Mindfulness meditation practice can make concentration feel a little easier

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Abstract
In order to expand existing thinking about the effects of mindfulness meditation practice on attentional resource efficiency, the present study exposed 16 experienced meditators and 16 non-meditators to a 13-minute sustained attention task and concurrent subjective workload measures. Results did not detect a between group difference in task scores, however a minimising effect of meditation practice on perceived workload was detected. This finding was interpreted to indicate an effect of mindfulness meditation practice on attentional resource efficiency.

Keywords
mindfulness meditation; sustained attention; workload; resource efficiency

Introduction
Maintaining concentration requires effort to maintain a focus of attention in the face of potential distraction from thought, emotion or environmental event. Because of this persistent demand, we cannot control our attention indefinitely. Resource theory suggests that the voluntary control of attention represents a drain on a limited pool of attentional resources.

When people are subject to a task requiring sustained attention, resource-drain is seen as a deterioration in correct responses over time. This phenomena has been labelled the ‘vigilance decrement’ (for review see, Warm et al., 2008a). In a laboratory setting, the onset and magnitude of the decrement has been altered with the manipulation of level and type of attention demand in the task. Incorporating decision-making and memory demands can increase task demand (e.g., Smit et al., 2004) and would therefore be expected to increase resource demand and speed resource depletion.

The notion of attentional resource utilisation is also important in research into the effects of some Buddhist meditation techniques. Research from a number of authors has found a link between mindfulness meditation practice and improved attentional resource efficiency. In particular, research has found a reduction in task-induced brain activation in meditating participants with no concurrent drop in performance. This has been observed during a variety of cognitive tasks; some demanding inhibition of automatic responses and conflict resolution (e.g., Moore et al., 2012) and others demanding focused attention on one point (e.g., Lutz et al., 2009). Although not yet investigated using subjective measures, brain
imaging findings might suggest a reduction in required mental effort (e.g., Kozasa et al., 2012), possibly a result of mindfulness training-related attentional skill acquisition (Slagter et al., 2011).

Considering these findings in relation to a resource theory of vigilance performance, it could be expected that greater efficiency in resource allocation could delay resource depletion and reduce the performance decrement in sustained attention. The aim of the present study was to investigate this possibility.

The research reviewed in this article is concerned with a particular form of Buddhist meditation known as mindfulness meditation. This practice encourages non-judgemental and deliberate awareness of subjective experience in the present moment. The reported short-term effect of mindfulness meditation is a gradual settling of the mind (Gunaratana, 2002). The long-term goal is to cultivate an attitude of non-reactivity to any conscious phenomena; to simply be aware without attachment (Suzuki & Chadwick, 2010). It is widely reported that continually returning one’s attention to the present moment can feel effortful for a beginner, but is more easily sustained with practice, as the mind’s habitual tendencies reduce (Brefczynski-Lewis et al., 2007). Advanced practitioners are reported to be able to sustain their attention for long periods with little effort (Wallace, 2006). The meditative practices mentioned above are expected to train the core cognitive skills required to remain focussed in the face of distraction (Slagter et al., 2011).

The vigilance task used in this study was a novel task designed to exercise sustained executive attention by incorporating a persistent decision-making factor. As such, the task required the active maintenance and updating of short-term memory, a process expected to rely upon an executive attentional control (Engle, 2002). Comprehensive behavioural data allowing for the interpretation of effort/workload was provided by the NASA Task Load Index (NASA-TLX: Hart & Staveland, 1988). This tool is used routinely in cognitive and vigilance research (Warm et al., 2008). Two novel factors were added to the tool to measure the extent to which each participant noticed themselves feeling bored during the tasks, and to what extent they noticed their minds wandering.

The present study had two hypotheses. Firstly, it was expected that as a result of attentional skill acquisition and the subsequent efficiency in resource allocation, meditators would be better able to meet the attentional demands of the response selection task. This was expected to be observed as an overall difference in performance scores (main effect of group), or as a greater consistency in performance during each task (group x time interaction effect), or as a positive relationship between meditation experience and performance scores.

Secondly, it was expected that for the same reasons, experienced meditators would perceive the tasks to be less demanding than non-meditating controls.

**Method**

**Participants**

Sixteen meditators (11 female, 5 male) were recruited from Buddhist meditation groups and one monastery in the North of England. All meditators reported practising meditation regularly for at least two years. Ages ranged from 29 to 69 (M = 51.4, SD = 10.6) and meditation experience from 624 to 31,200 approximate hours (M = 6, 209, SD = 7960). None of the meditating participants reported practising meditation in isolation from any other task within two hours of the beginning of the study.

Sixteen non-meditators (9 women, 7 men) were recruited from the North West of England by word of mouth. Age ranged from 32 to 75 (M = 51.8, SD = 16.0) in the non-meditating group. All participants reported normal or corrected-to-normal vision and no diagnoses of cognitive impairment. All participants were asked to abstain from caffeine for at least 4 hours prior to the study.

**Materials**

**Response selection task**

Participants were instructed to monitor the repetitive presentation of 12mm x 12mm light grey capital letters (O, D and backwards D) appearing in the centre of a plain white computer display. Participants were instructed to alternate responses to the letter O between hitting and not hitting the space bar (hit one, miss one, hit one, miss one…). They were instructed to ignore the other two letters. Incorporating this decision-making factor into the response selection task (RST) instructions was expected to increase executive attentional demand. A response was considered erroneous if it followed a similar response, i.e., two consecutive ‘hits’ in response to two.
consecutive Os.
Each letter was exposed for 100ms followed by a gap of 1,200ms. As such, the event rate was calculated at 46.15 events/min.

**Subjective workload measures**
Workload measures were provided by the NASA-TLX (Hart & Staveland, 1988) and subjective boredom and perceived mind-wandering items. The NASA-TLX provides six measures pertaining to workload, mental demand, physical demand, perceived performance, effort exerted, and frustration. Subjective boredom and mind-wandering measures required a response from 0 to 100 on a visual analogue scale relative to how bored the participant felt while completing each task and how much they noticed their mind wandering.

**Procedure**
Following study briefing, each participant completed the RST which lasted for 13 mins. Upon completion of the RST, participants were asked to complete the NASA-TLX to demonstrate their perceptions of the task. Meditating participants were not instructed to adopt meditative strategies during the task.

**Results**

**Response selection task**
Mean percentages of correct responses to critical signals for both groups are given in Figure 1, in 3 x 200-letter (4 mins and 20secs) blocks.

**Figure 1: Mean percentages of correct responses to critical signals for both groups (note that the y-axis does not begin at 0; error bars reflect standard error)**

A 2(group) x 3(time-block) analysis of variants (ANOVA) was conducted on an arcsine transformation of the dependent variable, response accuracy. The analysis did not detect a significant main effect of time-block, $F(2,60) = 0.31, p = .74$, therefore a vigilance decrement was not detected for either group. Contrary to study hypotheses, the interaction effect, time-block x group, was not significant, $F(2,60) = 0.28, p = .76$ and no main effect was detected for the between-subject variable group, $F(1,30) = 0.63, p = .43$. A linear regression analysis was also conducted on an arcsine transformation of the overall mean response accuracy scores. The analysis did not detect a relationship between the dependent variable and total meditation experience, $\beta = -0.21, F(1,14) = 0.62, p = .60$.

**RST workload data**
Mean scores and standard errors for the NASA-TLX workload factors and perceived boredom and mind-wandering measures for the RST are displayed in Figure 2.

**Figure 2: Means for RST workload factors and perceived boredom and mind-wandering measures for both groups (MD = Mental demand; TD = Temporal demand; E = Effort exerted; P = Performance; F = Frustration; B = Boredom; MW = Mind-wandering; error bars reflect standard error)**

A multivariate ANOVA detected a significant between-subjects effect of group for the dependent variables – frustration, $F(1,30) = 9.07, p = .005$ and boredom, $F(1,30) = 8.31, p = .007$ – indicating that the meditating group reported the RST to be less frustrating ($M = 25.3$, $SD = 18.5$) than non-meditating controls ($M = 47.8$, $SD = 23.3$) and less boring ($M = 23.0$, $SD = 20.4$) than non-meditating controls ($M = 49.4$, $SD = 30.5$). No significant effect of group was detected for the other variables: mental demand, $F(1,30) = 0.14, p = .71$; temporal demand, $F(1,30) = 1.52, p = .23$; effort, $F(1,30) = 1.01, p = .32$; performance, $F(1,30) = 2.65, p = .11$; or mind-wandering, $F(1,30) = 3.90, p = .058$.

In contrast to the above between-group analysis, linear regression analysis revealed that total meditation hours significantly predicted all of the contributing workload factors: mental demand, $\beta = -0.52, F(1,14) = 5.05, p = .041$; temporal demand, $\beta = -0.53, F(1,14) = 5.33, p = .037$; effort, $\beta = -0.58, F(1,14) = 7.01, p$
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In support of part of the second hypothesis (that experienced meditators would perceive the tasks to be less demanding than meditation-naive controls), study data showed a relationship between meditation experience and perceived task demand for the RST. This indicated that as meditation experience increased, perceived cognitive workload decreased. This was reflected in all four demand-related contributing workload factors: perceived mental demand, temporal demand, effort exerted, and frustration. These findings were accompanied by between-group differences in frustration showing that the meditating group reported being less frustrated than the non-meditating group during the RST. A resource theory of vigilance would suggest that these findings reflect that as meditation practice increased, the magnitude of resource utilisation demanded by the RST decreased. So, although no effect of meditation on performance scores was demonstrated, the most experienced meditators tended to be able to achieve their performance levels with a lesser drain on their attentional resources. This suggestion is in agreement with previous research making use of brain imaging techniques (e.g., Kozasa, et al., 2012; Lutz, et al., 2009) and provides subjective support for previous interpretations of brain imaging data (Kozasa, et al., 2012; Lutz, et al., 2009).

In contrast, between group differences were not detected for the mental demand, temporal demand and effort measures. This might be a product of insufficient sample size. None the less it can be concluded that regular mindfulness meditation practice can reduce the perceived demand of an executive sustained attention task, but only after a great deal of meditation practice might one expect these effects to be observable against the normal variation expected in any population.

Interestingly the observed effect of meditation experience on the perceived temporal demand of the RST indicates that experienced meditators tended to find the pace of the RST to be more manageable than non- or inexperienced meditators. This could perhaps suggest an effect of meditation practice on processing speed and should be explored in future research. Alternatively, this finding might reflect a benefit of a reduction in task-irrelevant processing (mind-wandering) which might normally compete for limited resources (see Figure 1). If a reduction in mind-wandering facilitated more effective task-relevant processing, perceived workload might be expected to decrease as a function of reduced mind-wandering.

This study clearly identifies that frustration during the RST was reduced by meditation experience. This manifested as both a between-group difference and as a function of increasing meditation experience. This might indicate that the meditating group did not judge the RST as
Mindfulness meditation practice can make concentration feel a little easier. Alternatively, this finding might reflect group differences in emotion regulation. This would suggest that meditators were better able to regulate their affective state even when occupied with another task. Although improvements in emotion regulation have previously been linked with meditation practice (Baer, 2006), this finding is novel in that effects have been demonstrated in the presence of a concurrent, attentionally demanding task. This finding might suggest that meditators are better able to notice and disengage from the thoughts and feelings associated with frustration, even while devoting significant resources to another task. This alludes again to notable group differences in the way that attentional resources were distributed during the RST. Over a longer duration, increasing levels of frustration might be expected to provide a significant distractor and might influence task performance. Meditation practice probably allowed meditating participants to allocate fewer attentional resources to the cognitive and affective markers of frustration.

A similar explanation might be considered for group differences in reported boredom. The meditating group may have been more proficient at noticing judgmental appraisals of the task and disengaging from them, again at the same time as devoting a large quantity of attentional resources to the tasks. It is conceivable that, in the event that fewer resources are devoted to self-concern and cognitive appraisal of the present situation, an experience of absorption in the present task might occur. This kind of interpretation finds some cohesion with traditional meditation literature suggesting that absorption states can occur as a result of extensive meditation practice and an environment free from distraction (Gunaratana, 2009).

It is also possible that group differences in self-report boredom could reflect individual differences in boredom proneness which may have existed even before meditation practice. To further this line of thinking, it is plausible that those who are less prone to boredom are more likely to stick to a regular meditation practice.

A particular strength of the present study was its inclusion of comprehensive behavioural measures allowing for the investigation of both the inner and outer effects of meditation practice during sustained executive and orienting attention. These behavioural data demonstrated that the act of sustaining concentration on one task may feel a little easier following a history of mindfulness meditation practice. In addition, other negative emotional responses to the act of sustaining concentration such as frustration and boredom can be reduced.
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