants completed 6 practice trials followed by 48 experimental trials. In the experimental trials, 24 trials contained the letter T and 24 contained the letter H. The target letters were presented as the global feature in 12 trials and as the local feature in 12 trials. All trials were presented in a random order.

Following the first block, participants in the MM group completed the breath-counting task for 10 min. They were asked to count their breaths whilst watching the stimuli on screen, with each exhalation counting as one breath. They were instructed to press the down arrow key on the keyboard after the first eight exhalations, followed by the right arrow key after every ninth breath. If a key was pressed incorrectly, a visual prompt of a blinking eye appeared on the screen. Participants in the control group were free to complete any activity of their choice but were asked to remain in the laboratory. The majority of these participants chose to spend time on their mobile phones (e.g. texting and checking emails). Some used the computer in the laboratory to check emails and search the internet, and a small number engaged in conversation with the experimenter.

After their respective interventions, both groups completed the PANAS, the global-local task, and their 10-min interventions once again. Following the second intervention, all participants completed the PANAS and the global-local task a final time. The experiment lasted a total of 30 min.

Statistical Analysis

Data was checked to ensure assumptions of normality and sphericity were assumed. Where sphericity was violated, the degrees of freedom were adjusted using the Greenhouse-Geisser correction; however, the uncorrected degrees of freedom are reported unless this correction changed the significance level. Mean RTs in the global-local processing task were analysed using a 3 (time) × 2 (group) × 2 (target feature) mixed measures ANOVA, followed by repeated planned contrasts for the variable of time. The planned contrasts allowed

comparisons of RT between pre- and mid-intervention and between mid- and post-intervention. Data from the PANAS was analysed using two 3 (time) × 2 (group) mixed measures ANOVAs (one for positive affect and one for negative affect) followed by repeated planned contrasts for the variable of time. Significant interactions were further explored using 1 × 3 within-participant ANOVAs, again with repeated planned contrasts. Following Lakens (2013), effect sizes were calculated as generalised eta squared (η_G^2). Pearson's correlations were also conducted to measure the correlation between attentional broadening (using the differences in mean RT to global and local targets) and positive and negative affect.

Results

Data collected from the global-local task was RTs to correctly detect the target feature. Incorrect trials (3.79%) and RTs more than two and a half standard deviations from the overall sample mean (3.17%) were removed. Analysis of RT (see Table 1 for means and standard deviations, and Table 2 for ANOVA results) showed a significant effect of time. Response times decreased from pre-intervention to mid-intervention (means of 836 ms and 697 ms respectively) and from mid- to post-intervention ($M = 657$ ms). There was no significant difference between the two groups; however, there was a significant effect of target feature. Target letters were detected faster when presented as global features compared to local features (means of 720 ms and 740 ms respectively). There was no significant interaction between time and group, or target feature and group. There was no interaction between time and target feature, and no interaction between time, group, and target feature. Performance in the global-local task therefore improved across the course of the experiment and participants showed a consistent global-precedence effect; however, this did not vary between the MM and the control group.

Analysis of positive affect (see Table 3 for means and standard deviations, and Table 4 for ANOVA results) showed a significant effect of time. Positive affect did not differ significantly between pre- and mid-intervention; however, it decreased from mid- to post-intervention. There was no significant effect of group, yet there was a significant interaction between time and group. A 1 × 3 ANOVA showed a significant effect of time for the MM group. Positive affect decreased from pre-intervention to mid-intervention, and from mid- to post-intervention. In contrast, positive affect did not vary across the three blocks for the control group. This shows that whilst positive affect remained constant for the control group, it decreased across the experiment for the MM group.

For negative affect (see Table 3 for means and standard deviations, and Table 5 for ANOVA results), there was a significant effect of time. Negative affect decreased from pre-intervention to mid-intervention, but not from mid- to post-intervention. There was no significant effect of group; however, there was a significant interaction between time and group. A 1 × 3 ANOVA showed a significant effect of time for the MM group. Negative affect decreased from pre-intervention to mid-intervention, but not from mid- to post-intervention. For the control group, there was a trend towards a reduction in negative affect from pre- to post-intervention; however, the difference in negative affect across the experiment was non-significant. Again, the analysis shows that negative affect remained constant for the control group between each block but decreased for the MM group following the first intervention.

A final analysis was conducted to explore the relationship between affect and attentional broadening by correlating the difference between RTs to global and local targets with self-reported positive and negative affect. To remove any influence of the interventions, this was conducted on results from block 1 only. The results showed no correlation between global-local processing and positive affect ($r\ (70) = 0.060$, $p = 0.619$) or negative affect ($r\ (70) = -0.119$, $p = 0.325$). Therefore, differences in self-rated emotional affect were not associated with performance in the global-local task.

Discussion

Mindfulness meditation (MM) has been found to improve psychological well-being and efforts are now being made to explain the processes responsible for these improvements. A number of theories suggest that attention is a key aspect within

Table 1 Means (and standard deviations) for response times (ms) in the global-local processing task for the mindfulness meditation (MM) group and the control group before the first intervention (pre), after the first intervention (mid), and after the second intervention (post)

	Pre-intervention		Mid-intervention		Post-intervention		
	Global	Local	Global	Local	Global	Local	Total
MM	830 (162)	846 (172)	693 (133)	706 (125)	648 (113)	677 (116)	733 (83)
Control	820 (149)	849 (158)	683 (96)	709 (116)	649 (93)	655 (93)	728 (86)
Total	825 (155)	847 (164)	688 (115)	708 (120)	649 (103)	666 (105)	730 (81)

Table 2 ANOVA results for reaction time in the global-local processing task. df_{Num} degrees of freedom numerator, df_{Den} degrees of freedom denominator, *MSE* mean square error, η_G^2 generalised eta squared

Variable	Contrast	df_{Num}	df_{Den}	MSE	*F*	*p*	η_G^2
Time		2	136	16,937.449	103.326	< 0.001	0.392
	Pre to mid	1	68	25,669.980	104.536	< 0.001	0.606
	Mid to post	1	68	9707.153	28.810	< 0.001	0.259
Group		1	69	22,532.757	0.049	0.825	0.001
Target feature		1	68	6364.329	6.305	0.014	0.010
Time × group		2	136	16,937.449	0.055	0.890	0.001
Target feature × group		2	136	6364.329	0.006	0.941	0.065
Time × target feature		2	136	1710.103	0.125	0.883	0.001
Time × group × target feature		2	136	2050.089	2.064	0.140	0.002

the practice of mindfulness, shifting the focus of attention away from negative thoughts and broadening the scope of attention to allow for processing of positive information. The present study explored the impact of a short-term MM intervention on emotion and the scope of attention by asking participants to provide a measure of emotional affect and complete a global-local processing task across three experimental blocks. Between each block, half the participants engaged in a breath-counting task and the other half engaged in a task of their choosing. Despite an effect of MM on self-reported emotional affect (with reductions in both negative and positive affect across the experiment), there was no influence of MM on the global-local processing task and therefore no evidence of a broadening of attention.

Wolkin (2015) argues that MM reduces rumination and therefore improves psychological well-being through two processes. The first is focused attention on the current experience (e.g. the breath) and the second is the broadening of attention to allow for more information to be considered. Wolkin suggests that the ability to focus attention takes practice, and it may be argued that the broadening effect would only be apparent after more prolonged MM. The MMT (Garland et al. 2015) also indicates that the effects of MM on attention (and well-being) occur in stages, with focused attention, decentering, and then broadening, followed by positive reappraisal and positive affect. This would explain why brief MM interventions affect measures of focused attention (e.g. Gorman and Green 2016; Zeidan et al. 2010) but had no influence on performance in the present study. It may be the case that a short-term MM allows for the initial stages of improved attentional focus and decentering, but a more long-term intervention would be required for the later stages.

The influence of MM on emotion in the current study provides some evidence that participants were moving through the stages proposed by the MMT. Decentering is hypothesised to be the focus of attention away from negative thoughts and emotions, which then allows space for other information to be processed (the broadening). In the current study, negative affect reduced for the MM group following the first intervention, supporting the idea that attention shifts from a focus on negative information to the current experience. It was predicted that positive affect would increase for the MM group across the experiment; however, in comparison to the control group, positive affect decreased across the three blocks. This may suggest that the MM group was moving towards a more neutral emotional state (with a reduction in both positive and negative affect). Again, the MMT suggests that increased positive affect occurs at a later stage, with broadening allowing for the focus on previously unattended positive information, which can then be used for positive reappraisal. Given there was no evidence of broadening, it follows that there was no increase in positive affect due to the length of the MM intervention.

Overall, it would appear that the current MM intervention was too brief to elicit the effects of broadening. A longer

Table 3 Means (and standard deviations) for self-reported positive and negative affect in the mindfulness meditation (MM) and control groups measured pre-, mid-, and post-intervention

	Positive affect				Negative affect			
	Pre	Mid	Post	Total	Pre	Mid	Post	Total
MM	31.69 (7.61)	29.20 (8.45)	26.00 (9.79)	28.96 (9.01)	13.83 (4.46)	11.54 (2.79)	11.06 (2.06)	12.14 (3.42)
Control	29.34 (7.17)	29.91 (8.49)	28.71 (9.48)	29.32 (8.37)	13.26 (5.35)	12.66 (6.27)	12.43 (6.36)	12.78 (5.96)
Total	30.5 (7.43)	29.56 (8.42)	27.36 (9.67)	29.14 (8.68)	13.54 (4.89)	12.10 (4.85)	11.74 (4.74)	12.46 (4.84)

Table 4 ANOVA results for positive affect. df_{Num} degrees of freedom numerator, df_{Den} degrees of freedom denominator, *MSE* mean square error, η_G^2 generalised eta squared

Variable	Contrast	df_{Num}	df_{Den}	MSE	F	p	η_G^2
Time		2	136	17.900	12.305	< 0.001	0.055
	Pre to mid	1	68	28.402	2.258	0.138	0.010
	Mid to post	1	68	19.018	17.815	< 0.001	0.144
Group		1	68	63.174	0.036	0.850	0.001
Time × group		1.666	113.263	17.900	7.615	0.002	0.035
Time × group (MM)		2	68	20.881	15.972	< 0.001	0.144
	Pre to mid	1	34	32.316	6.692	0.014	0.149
	Mid to post	1	34	24.753	14.479	< 0.001	0.107
Time × group (control)		1.593	54.162	15.080	1.050	0.343	0.010

intervention that measures both attentional focusing and attentional broadening over time would be more suitable to help identify the time course of the different features of the MMT. It may be suggested that a limitation to the current study was the choice of the global-local task. Garland et al. (2017) make the case that this is an appropriate task to use for exploring the broadening impact of MM, yet researchers have proposed that this task measures processing style rather than attentional broadening (Taylor et al. 2017). Processing style is the manner in which an individual processes information, for example allocating resources towards the wider field but not processing individual features in detail (global processing) or allocating resources to individual items but not paying attention to the wider context (local processing). This is therefore different to a broadening of attentional scope to allow for a range of information to be processed, as suggested by the MMT. To support the argument that the global-local task does not measure attentional broadening, the correlation analysis from block 1 shows no relationship between attentional broadening and emotional affect, suggesting that the task is not sensitive to variations in affect. This contrasts with past findings showing increased global precedence under positive emotions (Fredrickson and Branigan 2005). The findings also contradict the broaden-and-build theory (Fredrickson 2001), although it may be the case that the differences in affect present in the current experiment were not large enough to influence the scope of attention.

Wenk-Sormaz (2005) links broadening to the deautomatisation hypothesis (Deikman 1966) whereby MM promotes a reduction in automatic processing. The move from automatic processing to more controlled processing means an individual will consider information that was previously ignored, and this then has the potential to alter the "habitual cognitive sets". It could be argued that the global-local task measures habitual processing style (Navon 1977) and would therefore be suitable to measure broadening. Participants in both groups did show the expected global precedence effect in the first block, revealing evidence of habitual processing. However, in this task, the "undoing" of automatic processing suggested by Wenk-Sormaz would lead to greater focus on local processing following MM. The different explanations for broadening present a challenge for the global-local task due to the opposing predictions, and in the future, it would be prudent to utilise a different paradigm, or incorporate a number of cognitive tests into a battery, similar to other studies (e.g. Garland et al. 2017; Josefsson et al. 2014; Zeidan et al. 2010). Using a single measure does limit the knowledge gained from a particular study, and with a recognised paradigm such as the global-local task, it also raises concerns of common method bias (c.f. Podsakoff et al. 2012).

Table 5 ANOVA results for negative affect. df_{Num} degrees of freedom numerator, df_{Den} degrees of freedom denominator, *MSE* mean square error, η_G^2 generalised eta squared

Variable	Contrast	df_{Num}	df_{Den}	MSE	F	p	η_G^2
Time		2	136	4.314	20.528	< 0.001	0.064
	Pre to mid	1	68	6.876	21.195	< 0.001	0.071
	Mid to post	1	68	2.543	3.511	0.065	0.005
Group		1	68	21.321	0.334	0.565	0.004
Time × group		1.436	97.633	4.314	6.293	0.007	0.020
Time × group (MM)		2	68	6.361	18.225	< 0.001	0.217
	Pre to mid	1	34	9.210	19.854	< 0.001	0.239
	Mid to post	1	34	2.845	2.902	0.098	0.022
Time × group (control)		1.669	56.748	2.382	3.224	0.056	0.010

One alternative (or additional) measure would be the flanker task (Eriksen and Eriksen 1974), which has been used to measure broadening of attention under positive affect (e.g. Rowe et al. 2007). This task has also been successfully used to demonstrate a positive impact of brief MM on focused attention (Gorman and Green 2016) and therefore it could be suitable for measuring the different improvements in attention specified by the MMT. One potential disadvantage with the flanker task however is that broadened attention would arguably lead to poor performance in this task, therefore would not necessarily reflect an "improvement" in attention. When completing the flanker task, participants are usually presented with a central stimulus (e.g. an arrowhead) surrounded by flanking distracters that are either congruent, incongruent, or neutral to the central target. Participants are asked to make a speeded response to the target whilst ignoring the flankers. A broadened scope of attention would allow distracters to be processed, therefore leading to slower response times (as found by Rowe et al. 2007 under positive emotional states). It may therefore be predicted that performance in a flanker task would change over time, with greater accuracy and reduced response times following limited practice with MM (e.g. Gorman and Green 2016), but with increased practice, the hypothesised broadening of attention would lead to a decrease in accuracy and longer response times.

The flanker task has been modified to create the Attention Network Task (ANT; Fan et al. 2002) and this measures the three components of attention specified by Posner and Petersen (1990): altering, orienting, and executive control. Given the proposed importance of attention within MM, the ANT may be utilised in future studies measuring the impact of a short-term MM intervention. This task has already been used with some success, for example Tang et al. (2007) found improvements in executive control following five 20-min MM sessions over 1 week. In an emotional version of the ANT, Ainsworth et al. (2013) also found that MM improved executive attention. Of note, the study by Ainsworth et al. compared performance across three groups: one group that engaged in focused attention meditation, one group that engaged in open monitoring meditation, and a control group. Despite the proposed differences between these two forms of meditation (e.g. Lutz et al. 2008), compared to the control group, both meditation groups showed improvements in executive control. The mindfulness interventions in their study were completed over the course of 8 days, with three 1-h training sessions during the 8 days, and 10 min of mindfulness practice each day. This is substantially longer than the intervention used in the current study and the same improvements in attention may not be found following short-term MM. Indeed, Josefsson et al. (2014) found no improvement in executive attention (measured using a Stroop task) following seven sessions of guided MM involving, for example, attention to the breath and awareness of internal thoughts and bodily sensations. They concluded that mindfulness-based interventions should include more than seven sessions.

The changes in improvements to attention (and well-being) vary substantially across the different studies in this field. Reasons for this may include both the type of task used to measure attention and emotional affect (from self-report measures to a variety of computer-based tasks that each measure different aspects of cognitive processing) and also the length of the MM intervention. It appears that short-term MM may have limited benefit (and to date, there are no studies that measure any lasting benefits of short-term MM). An additional reason for the different findings across studies may be the choice of the MM intervention. The practice of MM takes different forms, most notably separated into focused attention and open monitoring (Lutz et al. 2008). The present study used a focused attention technique of breath counting following previous studies by Gorman and Green (2016) and Levinson et al. (2014). Returning to the argument of Wolkin (2015) that MM improves well-being through two processes of focused attention and broadening, the non-significant effects of MM on attention may be attributed to the selected MM practice. As breath counting is considered a focused attention form of meditation, it may not have an impact on broadening. Levinson et al. (2014) have validated the practice of breath counting as a mindfulness technique, showing that it correlates with self-reported mindfulness, reduces mind-wandering, and can be used to identify experienced meditators. They argue that breath counting can be used as a way to measure mindfulness, but they did not assess the effects of this technique on the different processes of focused attention and broadening.

Lindsay and Cresswell (2017) separate MM into two basic components of attentional monitoring and acceptance. They make the argument that mindfulness training usually begins with attention monitoring, and training in acceptance follows this. Breath counting clearly incorporates the component of attentional monitoring, but it does not involve the training of acceptance, and whilst attentional monitoring can lead to improvements in attentional control, selective attention, and task switching, these processes are not measured by the global-local task. On that basis, given the use of breath counting as the MM intervention and the choice of attention task, it is perhaps not surprising that there was no effect of mindfulness on cognitive performance in the current experiment.

The choice of the breath-counting technique may pose further limitations to the study because it was not possible to measure accuracy in the MM task. Participants were asked to monitor their breath, pressing a key after every breath, but changing the key press on the ninth breath. Key presses were not recorded however, meaning that there was no way to assess how engaged participants were with the MM. This should be assessed in future work as individual differences in MM may interact with any benefits to performance and well-being.

It may be proposed that the chosen MM technique is suitable for individuals who have no prior experience of meditation due to its simplicity and the fact that participants are supported by visual prompts when moving through the task (e.g. if the wrong key press is made). Yet there is an argument that this induces a dual task component to the MM as participants are having to monitor their breath but also monitor their responses on the keyboard. Although the technique has also been used by other researchers, it does contrast with some of the other methods of MM used. For example, Josefsson et al. (2014) made use of "standard sitting mindfulness practices" (p. 25) incorporating breath focus, body scan exercises, and awareness to sensations such as taste and smell. The MM was also given by a trained instructor and, related to the point above about engagement, the authors reported drop-out rates from their study (one possible indication of a lack of engagement). Despite this, similar to the present study, Josefsson et al. (2014) found no improvements to attention following their MM intervention, but did show changes in emotional affect, with improved well-being measures for the MM group compared to a control.

The current study aimed to investigate the effects of a short-term MM intervention on emotion and the broadening of visual attention. Participants who engaged in MM reported a reduction in both positive and negative emotional affect across the experiment but there was no impact of MM on the scope of visual attention. This is one of the first attempts to measure the predicted broadening effect of MM but whilst there was evidence that participants were moving towards a more neutral emotional state (as predicted by the mindfulness-to-meaning theory), it may be concluded that a short-term MM intervention is not sufficient to broaden the scope of visual attention and enhance positive affect.

Compliance with Ethical Standards

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study.

Conflict of Interest The authors declare that there is no conflict of interest.

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