Mindfulness and mind wandering: The protective effects of brief meditation in anxious individuals

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A R T I C L E   I N F O

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A B S T R A C T

Mind wandering can be costly, especially when we are engaged in attentionally demanding tasks. Preliminary studies suggest that mindfulness can be a promising antidote for mind wandering, albeit the evidence is mixed. To better understand the exact impact of mindfulness on mind wandering, we had a sample of highly anxious undergraduate students complete a sustained-attention task during which off-task thoughts including mind wandering were assessed. Participants were randomly assigned to a meditation or control condition, after which the sustained-attention task was repeated. In general, our results indicate that mindfulness training may only have protective effects on mind wandering for anxious individuals. Meditation prevented the increase of mind wandering over time and ameliorated performance disruption during off-task episodes. In addition, we found that the meditation intervention appeared to promote a switch of attentional focus from the internal to present-moment external world, suggesting important implications for treating worrying in anxious populations.

1. Introduction

Mind wandering accounts for almost half of our daily stream of consciousness (Killingsworth & Gilbert, 2010). A thought is identified as signifying mind wandering when it is: (1) unrelated to the current task, and (2) decoupled from the external environment (Stawarczyk, Majerus, Maquet, & D’Argembeau, 2011). For example, while writing an algebra exam in a large gymnasium, a thought about lemon pie would constitute mind wandering because it is both unrelated to the exam and independent of the external environment. Intuitively, we all know that mind wandering can cause us to make errors on important tasks (e.g., mailing an envelope without its contents), and consistent with this intuition, a considerable amount of research has demonstrated that mind wandering disrupts performance on numerous tasks that require focused attention (for a review see Mooneyham & Schooler, 2013). For example, mind wandering has been associated with an increased risk of injury and death while driving (Knowles & Tay, 2002), difficulties in educational settings (Seli, Wammes, Risko, & Smilek, in press), increased response variability in tasks assessing sustained attention (Seli, Carriere, Levene, & Smilek, 2013), and impaired performance in everyday life (McVay, Kane, & Kwapil, 2009).

Hence, there is an imperative need for strategies that not only reduce the occurrence of mind wandering but also ameliorate its disruptive impact on performance (Mooneyham & Schooler, 2013). A logical starting point is to investigate strategies that enhance mindfulness, a mental state that is, by definition, characterized by the absence of mind wandering. Mindfulness is commonly defined as “paying attention in a particular way, on purpose, in the present moment, and non-judgmentally” (Kabat-Zinn, 1994, p. 4). If mind
wandering is a state characterized by the occurrence of task-unrelated and stimulus-independent thoughts (Stawarczyk, Majerus, Maquet, & D'Argembeau, 2011), then mindfulness, a state characterized by thoughts centred on the “here and now”, should be considered its opposite.

Indeed, research has found that individuals low in trait mindfulness report higher rates of mind wandering in everyday life (Carriere, Seli, & Smilek, 2013; Seli, Carriere, & Smilek, 2015). Meanwhile, several clinical trials have demonstrated that mindfulness-based therapy is effective in the reduction of both rumination and worry (i.e., a form of mind wandering) (for a review see Querstret & Cropley, 2013). Despite these promising results, only a handful of studies have directly examined the impact of mindfulness training on mind wandering in a controlled experimental setting and research evidence is mixed. While mindfulness training appeared to be generally beneficial for unselected, healthy populations, it only exhibited protective effects for individuals with high negative affect.

Several studies have demonstrated that mindfulness training can reduce the frequency of mind wandering and ameliorate its disruptive impact on performance in general populations. In one such study (Mrazek, Franklin, Phillips, Baird, & Schooler, 2013), university students who were given two weeks of mindfulness training showed improved performance on a GRE test and a working memory test, and reported less mind wandering during completion of both measures. In another study (Morrison, Goolsarran, Rogers, & Jha, 2014), university students who were given seven weeks of mindfulness training demonstrated higher response accuracy and reported more on-task thoughts during the Sustained Attention to Response Task (SART; Robertson, Manly, Andrade, Baddeley, & Yiend, 1997). Similar results were revealed in more recent studies. Jazaieri et al. (2016) had a community sample complete a nine-week compassion meditation program, which led to significant reductions in their daily experience of mind wandering. Zanesco et al. (2016) conducted two studies in which unselected participants were given an intensive, residential mindfulness training for either one or three months and observed that participants engaged in less mind wandering and less mindless reading after training. Shorter mindfulness training delivered similar benefits. University students who practiced eight minutes of mindful breathing showed fewer attentional lapses during the SART, compared to those who received passive relaxation or a reading task (Mrazek, Smallwood, & Schooler, 2012).

However, for individuals experiencing high negative affect, available studies have only shown protective effects of mindfulness training on mind wandering. Jha et al. (2015) had two military cohorts complete eight weeks of either didactic-focused or practice-focused mindfulness training during a high-demand interval of pre-deployment training, while a third military cohort and a civilian sample received no training and served as control groups. Mindfulness training did not improve performance on the SART but prevented attentional lapses from increasing over the course of pre-deployment training, with the practice-focused intervention group outperforming the didactic-focused group (Jha et al., 2015). In a similar study, Jha, Stanley, Kiyonaga, Wong, and Gelfand (2010) delivered eight weeks of mindfulness training with daily practice to a military cohort during a stressful pre-deployment interval, while another pre-deployment military cohort and a civilian sample served as control groups. Results indicated that mindfulness training prevented degradations in working memory over the pre-deployment interval. However, this protective effect was only present for those who spent more time practicing mindfulness. The same results were replicated in a study conducted by Banks, Welhaf, and Sour (2015). Participants who received one week of mindfulness training (15 min of guided practice plus daily home practice) showed no increase in working memory or decrease in mind wandering as measured during the working memory test. However, mindfulness training prevented working memory from decreasing following experimentally induced stress. It was concluded that mindfulness training was effective in reducing the negative impact of mind wandering only at low to moderate levels of negative affect (Banks et al., 2015).

Therefore, research has rendered mixed results on the specific impact of mindfulness on mind wandering. For the general population, mindfulness training appears to be effective in reducing the occurrence of mind wandering and improving task performance, regardless of its intensity. In contrast, for individuals experiencing high negative affect, mindfulness training did not reduce the occurrence of mind wandering and only prevented performance degradations. Taken together, existing research suggests that the extent to which mindfulness is effective in reducing mind wandering might be conditional on the characteristics of its target population. Mindfulness training only demonstrated protective effects for individuals encountering high stress either in real life (Jha et al., 2010, 2015) or in a laboratory setting (Banks et al., 2015). Unfortunately, research on this topic is limited and no conclusion can be drawn at this point.

People who are high in trait anxiety experience high levels of negative affect. However, to the best of our knowledge, no published study has investigated the effectiveness of mindfulness as a remedy for mind wandering in anxious people. Given anxious individuals tend to experience more off-task thoughts and have greater difficulty managing their wandering minds (for a review see Aldao, Nolen-Hoeksema, & Schweizer, 2010), it is particularly important to examine the extent to which mindfulness training is beneficial for this population. Moreover, research of this kind would provide more insight into the hypothesis that mindfulness training only has prophylactic effects for individuals experiencing high stress (Banks et al., 2015).

Despite some encouraging findings from recent studies, research examining the impact of mindfulness on mind wandering is still in a preliminary stage. The underlying mechanism(s) by which mindfulness attenuates mind wandering is left entirely to speculation. One promising line of research focuses on motivational states (Unsworth & McMillan, 2013). Recent research from our lab suggests that higher motivation to succeed on a laboratory task was associated with less mind wandering and better performance (Seli, Cheyne, Xu, Purdon, & Smilek, 2015). Given the absence of research linking mindfulness to motivation, the current study served as an attempt to explore this possible association.

The goal of the current study was to: (1) examine whether a brief mindfulness meditation would have protective effects on mind wandering among anxious individuals, and (2) explore the extent to which mindfulness might influence one’s motivational states. In particular, undergraduate students high in trait anxiety completed two blocks of the Metronome Response Task (MRT), which
required them to respond (via key-press) synchronously with a series of tones. In between the two MRT blocks, participants either practiced mindfulness meditation or listened to an audiobook for ten minutes. It was hypothesized that: (1) mindfulness meditation would prevent mind wandering from increasing; (2) mindfulness meditation would ameliorate performance disruption during episodes of mind wandering; and (3) mindfulness meditation would result in changes to motivational states.

2. Method

2.1. Participants

During the first month of the academic term, a total number of 2551 undergraduate students from the University of Waterloo underwent a mass testing procedure, in which they completed a large set of various questionnaires for partial course credits. Among these questionnaires, the State-Trait Inventory for Cognitive and Somatic Anxiety-Trait (STICSA; Ree, French, MacLeod, & Locke, 2008) was the only scale that was intended for this study. Based on their responses to the STICSA, only those with a minimum total score of 43 were invited to participate in this study, which was suggested as an optimal cut-off score for identifying clinical anxiety (Van Dam, Gros, Earleywine, & Antony, 2013). In total, 713 undergraduate students were eligible to participate in the present study and 91 of them gave informed consent and completed all study procedures in exchange for course credits.

Out of the original 91 participants, data from five participants were discarded because they had difficulty staying focused during the study. We also discarded data from two participants in the meditation group who reported having previous meditation experience and two other participants with outlying scores on mean response time (more than two standard deviations from the mean). There were 82 participants (55 females) with complete data for analyses, with a mean age of 20.0 years ($SD = 1.8$). Participants were randomly assigned to either the meditation group ($N = 42$; all novices) or the control group ($N = 40$). Analyses showed no significant difference between two groups in trait anxiety, trait mindfulness, or baseline mood states (all $p_s > 0.07$). Participants in the meditation group were slightly younger ($M = 19.57$, $SD = 1.66$) than those in the control group ($M = 20.43$, $SD = 1.95$), $p < 0.05$. However, there was no significant correlation between age and the frequency of off-task thoughts ($p > 0.56$). Therefore, age was not included in the following analyses. The protocol received ethical clearance from the Office of Research Ethics at the University of Waterloo.

2.2. Self-report measures

2.2.1. State-trait inventory for cognitive and somatic anxiety-trait

In the beginning of the academic term, participants completed the STICSA (Ree et al., 2008) as part of a mass-testing procedure. The STICSA contains 21 items measuring general trait anxiety. Participants rated to what extent they agreed with each statement on a 4-point Likert scale (from 1 “not at all” to 4 “very much so”). This measure has demonstrated good validity and reliability in clinical samples (Gros, Antony, Simms, & McCabe, 2007). We included the STICSA to pre-select participants who were high in trait anxiety.

2.2.2. Mindfulness attention awareness scale

At the beginning of the experiment, participants completed the Mindfulness Attention Awareness Scale (MAAS; Brown & Ryan, 2003). The MAAS contains 15 items measuring awareness of attention in everyday life. Participants rated the frequency at which they failed to sustain awareness of attention on a 6-point Likert scale (from 1 “almost always” to 6 “almost never”). This measure has demonstrated satisfactory psychometric properties (MacKillop & Anderson, 2007). The MAAS was included to rule out the possibility of any between-group difference in trait mindfulness at baseline.

2.2.3. Positive and negative affect schedule

Participants completed the Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988) both at baseline and before the experiment concluded. The PANAS consists of 20 items measuring mood states (i.e., how the individual is feeling at the moment). This schedule generates two subscales: one measuring positive affect and the other measuring negative affect (10 items per scale). Using a 5-point Likert scale (from 1 “very slightly or not at all” to 5 “extremely”), participants rated the extent to which their feeling was consistent with each item. The PANAS has demonstrated good validity and internal consistency in a large sample (Crawford & Henry, 2004). The PANAS was included to assess changes in mood states throughout the experiment.

2.3. Mindfulness intervention

Participants in the meditation group listened to an audio recording of “Mindfulness of body and breath” (Williams & Penman, 2011), which instructed them to focus their attention on breathing and remain open-minded to their experience. This exercise was designed for novices and has been used extensively in experimental studies on mindfulness (Erisman & Roemer, 2010; Kramer, Weger, & Sharma, 2013).

2.4. Control intervention

Participants in the control group were asked to sit quietly. The first eight paragraphs of the first chapter (“An unexpected party”) from an audiobook version of JRR Tolkien’s “The Hobbit” (Inglis, 2012) were then played through speakers. We used a narrated story
because the extent to which this story required auditory attention was comparable to the mindfulness exercise. Moreover, “The Hobbit” has been used as the control condition in several studies on mindfulness (Johnson, Gur, David, & Currier, 2013; Kramer et al., 2013). The control group reported a proportion of intervention-related thoughts that was equivalent to that of the meditation group at post-test ($p = 0.87$), verifying that there was indeed comparable engagement across both the mindfulness and control conditions.

2.5. The Metronome Response Task (MRT)

The MRT (Seli, Cheyne, & Smilek, 2013) is a sustained-attention task in which participants have to respond to a periodic metronome tone presented through the speakers. On each MRT trial, participants were presented with 650 ms of silence, followed by a metronome tone lasting 75 ms, and then another 575 ms of silence. Participants were instructed to press the spacebar in synchrony with the metronome so that their key-press was made at the exact time at which each metronome tone was presented. Participants completed two blocks of the MRT on a computer using the E-Prime software (Psychology Software Tools, 2007) and there were 250 trials in each block.

2.6. Thought probes

To obtain real-time measures of mind wandering, we intermittently presented “thought probes” throughout the MRT. These probes are simply task interruptions that require participants to report on their mental state in the moments just prior to the presentation of each probe. One probe was randomly presented within every set of fifty MRT trials. Hence, there were five thought probes in each MRT. Upon the presentation of each thought probe, the MRT temporarily stopped and the computer gave the prompt: “what was the thought you were having just prior to this moment”. Participants were to type their thought(s), verbatim. Next, participants provided three separate reports of motivation using a 9-point Likert scale from 1 (no motivation at all) to 9 (very strong motivation): (1) “how motivated were you to think about this thought”; (2) “how motivated were you to avoid thinking about this thought”; and (3) “how motivated were you to perform well on this task”.

Three independent judges were recruited to code reported thoughts. Each thought was rated on task-relatedness (i.e., whether the thought was directly related to completing the task or the nature of the task) and stimulus-dependency (i.e., whether the thought referred to an external stimulus or a physical sensation in the current environment) using established criteria (Stawarczyk, Majerus, Maquet et al., 2011). Each thought was then assigned to one of four categories: (1) on-task thoughts (task-related and stimulus-dependent, e.g., “focusing on the metronome”); (2) task-related interferences (TRIs; task-related and stimulus-independent, e.g., “what is the purpose of this study”); (3) external distractions (EDs; task-unrelated and stimulus-dependent, e.g., “the screen is a little dirty”); and (4) mind wandering (task-unrelated and stimulus-independent, e.g., “thinking of tomorrow’s studying plan”). In addition, we collapsed data across TRIs, EDs, and mind wandering, as they all represent off-task thoughts (i.e., thoughts that are not on-task). Inter-rater reliability (Cohen’s kappa) ranged from 0.69 to 0.92, suggesting satisfactory reliability across coders. Inter-rater averages were calculated and significant discrepancies were resolved through discussion.

2.7. MRT measures

The Rhythmic Response Time (RRT) was first calculated as the difference between the time of the key-press and the onset of the metronome tone. A higher RRT variance indicates less synchronous responding, which in turn reflects poorer performance (Seli, Carriere et al., 2015). As variance data from the MRT was highly skewed in the positive direction, we followed established procedures and adjusted RRT variance using a natural logarithm transform (see Seli, Cheyne et al., 2013). Mean RRT variance was calculated by using a moving window of the current and preceding four trials across all trials except the very first five trials and the five trials following each thought probe. We also calculated RRT variance for the five trials immediately preceding each category of thought reports: (1) on-task RRT variance; (2) TRIs RRT variance; (3) EDs RRT variance; and (4) mind wandering RRT variance.

2.8. Procedure

Participants were tested individually. Participants first completed the MAAS and the PANAS, and were then randomly assigned to either the meditation or control condition. Following this assignment, participants completed the first block of the MRT (pre-test). Upon completion, they were invited to an adjacent, quieter room and listened to a ten-minute audio recording (either meditation or audiobook) in the presence of a research assistant. Participants were instructed to follow along the audio recording as best as they could. After the intervention, participants performed the second block of the MRT (post-test) and completed the PANAS again. In total, the whole procedure lasted roughly 50 min.

3. Results

3.1. Did mindfulness meditation prevent the occurrence of mind wandering from increasing?

The proportions of each of the thought categories at pre-test and post-test are presented in Table 1. Separate mixed ANOVA analyses were performed on each dependent variable, in which the proportion of thought report was tested as a function of time (pre-test vs. post-test), condition (meditation vs. control), or their interaction. For the proportion of on-task reports, the mixed ANOVA
To further examine the significant time by condition interaction, we conducted paired-sample t-tests on the proportions of EDs and mind wandering for each intervention group. For the proportion of EDs, it stayed constant for the meditation group, \( t (41) = 2.04, p = 0.048 \). For the proportion of mind wandering, it again stayed constant for the meditation group, \( t (41) = 0.27, p > 0.79 \), but increased significantly after intervention for the control group, \( t (39) = -4.42, p < 0.001 \). Therefore, our first hypothesis was confirmed: mindfulness meditation prevented the occurrence of mind wandering from increasing over time.

### 3.2. Did mindfulness meditation ameliorate performance disruption during episodes of mind wandering?

Measures of MRT performance are presented in Table 1. We first calculated mean RRT variance, which represents overall task performance on the MRT. A mixed ANOVA found a significant main effect of time, \( F(1,80) = 27.07, \eta^2_p = 0.253, p < 0.001 \), but no main effect of condition or interaction (both \( p_s > 0.46 \)), suggesting that both groups performed poorer on the MRT after intervention.

We then examined RRT variance associated with on-task thoughts, which is the response variability participants exhibited prior to a thought probe in which they reported on-task thought(s). A mixed ANOVA found a significant main effect of condition, \( F(1,15) = 5.41, \eta^2_p = 0.265, p = 0.034 \), but no main effect of time or interaction (both \( p_s > 0.61 \)). For RRT variance associated with off-task thoughts, the same mixed ANOVA revealed a significant main effect of time, \( F(1,79) = 5.17, \eta^2_p = 0.061, p = 0.026 \), and a significant time by condition interaction, \( F(1,79) = 7.50, \eta^2_p = 0.087, p = 0.008 \), but no main effect of condition, \( F(1,79) = 0.79, p = 0.38 \). We also performed the same analysis on RRT variance associated with TRIs, EDs, and mind wandering. For all three categories, the mixed ANOVA indicated no main effect of time, condition, or interaction (all \( p_s > 0.46 \)). For RRT variance associated with on-task thoughts, which combined task-related interferences, external distractions, and mind wandering; TRIs: task-related interferences; EDs: external distractions; MW: mind wandering. Standard deviations from the mean are presented in brackets. Paired-sample t-tests were performed to examine between-group differences.

### Table 1

<table>
<thead>
<tr>
<th>Measures</th>
<th>Meditation group (( N = 42 ))</th>
<th>Control group (( N = 40 ))</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Pre-test</td>
<td>Post-test</td>
<td>( t )</td>
<td>Pre-test</td>
</tr>
<tr>
<td>Proportions of thought reports</td>
<td></td>
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</tr>
<tr>
<td>On-task%</td>
<td>42</td>
<td>17.14 (20.99)</td>
<td>10.95 (17.22)</td>
<td>1.57</td>
</tr>
<tr>
<td>Off-task%</td>
<td>42</td>
<td>82.86 (20.99)</td>
<td>87.62 (17.64)</td>
<td>-1.24</td>
</tr>
<tr>
<td>TRIs%</td>
<td>42</td>
<td>7.62 (13.22)</td>
<td>6.67 (13.00)</td>
<td>0.33</td>
</tr>
<tr>
<td>EDs%</td>
<td>42</td>
<td>30.95 (29.03)</td>
<td>38.10 (25.30)</td>
<td>-1.46</td>
</tr>
<tr>
<td>MW%</td>
<td>42</td>
<td>44.29 (29.81)</td>
<td>48.26 (25.21)</td>
<td>2.27</td>
</tr>
<tr>
<td>Future-oriented MW%</td>
<td>33</td>
<td>34.55 (21.95)</td>
<td>25.45 (23.06)</td>
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<tr>
<td>MRT performance</td>
<td></td>
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</tr>
<tr>
<td>Mean RRT variance</td>
<td>42</td>
<td>8.01 (0.67)</td>
<td>8.19 (0.66)</td>
<td>-4.30***</td>
</tr>
<tr>
<td>On-task RRT variance</td>
<td>28</td>
<td>8.23 (1.44)</td>
<td>9.22 (1.22)</td>
<td>-3.54*</td>
</tr>
<tr>
<td>Off-task RRT variance</td>
<td>42</td>
<td>8.03 (0.86)</td>
<td>7.98 (0.99)</td>
<td>0.31</td>
</tr>
<tr>
<td>TRIs RRT variance</td>
<td>19</td>
<td>8.08 (1.17)</td>
<td>7.95 (3.41)</td>
<td>0.16</td>
</tr>
<tr>
<td>EDs RRT variance</td>
<td>40</td>
<td>7.92 (0.95)</td>
<td>9.41 (1.09)</td>
<td>-7.37***</td>
</tr>
<tr>
<td>MW RRT variance</td>
<td>42</td>
<td>7.98 (0.95)</td>
<td>9.38 (1.05)</td>
<td>-8.36***</td>
</tr>
<tr>
<td>Mood measures</td>
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<tr>
<td>Positive affect</td>
<td>42</td>
<td>23.86 (6.62)</td>
<td>20.86 (9.12)</td>
<td>2.73*</td>
</tr>
<tr>
<td>Negative affect</td>
<td>42</td>
<td>15.55 (6.41)</td>
<td>13.64 (5.41)</td>
<td>2.98*</td>
</tr>
</tbody>
</table>

Note: On-task: on-task thoughts; Off-task: off-task thoughts, which combined task-related interferences, external distractions, and mind wandering; TRIs: task-related interferences; EDs: external distractions; MW: mind wandering. Standard deviations from the mean are presented in brackets. Paired-sample t-tests were performed to examine between-group differences.

\* \( p < 0.05 \)

\** \( p < 0.01 \)

\*** \( p < 0.001 \)

revealed a significant main effect of time, \( F(1,80) = 12.48, \eta^2_p = 0.135, p < 0.001 \), but no main effect of condition or interaction (both \( p_s > 0.29 \)). Similarly, for the proportion of off-task reports, the mixed ANOVA showed a significant main effect of time, \( F(1,80) = 8.96, \eta^2_p = 0.101, p = 0.004 \), but no main effect of condition or interaction (both \( p_s > 0.29 \)). These results suggest that both groups experienced an increase in off-task thoughts after intervention.

To further examine if meditation affected the composition of off-task thoughts, we performed the same analyses on the proportions of TRIs, EDs, and mind wandering. For the proportion of TRIs, the mixed ANOVA indicated no main effect of time, condition, or a time by condition interaction (all \( p_s > 0.34 \)). For the proportion of EDs, we observed no main effect of time or condition (both \( p_s > 0.46 \)), but we found a significant time by condition interaction, \( F(1,80) = 6.09, \eta^2_p = 0.071, p = 0.016 \). Similarly, for the proportion of mind wandering, the analysis revealed no main effect of time, condition, \( F(1,80) = 0.07, p = 0.79 \), but a significant main effect of time, \( F(1,80) = 6.97, \eta^2_p = 0.080, p = 0.01 \), and a significant time by condition interaction, \( F(1,80) = 9.28, \eta^2_p = 0.104, p = 0.003 \).

To better understand the significant time by condition interactions, we conducted paired-sample t-tests on the proportions of EDs and mind wandering for each intervention group. For the proportion of EDs, it stayed constant for the meditation group, \( t (41) = -1.46, p = 0.153 \), but decreased significantly after intervention for the control group, \( t (39) = 2.04, p = 0.048 \). For the proportion of mind wandering, it again stayed constant for the meditation group, \( t (41) = 0.27, p > 0.79 \), but increased significantly after intervention for the control group, \( t (39) = -4.42, p < 0.001 \). Therefore, our first hypothesis was confirmed: mindfulness meditation prevented the occurrence of mind wandering from increasing over time.
increased significantly after intervention for the control group, \( t (38) = -3.81, p < 0.001 \), indicating deteriorated performance during episodes of off-task thoughts. Therefore, our second hypothesis was partially confirmed: mindfulness meditation prevented performance deterioration during episodes of off-task thoughts but not during episodes of mind wandering.

3.3. To what extent did mindfulness meditation influence motivational states?

One additional purpose of this study was to explore the possibility that mindfulness might attenuate mind wandering through altering motivation. To examine the extent to which meditation influenced motivation, a mixed ANOVA was performed on each of the three motivation measures. We observed no significant main effect of condition, and no time by condition interaction for all three (all \( p_s > 0.08 \)), suggesting no significant impact of meditation on motivation.

3.4. Exploring other explanations for the protective effects of mindfulness meditation

Given the absence of influence of meditation on motivational states, we decided to further explore if other factors might have contributed to the protective effects of mindfulness on mind wandering. In particular, we examined the following three possibilities: (1) if the observed shift from EDs to mind wandering (as in the control condition) was detrimental to task performance, (2) if changes in mood states were associated with changes in the proportions of thought reports and task performance, and (3) if meditation cultivated a shift to present-moment awareness during episodes of mind wandering.

To answer the first question, we conducted a mixed ANOVA, in which response variance was tested as a function of thought category (on-task vs. TRIs vs. EDs vs. mind wandering) and condition (meditation vs. control), when combining pre-test and post-test. We observed a trending main effect of condition, \( F (1,20) = 4.01, \eta^2_p = 0.167, p = 0.059 \), but no main effect of thought category or interaction (both \( p_s > 0.14 \)). We also performed a linear mixed model in which thought category was entered as a fixed factor, subject was entered as a random factor, and response variance was entered as a dependent factor. We observed no significant effect of thought category (\( p = 0.46 \)). These results indicate there was no significant difference between EDs and other thought categories in their associated response variance.

To answer the second question, we conducted a mixed ANOVA, in which time (pre-test vs. post-test) was entered as the within-subject factor and condition (meditation vs. control) was entered as the between-subject factor. Measures of mood states are presented in Table 1. For positive affect, we observed a significant main effect of time, \( F (1,80) = 16.87, \eta^2_p = 0.174, p < 0.001 \), but no main effect of condition or interaction (both \( p_s > 0.28 \)). For negative affect, we found a significant main effect of time, \( F (1,80) = 7.71, \eta^2_p = 0.088, p = 0.007 \), but no main effect of condition or interaction (both \( p_s > 0.10 \)). These results suggest that intervention had a similar impact on positive and negative affect for both groups. Furthermore, correlational analyses revealed that changes in mood states were not significantly associated with changes in the proportions of different thought reports (e.g., on-task, off-task, TRIs, EDs, and mind wandering), overall task performance, or off-task RRT variance (all \( p_s > 0.10 \)).

To answer the third question, we first recoded thought probes on temporal orientation (i.e., whether the thought report was past-oriented, present-oriented, or future-oriented). Inter-rater reliability (Cohen’s kappa) was 0.86 and significant discrepancies were resolved through discussion. As there were only eight participants who reported past- or present-oriented mind wandering in both pre- and post-tests, we calculated the proportion of future-oriented mind wandering instead (as presented in Table 1). We then conducted the same 2 (Time: pre-test vs. post-test) × 2 (Condition: meditation vs. control) mixed ANOVA and observed no main effect of time or condition (both \( p_s > 0.36 \)), but a trending time by condition interaction, \( F (1,61) = 3.92, \eta^2_p = 0.060, p = 0.052 \). Follow-up paired-sample t-tests revealed that while the proportion of future-oriented mind wandering remained constant for the control group, \( t (32) = -0.68, p = 0.502 \), it decreased significantly for the mindfulness group, \( t (32) = 2.27, p = 0.03 \). These results suggest that meditation promoted a shift away from future-oriented mind wandering.

4. Discussion

The aim of this study was to examine whether a brief session of mindfulness meditation would have protective effects on mind wandering for highly anxious individuals, as measured in a sustained-attention task. Results suggest that, although both groups experienced an increase in off-task thoughts after intervention, ten minutes of mindfulness meditation did prevent an increase in mind wandering. Similarly, mindfulness meditation prevented performance deterioration when participants experienced off-task thoughts but not when they experienced mind wandering. However, mindfulness meditation did not demonstrate any additional benefit on motivational or mood states, as compared to the control task.

Most importantly, our results confirmed that mindfulness, as an intervention for mind wandering, was largely preventative for anxious individuals. Mindfulness training only prevented mind wandering from increasing and stopped performance from deteriorating during episodes of off-task thoughts, while such protective effects were not observed in the control condition. Our results are contradictory to findings from prior work (Morrison et al., 2014; Mrazek et al., 2013), which demonstrated that mindfulness training, regardless of its intensity, can significantly reduce mind wandering and improve task performance in the general population. However, our results are consistent with findings from some other studies (Banks et al., 2015; Jha et al., 2010, 2015), which showed that mindfulness training can only prevent the detrimental impact of mind wandering for individuals experiencing high negative affect. Therefore, the present study provides further evidence for the hypothesis that mindfulness training, as an intervention for mind wandering, is less effective for individuals with high levels of negative affect. For an unselected sample of university students, eight minutes of meditation was able to deliver significant improvements on the SART (Mrazek et al., 2012). On
the contrary, for individuals experiencing high levels of stress, mindfulness training that was of a longer duration (e.g., eight weeks as in Jha et al., 2013) and a higher intensity (e.g., involving home practice as in Banks et al., 2015), only demonstrated protective effects on mind wandering. Hence, we believe that the small effect size of intervention in this study cannot be solely attributed to its short duration but more so to the characteristics of its recipients.

The most surprising yet interesting finding is that mindfulness meditation had a significant impact on the specific composition of conscious experiences reported by participants. Both groups experienced an increase in off-task thoughts from pre-test to post-test. However, when we looked further at subcategories of off-task thoughts (e.g., task-related interferences, external distractions, and mind wandering), we observed a significant time by condition interaction on the proportions of both mind wandering and external distractions. In particular, the meditation group reported fewer mind wandering episodes but more external distractions than the control group at post-test, while no such differences existed at pre-test. By definition, external distractions are only different from mind wandering thoughts insofar as they are stimulus-dependent (i.e., they are related to stimuli or physical sensations that are present in the immediate, external environment). Hence, meditation seemed to cultivate a focus of attention towards external stimuli and away from internal information. Given that participants recruited in this study endorsed clinical levels of trait anxiety, it is possible that a significant number of participants were engaging in future-oriented, repetitive thinking such as worries, which would cause more anxiety and interference with performance. In fact, when we recoded thought reports on their temporal orientation, results supported such a possibility: while the majority of mind-wandering episodes were rated as future-oriented, most external distractions were rated as present-oriented. Moreover, the mindfulness group reported a significant decrease in their future-oriented mind wandering, while the control group did not. Therefore, a shift of attentional focus from internal to external might help individuals disengage their attention from future-oriented worries and focus more on the “here and now”.

In addition, the demonstrated shift in attentional focus from internal to external stimuli might have important implications for treating repetitive thinking in anxious populations. In fact, being internally oriented is a defining feature of repetitive thoughts (Watkins, 2008). If a ten-minute meditation could promote a focus of attention away from internal, abstract information, and towards stimuli that are in the “here and now” among individuals with trait anxiety at a clinical level, then this might explain why mindfulness-based interventions are effective in treating ruminating (Campbell, Labelle, Bacon, Faris, & Carlson, 2012) and worry (Robins, Keng, Ekblad, & Brantley, 2012). Our results seemed to suggest that the key factor in treating repetitive thinking might be a heightened awareness of the present moment. Such a finding interestingly echoes the conclusion made in an previous study: that it is not mind wandering, per se, that is responsible for psychological distress, but instead a lack of present-moment awareness (Stawarczyk, Majerus, Van der Linden, & D’Argembeau, 2012).

In addition to these interesting findings, we also attempted to identify processes that might have mediated the observed protective effects of mindfulness on mind wandering. We first explored if motivation might be a potential pathway through which mindfulness attenuates mind wandering. The ten-minute mindfulness meditation did not have any significant impact on either performance motivation or motivation to approach/avoid reported thoughts, thus disconfirming our hypothesis. We then examined if the observed shift from external distractions to mind wandering was related to performance degradations noted in the control group. Our results did not support this hypothesis, given there was no significant difference in task performance between external distractions, task-related interferences, and mind wandering. Such findings are consistent with those from prior work (Stawarczyk, Majerus, Maj, Van der Linden, & D’Argembeau, 2011; Stawarczyk, Majerus, Maquet et al., 2011). Thirdly, we looked at if the benefits of mindfulness meditation were a result of changes to mood states. Results showed no difference between meditation and the control task in their influence on positive or negative affect. Furthermore, changes in mood states were not associated with measures of thought reports or task performance. Lastly and most interestingly, we tested if mindfulness promoted present-moment awareness during episodes of mind wandering. Our results suggest that meditation significantly reduced the proportion of future-oriented mind wandering, while the control task did not. Although our analysis was constrained by the relatively small sample size and the fact that we were unable to directly examine the proportion of present-oriented mind wandering, we believe this might be an important research direction to pursue in future.

Despite these interesting findings, there are some limitations to the current study. The first limitation is the lack of control for expectancy effects in our control condition. Although this specific control task has been used in previous work on mindfulness (Johnson et al., 2013; Kramer et al., 2013), there is a possibility that participants in the control condition had lower expectations for improvement, which then led to differential outcomes (for a review see Boot, Simons, Stothart, & Stutts, 2013). We are confident this was not the case, given participants in both conditions reported similar levels of performance motivation before and after the intervention. However, we do recommend future studies to adopt control tasks that produce similar expectancy to mindfulness, such as the progressive muscle relaxation task (Feldman, Greeson, & Senville, 2010). The second limitation is that, due to time constraints, we only included five thought probes in each block of the MRT. The majority of participants did not report at least one instance of each of the four thought categories, which limited the statistical power for our analyses on some of the behavioural measures (e.g., on-task RRT variance). Thus, we recommend that future studies include more thought probes. A third limitation is the lack of generalizability of our results to non-anxious individuals, which calls for replication using general populations. Finally, it is important to note that we adopted the experimenter-classification method in determining episodes of mind wandering (i.e., having participants report their thoughts verbatim and then having independent judges rate thought reports) instead of using self-classification (i.e., having participants choose if they were mind wandering or not). We opted for experimenter-classification because it has been demonstrated to produce comparable results to self-classification (Smallwood, O’Connor, Sudberry, Haskell, & Ballantyne, 2004; Smallwood et al., 2004) without inflating estimates of mind wandering (Smallwood & Schooler, 2006).

In summary, the present study is, to the authors’ best knowledge, the first to examine the effects of mindfulness training on mind wandering in anxious individuals. Despite the increase in off-task thoughts in both conditions, a ten-minute breathing meditation...
prevented mind wandering from increasing over the course of a sustained-attention task and ameliorated performance disruptions associated with off-task thoughts. Therefore, the present study provides support to the hypothesis that mindfulness training only has protective effects on mind wandering for individuals experiencing high negative affect (Bank et al., 2015). In addition, mindfulness training seemed to switch the focus of attention from internal information to external stimuli in the “here and now”, which likely has very important implications for methods of remediation used to treat worrying in anxious populations.

Compliance with Ethical Standards: This study involved human participations. This study received ethical clearance from the Office of Research Ethics at the University of Waterloo (#19446). Informed consent was obtained from all individual participants included in the study. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. The manuscript does not contain clinical studies or patient data. The authors declare that they have no conflict of interest.

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