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Abstract

Past research has found that mindfulness meditation training improves executive attention and that this effect could be driven by more efficient allocation of resources on demanding attentional tasks, such as the Flanker Task. However, it is not clear whether these changes depend on long-term practice. We sought to investigate the effects of a brief, 10-minute meditation session on attention in novice meditators, compared to a control activity. We also tested moderation by individual differences in Neuroticism. We found that participants randomly assigned to meditate for 10 minutes showed improved performance on incongruent trials on a Flanker task, with no detriment in reaction times, indicating better allocation of resources. Neuroticism moderated this effect, as only those low in Neuroticism showed improved allocation of attentional resources following meditation.

Keywords: mindfulness meditation; attentional network test; executive attention; neuroticism

Introduction

Mindfulness is often defined as a two component process: (1) attention to present moment experience, coupled with (2) an attitude that is open, non-reactive, and accepting of things as they are (Bishop et al, 2004; Ludwig & Kabat-Zinn, 2008). Over the past few decades a wealth of research has emerged in both popular science and academic journals on the benefits of mindfulness meditation for cognitive performance (e.g., creativity; Ding, Tang, Tang & Posner, 2014; attention; Sedlmeier et al., 2012), mental health (Hofmann, Sawyer, Witt, & Oh, 2010), negative mood (Goyal et al., 2014), treatment for addiction (Brewer et al 2011a; Bowen 2014), prejudice and discrimination (Lueke & Gibson, 2016), and many other psychological processes. One premise in this area of research is that becoming mindful of an internal state or physiological function, such as one's breath or heartbeat, can hone abilities such as focused attention, working memory, and acceptance. In turn, this is thought to have long-term positive consequences when mindfulness is trained and practiced over an extended period of time.

Much of the past research has focused on the effects of mindfulness meditation training on attentional processes, including alerting, orienting, and executive attention. For example, Maclean and colleagues (2010) found that 3 months of intense meditative training can improve performance on tasks of perceptual discrimination and sustained visual attention. Elliott, Wallace and Giesbrecht (2014) showed that a weeklong intensive meditation retreat can improve both executive attention and alerting (but not orienting). Jha, Krompinger and Baime (2007), however, found that both an 8-week MBSR (i.e., mindfulness based stress reduction) course and a 1-month intensive MBSR retreat improved orienting but not executive attention. To the contrary, Tang and colleagues (2007) used a slightly less time-intensive approach and reported that 5 days of 20-minute training sessions can improve executive attention and a more recent empirical article also found that mindfulness meditation increased executive attention (Ainsworth et al., 2013). In a review article comparing multiple forms of meditation, Lippelt, Hommel, & Colzato (2014) conclude that there is good evidence to suggest that focused attention meditation (such as mindfulness) increases sustained attention (Carter et al., 2005; Brefczynski-Lewis et al., 2007). Notably, all of these studies have utilized extensive meditation training, including multiple hour-long sessions administered over an extended period of time.

Clearly, the literature on the effects of meditation on attention is both diverse and in some disarray, with different approaches to meditation (e.g., MBSR retreats vs. daily self-guided sessions) having divergent effects on different forms of attention. In addition, most of these studies have examined the effects of intensive, longitudinal meditative training composed of multiple sessions over weeks and/or years, and often recruit meditation-motivated or experienced individuals as participants.

Mindfulness meditation training takes many forms in the literature, but most often involves either an extended immersive experience (e.g., a 3-month retreat) or repeated daily practice, either in the form of a multi-week course or weeks (or months) of self-guided meditation. Indeed, the vast majority of published work has been on the effects of 8 weeks of training or longer (e.g., Hofmann, Sawyer, Witt, & Oh, 2010, Brewer et al 2011b). And, although these studies have often documented beneficial outcomes of mindfulness meditation practice, the relevance of such time-consuming, extensive training is debatable for the average individual who might be either unmotivated or unable to dedicate the time and resources necessary to reap such benefits. This relates to the questions of "dose" – once someone begins to practice mindfulness, how soon can they expect to see beneficial effects (e.g., Tang et al., 2015; Zeidan, 2015)? A few recent studies have shown that 3-4 days of training are associated with some beneficial effects (e.g., Zeidan et al.,

2010a, 2010b). The current study focuses on meditation-naïve college students, to examine whether 10 minutes of meditation may have an immediate impact on attention. This approach represents an extreme test of the impact of mindfulness meditation on attention, but also may greatly expand our knowledge of the power of meditation, its boundary conditions, as well as its potential for practice in daily life. In the current studies we focus on whether a single brief audio-guided meditation can have similar benefits for attention in novice meditators.

` In an initial attempt to examine the effects of a brief guided meditation on attention in novice meditators, we asked participants to listen to an audio tape (mindfulness meditation vs. control) and then subsequently complete a version of the Flanker task (Eriksen & Eriksen, 1974; Eriksen, 1995), a measure of executive attentional control. Participants also completed the Big 5 Personality Dimension Inventory to allow for the investigation of moderation by individual differences in Neuroticism.

Method

Participants. 40 (14 female) undergraduate students between the ages of 17 and 22 (M = 19.48, SD = 1.18) were recruited from Swarthmore College. Three participants were omitted from final analyses because of scores greater than 3 SDs from the mean (i.e., outliers), leaving a final sample size of 37 (12 female; Mage = 19.51, SD = 1.19). Participants were entered into a raffle for one of two $25 prizes as compensation for completion of the study. All participants gave informed consent, and the study was conducted under the guidance of the Swarthmore College Institutional Review Board.

Procedure. Upon arriving at the laboratory, participants were told that the purpose of the study was to investigate the effects of audio attention on visual acuity. Each participant was seated in front of a desktop computer and was asked to wear headphones and a blindfold, to allow a focus on the audio recording. After the recording, the experimenter returned, removed the blindfold, and provided verbal instructions for the Flanker task. Participants completed twelve practice trials and were given the opportunity to ask questions before beginning the experimental trials. Following the Flanker task participants completed the Big 5 Personality Inventory (John, Donahue, & Kentle, 1991) and a demographic survey. Finally, the experimenter and participant engaged in a face-to-face funneled debriefing interview.

Experimental Conditions. Participants were randomly assigned to either listen to a 10-minute guided audio meditation tape (meditation) or a 10-minute audio control tape (control). The mindfulness meditation tape was developed based on classic mindfulness instructions used in MBSR, and in consultation with several meditation teachers. This tape led participants through a breath-focused mindfulness exercise oriented towards beginners. It included instructions such as "please set the intention to observe your experience with an accepting attitude," "please notice and begin to follow the natural and spontaneous movement of the breath, not trying to change it in any way," and "stay open and curious about your experience." The control tape was a reading of a National Geographic article about giant sequoias. Importantly, both recordings used the same speaker, speed of speech, number of words, and had similar word frequencies. In addition, both tapes began with instructions on posture within the first few seconds, and included pauses at approximately the same times and for similar durations, throughout.

Flanker Task. The flanker task was delivered using E-Prime 2.0 software on a Dell computer with a 22" LCD monitor (refresh rate = 60 Hz). The flanker array consisted of white arrowheads on a black background and was 4.5 cm wide by 1.3 cm high. On average participants sat approximately 70 cm from the screen, producing a visual angle of the array width of 0.026 degrees and of the array height of 0.091 degrees. Each trial consisted of a 500ms white fixation cross in the center of the black screen, followed by an array of five arrows, which remained on the center of the screen until a response was made. Participants pressed the "f" key with their left hand if the center arrow was facing left, and the "j" key with their right hand the center arrow was facing right. Flanking arrows were either facing in the same direction (i.e., congruent trials) or in the opposite direction (incongruent trials; Figure 1). There were 20 trials in each cell of the 2(direction: left, right) x 2(trial type: congruent, incongruent) design, resulting in a total of 80 trials, presented randomly. Participants were told to respond as quickly and accurately as possible. As soon as a response was made, the next trial began (i.e., there was no intertrial interval).

Big 5 Personality Inventory. After the flanker task, participants completed the Big 5 Personality Inventory (John, Donahue, & Kentle, 1991), a self-report survey consisting of 44 items designed to measure five personality factors: Openness, Conscientiousness, Extraversion, Agreeableness, and Neuroticism. Participants indicated the degree to which they agreed or disagreed with each item on a 5-point Likert scale, with endpoints labeled disagree strongly (1) and agree strongly (5). Each item began with the phrase "I see myself as someone who…"; sample items for the Neuroticism subscale items include: "worries a lot" and "is emotionally stable, not easily upset," with the latter reverse-coded.

Demographic Survey. Participants also completed a standard demographic survey in which they reported their age, gender (male, female), and self-reported their race and ethnicity.

Debriefing. Finally, participants completed a funneled debriefing interview in which they were given the

opportunity to report any suspicion about the true purpose of the study, as well as reporting any previous experience with meditation, including duration and frequency of practice.

Results

We conducted independent samples t-tests to examine any differences between groups of participants randomly assigned to listen to the meditation tape versus those randomly assigned to listen to the control tape on variables including: age, gender, race, Big 5 Personality traits, and meditation experience. There were no significant group differences on any of these measures.

Response times. RTs for correct trials only were subjected to a 2(condition: meditation, control) x 2(trial type: congruent, incongruent) general linear model (GLM), with the first factor manipulated between-participants and the second factor manipulated within-participants (collapsing across arrow direction). The main effect of trial type, $F(1,35) = 129.32$, $p < 0.001$, indicated that participants were faster to respond on congruent trials ($M = 427.05$ ms, $SE = 6.84$) than on incongruent trials ($M = 466.26$, $SE = 7.53$), a replication of past research. No other effects reached traditional levels of significance.

Accuracy. Rates of accurate responding were subjected to a similar 2(condition: meditation, control) x 2(trial type: congruent, incongruent) GLM. The main effect of trial type, $F(1,35) = 35.123$, $p < 0.001$, indicated that participants were more accurate on congruent ($M = 0.99$, $SE = 0.003$) than on incongruent ($M = 0.93$, $SE = 0.01$) trials, another replication of past research. The main effect of condition was marginally significant, $F(1, 35) = 3.10$, $p = .087$, and indicated that participants in the mediation condition were more accurate ($M = 0.97$, $SE = 0.007$) than were participants in the control condition ($M = 0.95$, $SE = 0.007$). Importantly, there was a significant interaction between trial type and condition, $F(1,35) = 5.24$, $p = 0.028$. Pairwise tests showed that whereas both groups of participants were more accurate on congruent than on incongruent trials (ps $< .05$), participants in the meditation condition performed better on incongruent trials ($M = 0.95$, $SE = 0.01$) than did those in the control condition ($M = 0.91$, $SE = 0.01$), $p = .044$ (Figure 2). Participants in the meditation condition ($M = 0.99$, $SE = 0.004$) and the control condition ($M = 0.99$, $SE = 0.004$) performed equally well on congruent trials, $p = .39$.

To further probe the effects of meditation on attention on the Flanker task, we calculated difference scores to capture the overall "Flanker effect" in correct RTs (incongruent – congruent) and accuracy (congruent – incongruent), separately. Two independent samples t-test conducted on these difference scores showed no difference between meditation and control conditions in correct RTs, $p = .48$, and a significant difference in accuracy, $t(35) = 2.29$, $p = 0.028$, such that participants in the meditation condition ($M = 0.04$, $SE = 0.06$) exhibited a smaller Flanker effect than those in the control condition ($M = 0.08$, $SE = 0.06$). Thus, participants in the meditation condition showed a decreased Flanker effect in accuracy – reflecting better executive attentional control – as compared to those in the control condition, due to their improved performance on incongruent trials.

Moderation by Neuroticism. First, we conducted an independent samples t-test to examine whether random assignment to condition (i.e., meditation versus control tape) affected self-reported Neuroticism. As expected, Neuroticism did not differ between participants assigned to the meditation tape ($M = 0.03$, $SD = 0.97$) and those assigned to the control tape ($M = -0.02$, $SD = 1.06$), $t(35) = 0.14$, $p = .89$. Thus, Neuroticism scores can be assumed to represent true, stable individual differences rather than an unintended effect of random assignment to condition.

To examine moderation of the effects of meditation on attention by individual differences in Neuroticism, RTs were subjected to a 2(condition: meditation, control) x 2(trial type: congruent, incongruent) x z-scored Neuroticism GLM, with the first factor manipulated between-participants, the second factor manipulated within-participants, and Neuroticism entered as a continuous between-participants covariate. This analysis allows for the examination of main effects and the interaction between condition and trial time holding Neuroticism constant, as well as investigating the main effect of Neuroticism and its interactions with all other variables. As expected, this analysis merely revealed a main effect of trial type, $F(1,33) = 126.30$, $p < .001$, such that participants were faster on congruent than on incongruent trials even when controlling for neuroticism.

A similar GLM was conducted on accuracy scores. As expected, the main and interaction effects reported above held when controlling for neuroticism, including the condition x trial type interaction, indicating that individuals in the meditation condition were more accurate on incongruent trials than were those in the control condition. However, we also found a condition x trial type x Neuroticism interaction, $F(1,33) = 3.72$, $p = .06$. To better understand this interaction, we examined accuracy estimates at 1 SD above and below the mean Neuroticism score. Those individuals lower in Neuroticism (-1 SD) generally exhibited the overall pattern: individuals in the control condition were more accurate to congruent than to incongruent trials ($p < .001$), the two groups did not differ in their accuracies to congruent trials ($p = .30$), but individuals in the meditation condition performed better on incongruent trials ($M = 0.98$, $SE = .02$) than did those in the control condition ($M = 0.91$, $SE = .02$; Figure 3). Indeed, meditation improved performance to such a degree that participants in this condition performed as well on incongruent trials ($M = 0.98$, $SE = .02$) as they did on congruent trials ($M = 0.99$, $SE = .01$), $p = .78$. Individuals higher in Neuroticism (+1 SD), however, showed no effect of meditation: both groups were more accurate on congruent than on incongruent trials (ps <

.005) and did not differ in accuracy on either trial type (*p*s > .75; Figure 3).

Discussion

Results indicate that a brief 10-minute guided meditation can improve executive attentional control even in naïve, inexperienced meditators. Perhaps more interesting is the fact that this meditation-induced improved performance was only observed for individuals relatively low in Neuroticism; individuals higher in Neuroticism did not exhibit any performance boost following meditation. Neuroticism, which is characterized by anxiety, high negative affect, and worry, may prevent individuals from reaping the benefits of meditation, as it may be difficult for individuals higher in Neuroticism to disregard their negative emotionality and focus on the early stages of mindfulness practice.

Previous research has focused on the reduction of neuroticism, anxiety, and stress due to meditation and less on personality predictors (e.g., Neuroticism) of response to meditation. For example, Williams, Francis, and Durham (1976) found that males who practiced transcendental meditation (i.e., a self-selected group) were more neurotic than the general population, but that they also became less neurotic over the course of a 6-month period of study and that decreases in Neuroticism were directly associated with frequency of meditation. Similarly, Lane and colleagues (2007) found that Neuroticism moderated treatment effects in a group of individuals who completed training in meditation, such that individuals higher in Neuroticism at baseline showed greater decreases in negative mood, perceived stress, and anxiety over the course of training. Thus, Neuroticism appears to have a positive impact on more long-term consequences of meditation. Less is known about its ability to predict who will benefit from the practice of meditation.

In an early review of the literature, Delmonte (1985) argued that prospective meditators often report higher than average anxiety levels, and that anxiety predicts lower frequency of practice. Ironically, Delmonte (1985) also reported that meditation reliably decreases levels of anxiety over the course of practice. Furthermore, many studies have shown that regular meditators tend to be lower in trait Neuroticism (Leung & Singhal, 2004). Thus, greater stress and anxiety may drive individuals to engage in meditation, while also negatively impacting the frequency of practice. If they, however, do persist in meditation, these individuals often show decreases in their anxiety and negative affect.

The current study is unique in that we recruited healthy undergraduate students who had not expressed any desire to practice meditation and simply measured Neuroticism; in this way, we did not bias our sample toward particular personality traits. Indeed, we did not tell participants that they were engaging in a guided meditation in order to minimize expectancy effects. And we controlled for frequency of practice by requiring that all participants simply complete one 10-minute guided meditation in the laboratory. Thus, our results suggest that trait Neuroticism may negatively impact the efficacy of short, guided meditation; individuals high in anxiety and self-awareness may not be able to relax and follow the instructions presented in guided audio meditation, thus preventing them from reaping the benefits of a meditation intervention. This finding has strong implications for the field, as it suggests that the very population thought to benefit most from meditation (i.e., individuals high in anxiety and Neuroticism) may have difficulty initially engaging in the practice. As meditation becomes more frequently prescribed as part of a holistic treatment for mental health disorders often associated with high Neuroticism, including depression, phobia, and other anxiety disorders, practitioners would benefit from an understanding of the difficulties individuals high in Neuroticism face in both learning and persisting in the practice of mindfulness meditation.

In sum, our results suggest that even in novices, one brief 10-minute audio-guided meditation improves attention. Specifically, on an attentional task performed under time pressure, participants in the meditation condition exhibited a boost in accuracy reflecting increased attentional control. Importantly, this effect was strongest for individuals lower in Neuroticism, indicating that personality may impact the ability to reap the benefits of brief meditation. Although much remains to be studied, the current paper suggests that brief meditation impacts attention even in novice practitioners and therefore has widespread implications.

Figures

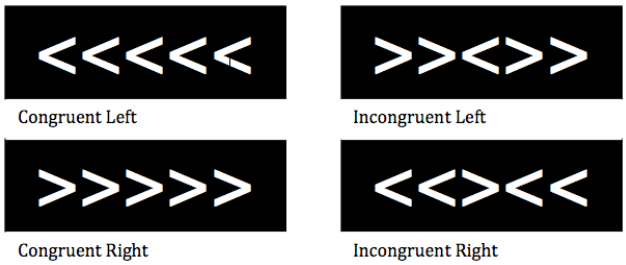

Figure 1: Trial schema for the Flanker Task.

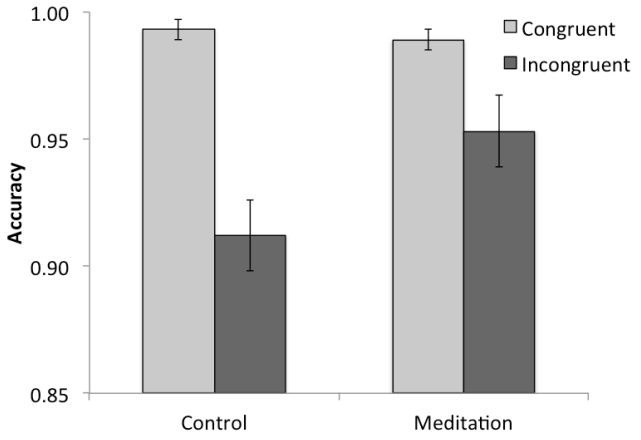

Figure 2: The condition x trial type interaction in accuracies. Both groups were more accurate on congruent than on incongruent trials, but individuals in the meditation condition performed better on incongruent trials than did those in the control condition.

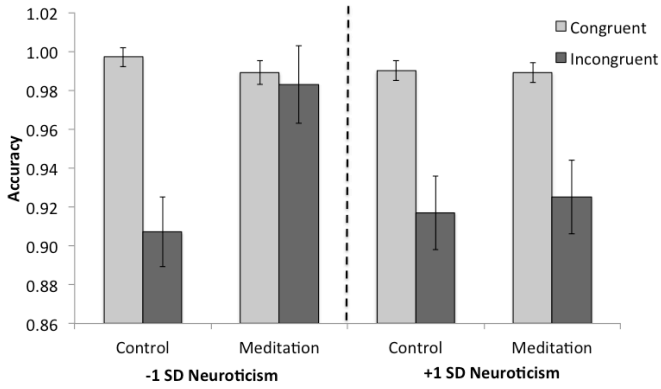

Figure 3: The interaction between condition, trial type, and Neuroticism. Meditation was effective in improving performance on incongruent trials for individuals lower in Neuroticism (-1 SD) but not for those higher in Neuroticism (+1 SD).

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