SITTING WITH IT: EXAMINING THE RELATIONSHIP BETWEEN MINDFULNESS,

SUSTAINED ATTENTION, AND BOREDOM

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Abstract

Concentrating on a stimulus or an activity seems like a trivial ability. Sustaining attention for extended periods of time, however, is a challenging experience which becomes increasingly difficult with time. When sustaining attention on an easy task, with the increase in difficulty, one also begins experiencing negative affect such as boredom and discomfort. Increased negative affect during the task is related to poorer performance on the task. This paper integrates and examines formulations derived from two distinct literatures, namely boredom and mindfulness. The present research both replicates and extends previous findings from the coming together of mindfulness and boredom research in the context of sustained attention. In extending past literature, this paper hypothesizes that trait mindfulness would be positively correlated with the ability to sustain attention. Furthermore, this paper argues that this relationship is a function of enhanced affect regulation and not due to enhanced cognitive capacity. While only replicating some findings in the literature, the results provide support for our novel hypotheses, linking mindfulness to sustained attention through enhanced affective regulation.

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Author's Declaration

I declare that this thesis is a presentation of original work and I am the sole author. This work has

not previously been presented for an award at this, or any other, University. All sources are

acknowledged as References.

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We are often required to sustain our attention for extended periods of time, on activities ranging from menial to exciting. We could be required to focus our attention on work-related tasks, a movie, or a lecture. At times, this experience can be positive: we may feel engrossed in the lecture, and when things go well, we may even lose track of time, experiencing a flow state where nothing is more important than the present moment (Csikszentmihalyi, 2009). Sometimes, however, this experience can be negative. The content of the lecture may be too simple, too advanced, or it may just feel too long, making engagement difficult (Carriere, Cheyne, & Smilek, 2008; Eastwood, Frischen, Fenske, & Smilek, 2012). Once we become aware of our disengagement with the lecture, we may quickly deem it inherently boring. Feeling like we are unable to engage with the activity, being aware of this difficulty, and attributing it to properties inherent to the unsatisfying activity rather to internal processes are all fundamental to the experience of boredom (Eastwood, Frischen, Fenske, & Smilek, 2012). This paper discusses the experience of boredom, its relevance for sustained attention, and the ways in which mindfulness may alleviate it.

Boredom and its Correlates

Eastwood, Frischen, Fenske, and Smilek (2012) suggest a pithy, rigorous definition for boredom: "an aversive state of wanting, but being unable to engage in satisfying activity" (p.482). Boredom is a quintessential part of human experience, and has some possible benefits under certain circumstances, in that it signals that a lack of optimal engagement (Hunter & Eastwood, 2018). Some individuals are more likely to experience boredom across many situations, a disposition referred to as boredom proneness (Struk, Carriere, Cheyne, & Danckert, 2017). This dispositional tendency is related to poor academic achievement and risky behavior (Caldwell & Smith, 2006), higher dropout rates (Farrell, Peguero, Lindsey, & White, 1988),

addictive behavior (Mercer & Eastwood, 2010), and depression (Goldberg, Eastwood, LaGuardia, & Danckert, 2011). Recent research has also shown that boredom proneness is related to increased attention failures and insensitivity to those errors (Malkovsky, Merrifield, Goldberg, & Danckert, 2012) as well as impoverished emotion regulation, expressed as anger and lack of inhibitory self-control (Isacescu & Danckert, 2016). Boredom is also related to the tendency to experience negative affect as measured by trait neuroticism (Sulea, van Beek, Sarbescu, Virga, & Schaufeli, 2015), which in turn is related to worse mental health outcomes (Kotov, Gamez, Schmidt, & Watson, 2010).

A theory of boredom

Since research has shown boredom proneness is related to negative life-course outcomes, it is important to further understand how it operates. One much studied aspect of boredom is attention. There is research to suggest that attentional failures are related to the tendency to experience of boredom (Gerritsen, Toplak, Sciaraffa, & Eastwood, 2014). Other research shows that attentional failures then lead to disengagement from the task at hand and task-avoidant behaviors such as mind-wandering (Raffaelli, Mills, & Christoff, 2017). Thus, when attentional failures occur, the spotlight of attention is turned away from the task, and is instead turned to task-unrelated thoughts, which lead to poorer performance on potentially boring tasks such as driving (Steinberger, Schroeter, & Watling, 2017). Becoming bored – and performing poorly – on a task like driving can have dire consequences.

Boredom has at least one other important factor, namely negative affect. Much work has examined the relevance of the aversive experience of boredom across domains, including laboratories (Tilburg & Igou, 2012), classrooms (Goetz, Lüdtke, Nett, Keller, & Lipnevich, 2013), and workplaces (van Hooff & van Hooft, 2014). These studies all converge to suggest that

while necessary, attentional failures alone are not sufficient for the experience of boredom: negatively evaluating the affective experience of attention failure is also necessary (Eastwood et al., 2012). Indeed, researchers have found that increased negative affect such as frustration is also related to boredom and worse performance on sustained attention tasks (Warm, Parasuraman, & Matthews, 2008), while more positive affect during the task is related to better performance (Smallwood, Fitzgerald, Miles, & Phillips, 2009).

Boredom and Sustained Attention

While some individuals tend to experience more boredom than others, a disposition measured by boredom proneness, boredom can also be experienced in the moment, as a state. The Multidimensional State Boredom Scale (MSBS) was developed to measure the transitory, current experience of boredom (Fahlman, Mercer-Lynn, Flora, & Eastwood, 2013). Hunter and Eastwood (2016) have shown that individuals who are higher on trait boredom also tend to experience greater state boredom in an under-stimulating environment, suggesting that state boredom is sensitive to both environment and disposition. When considering state boredom, the inverse relationship between task performance and negative affect is maintained (Hunter & Eastwood, 2016). When asked to focus on low-demand stimuli (i.e., when the task does not require significant mental capacity) for an extended period of time, participants are more likely to experience state boredom, attentional failures, and negative affect (Hunter & Eastwood, 2016; Malkovsky et al., 2012). Increased negative affect is related to low performance on sustained attention tasks: research has shown that low-demand sustained attention tasks elicit increasing feelings of frustration and mental demand, which are associated with feelings of boredom and worse performance (Warm, Dember & Hancock, 1996).

Boredom-related poor sustained attention is ubiquitous, and has negative consequences for educational outcomes (Mann & Robinson, 2013), can cause accidents due to reduced vigilance (Kass, Beede, & Vodanovich, 2010), and cause counterproductive work behavior (van Hooff & van Hooft, 2014). It appears that there is evidence to suggest that sustained attention and boredom are linked: first, sustained attention creates a cognitively challenging environment, in which attention failures are wont to occur. Second, sustained attention creates an affectively aversive environment, in which said attention failures are interpreted as negative experiences, and experienced as boredom. Attention and affect regulation are also key factors in the context of mindfulness. Perhaps a deeper understanding of mindfulness as a construct could provide insights for a deeper understanding of boredom.

The Relevance of Mindfulness

These two suggested pathways for the relationship between boredom and sustained attention are also highly relevant in the context of mindfulness meditation. Bishop et al. (2004, p. 232) suggested that mindfulness is "a kind of nonelaborative, nonjudgmental, present-centered awareness in which each thought, feeling, or sensation that arises in the attentional field is acknowledged and accepted as it is". In other words, mindfulness involves sustained attention on one's moment-to-moment experience and nonreactive acceptance of the content of that experience regardless of its content, inversely echoing the two components of boredom. The theoretical similarity between the two constructs is apparent in the specific mechanisms driving both.

According to Lutz, Slagter, Dunne and Davidson (2008), mindfulness may be composed of two distinct mechanisms. The first mechanism is based on the notion that developing one's skillful attention is a prerequisite for the cultivation of a "present-centered awareness". Learning

how to attend to stimuli, which are normally relatively low-salience, such as the somatic sense of breath or posture, is a necessary part of practicing mindfulness. It is possible that this skill can then be used selectively to deploy attention in other low-salience conditions, leading to enhanced sustained attention ability (Brefczynski-Lewis, Lutz, Schaefer, Levinson, & Davidson, 2007). The second mechanism focuses on accepting thoughts and feelings as they are. Once present-centered awareness is established, mindfulness practice leads to seeing one's experiences as they are, and accepting them as transient phenomena on the field of consciousness. This is a philosophical stance as well as a coping mechanism, in which self is defused from experience, and mental phenomena are impartially observed as they unfold without creating attachment to pleasant experiences or aversion to unpleasant ones (Hayes, 2004). A possible corollary is that mindfulness is related to a greater affective state regulation capacity through this pathway (Sears & Kraus, 2009). Does mindfulness indeed improve performance on sustained attention tasks then? The evidence is equivocal, especially when using mindfulness intervention as the only metric for measuring mindfulness.

On one hand, there is evidence to suggest that intensive long-term meditation practice enhances attention. For example, Jha, Krompinger, and Baime (2007) found that following a one-month intensive mindfulness retreat, participants performed better on a sustained attention task. Similarly, MacLean et al.'s (2010) findings suggest that after a three-month mindfulness retreat, participants were better at the perceptual discrimination part of a sustained attention task. On the other hand, a more recent study found that following a less intense 8-week part-time Mindfulness-Based Stress Reduction (MBSR; Kabat-Zinn, 1982) course, the experimental group was no better in sustained attention than the control (MacCoon, MacLean, Davidson, Saron, & Lutz, 2014). These findings replicate those of past research that has shown that an 8-week part-

time MBSR course has no significant effect on a vigilance-centered attention task (Anderson, Lau, Segal, & Bishop, 2007). There are at least two possible interpretations of these findings. First, more intense mindfulness interventions may be necessary before improvements in attention ability become noticeable. Second, there may be another aspect of an intense mindfulness retreat, other than mindfulness training per se that leads to enhanced attention capacity. For example, these intensive retreats involved relative isolation in nature, which is known to improve attention (Berman, Jonides, & Kaplan, 2008). In contrast, part-time interventions in the form of a weekly group session and daily individual meditations take place in urban settings.

Another approach to studying the relationship between mindfulness and sustained attention could use a complementary measure: psychometrically sound questionnaires that measure mindfulness as an individual differences construct. The relationship between trait mindfulness, based on self-reported responses to such questionnaires, rather than the length and intensity of mindfulness retreats, has a more consistent relationship with sustained attention. Research across labs, measures of trait mindfulness, and types of sustained attention tasks consistently point towards a positive relationship between trait mindfulness and sustained attention (Moore & Malinowski, 2009; Ruocco & Wonders, 2013; Schmertz, Anderson, & Robins, 2009).

Mindfulness and boredom

Mindfulness requires sustaining attention on a low-demand stimulus for an extended period of time, and ostensibly trains affective and attentive regulation. Boredom arises in situations that require sustaining attention on low-demand stimuli, and is comprised of failures of attention along with negative affect. Thus, the two appear to be theoretically linked, in that both contain attentive and affective components. There is also evidence that mindfulness has an

inverse relationship with many of the negative outcomes associated with boredom. For example, mindfulness has been shown to reduce depression and substance abuse (Bowen, Chawla, & Marlatt, 2011), improved emotion regulation (Arch & Craske, 2006) and is inversely related to trait neuroticism (Giluk, 2009). Despite the observation that mindfulness is inversely related to many of the purported consequences of boredom, there have been few empirical publications examining the relationship between mindfulness and boredom.

The first study examining the confluence between boredom and mindfulness, by LePera (2011), aimed to test the correlation between trait mindfulness and trait boredom using a community sample, and found a moderate inverse relationship between the two (r=-.52; LePera, 2011). Hallard (2014) then studied the effects of a low-demand task on measures of task load, including boredom, using a novel boredom-inducing sustained attention task dubbed the Response Selection Task (RST; Hallard, 2014), in which participants were instructed to alternate their responses to rarely occurring stimuli. Their sample consisted of meditators, who reported practicing mindfulness meditation regularly for at least two years, and nonmeditators. Data about meditation experience in the meditator group was collected as well. Thus, mindfulness was operationalized in two ways in this study: categorically, individuals with two or more years of experience were considered meditators, and out of those meditators, hours of meditation experience was used as a measure of mindfulness. In this study, state boredom was measured using a subjective, self-reported, 0-100 scale. The results showed that the meditator group experienced less frustration and reported less state boredom than the non-meditators, and that individuals with more mindfulness meditation experience reported less task load as compared to non-meditators. Furthermore, frustration and boredom scores covaried as emotional concomitants of completing a sustained attention task, supporting the notion of boredom as

emotionally aversive. Finally, Koval and McWelling (2015), used an experimental setting to

assess whether state boredom constrains state mindfulness immediately following a boring task.

In this experiment, participants read a moderately interesting short story as the control condition,

or performed the Vowel Cancellation Task (VCT), which is assumed to elicit boredom as the

experimental condition. After performing each of these tasks, participants' state mindfulness and

state boredom was measured. Those in the VCT condition reported significantly higher state

boredom and significantly lower state mindfulness. Furthermore, in the sample as a whole,

participants who reported meditating "weekly" or "almost every day" had higher state

mindfulness scores than those who reported meditating "sometimes" or less frequently. In

summary, boredom and mindfulness appear to be inversely related: more mindful individuals

experience less boredom, long term meditators experience less boredom in sustained attention

tasks, and boring tasks result in a significantly lower state mindfulness score.

Purpose and Aims of the Present Study

This study had three purposes. First, to replicate the extant findings in the boredom and

mindfulness literature in order to validate previous findings. Second, to ascertain whether trait

mindfulness is predictive of performance on a sustained attention task. Third, if trait mindfulness

is indeed predictive of sustained attention, to understand whether the mindfulness predicts better

sustained attention through enhanced affective regulation or a greater attentional capacity.

In our replication, we aimed to systematically repeat the procedure of LePera (2011) and

Hallard (2014) while conceptually replicating the work of Koval and Todman (2015). We

hypothesized that trait mindfulness is indeed inversely correlated with trait boredom (LePera,

2011), and that meditators would experience less task load when performing a sustained attention

task (Hallard, 2014). Task load, in this case, is measured using several questions regarding effort,

mental demand, frustration, and boredom. We were particularly interested in boredom, since mindfulness may be related to boredom through both cognitive capacity and affective regulation. Koval and Todman's (2015) work originally showed that participants who performed a boring task subsequently had significantly lower state mindfulness than those who performed a non-boring task, and that participants who meditate frequently displayed higher state mindfulness scores. Our conceptual replication of Koval and Todman's work examined whether participants who performed a boring task had a significantly lower state mindfulness following the task, as compared to their state mindfulness before the task. We also attempted to systematically replicate their findings regarding the relationship between meditation practice frequency and post-task state mindfulness.

Next, we turned to extending the literature. We hypothesized that trait mindfulness would be a good predictor of accuracy on a sustained attention task, and were interested in examining the contribution of affective regulation and attentional capacity to this relationship. To that end, we employed two statistical strategies. First, we examined the significance of the relationship between trait mindfulness and task accuracy and task-related emotional reactivity. Next, we assessed whether affective regulation or attentional control were the main drivers of this relationship. To do so, we examined the significance of the relationships between trait mindfulness, task accuracy, and task-related emotional reactivity when controlling for the variance accounted for by 1) experiential avoidance – which is inversely related to affective regulation (Kashdan, Barrios, Forsyth, & Steger, 2006) – and 2) attentional control. Finally, we used mediation models in order to evaluate the contribution of during-task emotional reactivity to the relationship between trait mindfulness and task accuracy, and the contribution of task accuracy to post-task emotional reactivity.

<center>**Methods**</center>

Participants and procedure

Ethics approval was received from York University (certificate # 2017 - 158). All participants were York University students, and received either course credit or $5 coffee shop gift card for participation. Participants provided written consent (see appendix for Informed Consent form). In total, 290 participants (mean age = 20.96, 74% female[1]) completed the experiment. Out of those, 14 were removed from the analysis due to incomplete data; 2 were removed due to data errors; 25 participants were excluded from SART accuracy analysis due to excessive (i.e. equal to or greater than 10%) go error rates.

An experimental session took about one (1) hour to complete, and consisted of two main stages. First, research participants completed a set of questionnaires assessing: trait neuroticism, trait mindfulness, trait experiential avoidance, trait attention control, and trait boredom as well as their mindfulness practice (see appendix). Second, participants performed a sustained attention task (SART; Robertson et al., 1997). Immediately before completing the SART participants rated their current level of state boredom and state mindfulness. During the SART participants were presented with a fixation cross, after which they were shown a digit between 1 and 9 for 250ms, followed by a mask (in which the fixation cross was presented again) for 900ms. The digits were presented in one of five randomly selected Symbol font sizes: 48 point, 72 point, 94 point, 100 point, and 120 point. Participants were asked to push a button whenever they saw a number, and withhold pushing a button when they saw the target digit (3). After instructions were provided,

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[1] We had no concrete hypotheses about gender differences. Gender data was collected and is reported to describe the diversity of our sample.

participants completed 44 practice trials[2]. Participants then went through five blocks of SART,

every one of which consisted of 200 non-targets and 25 targets, all single digits. The targets were

quasi-randomly distributed throughout each experimental block. The duration of each block was

4 minutes and 20 seconds. After each block participants were briefly asked: how effortful the

task is, how much discomfort they were experiencing, and how boring the task is. After

completing the SART participants were asked for their age, date of birth, and gender for

demographic purposes and to create a short pause. Participants were then asked to respond to the

state mindfulness and state boredom scales again, followed by retrospective ratings of the task

(see appendix).

Measures

      Meditation practice[3]. Participants were asked nine (9) questions about their meditation

practice, such as when they started practicing and how prominent meditation is in their lives.

This questionnaire uses some of the items suggested by Anderson and Farb (personal

communication, April 7, 2017; see Meditation Practice Questions in Appendix 2). Some

questions from Anderson and Farb were changed to better fit the questions from Hallard (2014)

and Koval and Todman (2015), whose designs we are replicating. The final set of questions

appears in the appendix. From these questions we created two meditator indices. First, we

calculated an estimated total hours of practice, based on frequency of meditation, average

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[2] Participants were also asked for their valence and arousal before and after performing the SART. Participants were also asked, after completing the practice trials, to forecast the level of discomfort, effort, enjoyment, fatigue, motivation, and performance they expected to experience during the SART. These data were not used in analyses for this study.

[3] . Our intention was to create a well-rounded meditation aggregate in order to better encompass the meditation habits of our participants, and with the hope of creating the scaffolding for a future mindfulness practice measure. The alpha value for our measure was extremely low (alpha = 0.34) and the measure did not play a significant role in any of our pre-registered hypotheses. We subsequently decided to not use the aggregate, and instead the replicate previous research design of Hallard (2014) and Koval and Todman (2015) directly.

meditation duration and total number of months practiced, so as to replicate the design of Hallard (2014). Second, we demarcated between meditators in two ways: frequent meditators (who practice weekly or almost every day) and infrequent meditators (who practice occasionally or not at all), in order to replicate the design of Koval and Todman (2015); and meditators (who have had at least two years of meditation experience) and nonmeditators (who have had less than two years of meditation experience), in order to replicate the design of Hallard (2014).

Trait Measures

Boredom proneness. The original Boredom Proneness Scale (BPS; Farmer & Sundberg, 1986) is a 28-item scale that measures an individual's proneness to experiencing boredom. Participants scoring high on this scale are more likely to experience boredom in their everyday lives. Recent work by Struck, Carriere, Cheyne and Danckert (2015) created a shorter, single-factor version of this scale. Our study used a 7-point Likert-type version of the scale ranging from 1 (strongly disagree) to 7 (strongly agree) that has been reported to have an internal consistency coefficient of .88 (Struck et al., 2015). A sample boredom proneness item is "I find it hard to entertain myself". In the current sample the alpha was 0.87.

Neuroticism. To assess neuroticism, we used only the 8 questions out of the 44 available in the Big Five Inventory (BFI; John & Srivastava, 1999) that deal specifically with this personality trait. Individuals with a high neuroticism score are more likely to experience feelings such as anxiety, frustration, and a depressed mood (Berenbaum, Bredemeier, & Thompson, 2008). In the BFI, each item is measured on a 5-point Likert-type scale, between 1 (strongly disagree) and 5 (strongly agree). Internal consistency typically ranges between .75 to .90 and three-month test-retest reliabilities range from .80 to .90 (John & Srivastava, 1999). A sample neuroticism item is "worries a lot". For the neuroticism subscale, we obtained an alpha of 0.79.

Trait Mindfulness. The Five Facet Mindfulness Scale (FFMQ; Baer, Smith, Hopkins, Krietemeyer, & Toney, 2006)) was used to measure trait mindfulness. This scale extends upon the four facets in the Kentucky Inventory of Mindfulness Skills (KIMS;Baer, Smith, & Allen, 2004) and is considered to be the most methodologically sound measure of mindfulness (Park, Reilly-Spong, & Gross, 2013). It contains 39 items and uses a 5-point Likert-type scale, between 1 (never or very rarely true) and 5 (very often or always true). A higher score on this measure means higher overall trait mindfulness, conceptualized to have five distinct facets: nonreactivity, noticing inner experience, acting with awareness, labeling inner experience, and nonjudging of experience. Chronbach's alpha for this test range between .67 and .93 (Park et al., 2013), and the test-retest reliability of .88 was reported for a 4- to 8-week interval (Baer et al., 2006). A sample item is "I perceive my feelings and emotions without having to react to them." Our sample produced an alpha of .89.

Experiential avoidance. The second version of the Acceptance and Action Questionnaire (AAQ-II; Bond et al., 2011) was used to measure participant tendency to attempt to alter the form, frequency, or situational sensitivity of negative private events such as thoughts and feelings, even when doing so leads to behavioral difficulties. A higher score on this measure is related to a heightened tendency to avoid negative experiences. This is a 7-item measure, using a 7-point Likert-type scale between 1 (never true) and 7 (always true). The internal consistency for this test is between .78 and .88, and the test-retest reliability is .81 after 3 months and .79 after 12 months (Bond et al., 2011). A sample item from the measure is "I'm afraid of my feelings". The alpha produced by our sample is 0.92.

Attentional control. Derryberry and Reed (2002) produced a self-report scale that measures a general capacity to control attention. This scale was used to achieve a better understanding of the role individual perceived attention capacity plays in task performance and experienced boredom. Items on this scale are ranked between 1 (almost never) and 4 (always). A higher score on this measure reflects an increased ability to focus perceptual attention, switch attention between tasks, and flexibly control thought. This scale is internally consistent (Alpha = .88), and a sample item is "I can quickly switch from one task to another." Our sample produced an alpha of .85.

State measures

Boredom. The short version of the Multidimensional State Boredom Scale (MSBS-8; Hunter, Dyer, Cribbie, & Eastwood, 2015) measures the experience of boredom in the moment, with a higher score meaning more boredom; participants respond by agreeing or disagreeing with items such as "I feel bored" using a 7-point Likert-type scale ranging from 1 (strongly disagree) to 7 (strongly agree). Our sample's alpha is .89. We measured state boredom both before and after the task.

State Mindfulness Scale. The State Mindfulness Scale (SMS; Tanay & Bernstein, 2013) was used to measure state mindfulness using a 5-point Likert type scale. A higher score is associated with a higher state of mindfulness. The authors report a test-retest reliability of .65 within 6 weeks. This measure asks participants to respond to 25 items in the context of the 15 minutes prior, using items such as "I noticed physical sensations come and go." Our sample produced an alpha of .93. We measured state mindfulness both before and after the task.

Within task state measures. Participants were asked to rate their ongoing experience during the task on a 7-point scale between 1 (none) and 7 (a lot) using three questions: "How much mental effort is this task currently requiring?", "How much discomfort or distress is this task currently causing?", and "How much boredom are you currently experiencing?"

Retrospective ratings of the task. In order to measure retrospective ratings of the SART we used the National Aeronautics and Space Administration's (NASA) measure which assesses subjective load of a given task on six subscales: mental demand, physical demand, temporal demand, performance, effort, and frustration. This scale, named the Task Load Index (NASA-TLX; Hart & Staveland, 1988), uses one question for each of the subscales in which the participant can rank their experience on this dimension between 0 (low) and 20 (high). A sample item is "how hard did you have to work to accomplish your level of performance?" The average consistency of this measure is .95, and a test-retest reliability of 0.83 within four weeks. We added six (6) questions to maintain the continuous tracking of variables asked about throughout the task. The added questions were: "how distressed or uncomfortable were you?", "how bored were you?", "how mentally fatigued were you?", "how much did you enjoy the task?", "how hard did you try to do your best?", and "how satisfied are you with your performance?"[4]

Sample statistics

Participants were 249 undergraduate students from York University (78% female), mean age 21.03 (SD = 4.55). Using Hallard's (2014) definition for meditators as having at least two years of experience, our sample contained 41 current meditators (78% female), mean age 21.66 (SD = 5.28) and 210 non-meditators (79% female), mean age 20.91 (SD 5.28). Meditators reported 4.52 mean years of practice experience (SD = 1.37, range 2 – 13), and 1689 (SD = 6959.65) estimated mean hours of meditation practice. These participants reported an average length of 54 minutes per sit (SD = 36.40). Out of the 41 current meditators, 12 participants reported meditating daily or almost daily, 13 reported meditating weekly, and 16 reported meditating occasionally.

Verifying core constructs

We conducted correlation analyses in order to determine how well our core variables predicted each other. Estimated total hours of meditation practice was correlated with trait mindfulness (r = 0.39, p < 0.001). As expected, we found that trait mindfulness predicted pre-task state mindfulness pre-SART (i.e., before performing the sustained attention task; r = 0.34, p < 0.001). We also found that boredom proneness predicted pre-task state boredom pre-SART (r = 0.73, p < 0.001). In accordance with the literature, trait mindfulness was correlated with experiential avoidance (r = -0.55, p < 0.0001), attentional control (r = 0.55, p < 0.0001), and trait neuroticism (r = -0.13, p = 0.042). Our findings also replicated the results of LePera (2011), showing that trait mindfulness was inversely related to trait boredom (r = -0.58, p < 0.0001). Table 1, below, summarizes correlations between trait variables and total estimated meditation experience.

Table 1

Correlations among traits and meditation experience

Variables	*M* (*SD*)	FFMQ	AAQ	ACS	BPS	MedXP
Neur	26.521 (3.18)	-.13*	.25*	.004	.24*	-.004
FFMQ	122.6 (18.53)		-.55*	.55*	-.58*	.39*
AAQ	24.9 (10.44)			-.35*	.65*	-.13*
ACS	49.47 (8.72)				-.48*	.15*
BPS	28.51 (10.34)					-.16*
MedXP	1689 (6960)					

Notes. *N* = 249. FFMQ = Five Facet Mindfulness Questionnaire. AAQ = Acceptance and

Action Questionnaire. ACS = Attentional Control Scale. BPS = Boredom Proneness Scale.

MedXP = Total estimated hours of meditation practice. * *p* < .05.

State mindfulness and state boredom before and after the SART

Pre- and post-task scores and group mean differences were compared using t-tests. The SART significantly increased state boredom compared to baseline (t = -4.50, p < 0.001, mean difference = -3.88), but mindfulness did not significantly change following the SART (t = -1.23, p = 0.20). This finding is somewhat incongruous with that of Koval and Todman (2015), who found that state mindfulness was significantly lower in a group that performed an ostensibly boring task than in a group who performed a control task. While the correlation between pre-SART state mindfulness and state boredom was non-significant (r = -0.08, p = 0.223), the correlation between post-SART state mindfulness and state boredom was significant (r = -0.24, p < 0.001). A t-test also did not find a significant difference between frequent meditators (who practice weekly or almost every day) and infrequent meditators (who practice occasionally or not at all) on post-task state mindfulness, t = -1.10 (p = 0.277).

Relating trait mindfulness and meditator status to SART accuracy.

We used correlation analyses to measure how well trait mindfulness predicted SART accuracy and performance decrement over time, and t-tests to compare whether meditators and non-meditators had different levels of SART accuracy and performance decrement (decrease in hits to errors ratio) over time. As hypothesized, trait mindfulness predicted overall SART accuracy (r = 0.16, p = 0.009). Similarly, meditators (defined here as individuals with more than two years of meditation practice) were significantly more accurate in performing the SART (t = -12, p < 0.001). It is of note that the relationship between trait mindfulness and accuracy remained significant when controlling for attentional control (r = 0.17, p = 0.007), but not when controlling for experiential avoidance (r = 0.10, p = 0.11) or boredom proneness (r = 0.02, p = 0.768). Trait mindfulness score did not significantly predict performance decrement throughout

the task (r = 0.09, p = 0.17). While participants as a whole exhibited the expected decrement in performance throughout the task (slope = -0.00545, t = -13, p < 0.001), the decrement was not significantly different for meditators (slope = -0.511) than for nonmeditators (slope = -0.551; t = -0.29, p = 0.80).

Relating trait mindfulness and meditation experience to emotional reactivity during SART

We used correlation analyses to examine the relationship of trait mindfulness and estimated total hours of practice with during-task discomfort, boredom, and effort. Trait mindfulness was inversely correlated with during-SART discomfort (r = -0.16, p = 0.01), but not significantly correlated with during-SART boredom (r = -0.1, p = 0.10) or during-SART effort (r = -0.05, p = 0.44). When controlling for attentional control, the correlation between trait mindfulness and during-task discomfort remained significant at r = -0.19 (p = 0.002), and the correlation between trait mindfulness and during-task boredom became significant at r = -0.17 (p = 0.007). When controlling for experiential avoidance, the correlation between trait mindfulness and during-task discomfort became nonsignificant (r = -0.08, p = 0.215), while the correlation between trait mindfulness and during-task boredom became significant (r = -.17, p = 0.026). We did not control for attentional control or experiential avoidance for the relationship between trait mindfulness and during-SART effort for two reasons. First, because the correlation between the two was not even marginally significant; and second, we had no concrete theory as to the relevance of attentional control and experiential avoidance for the relationship between trait mindfulness and during-SART effort. Total hours of practice were not significantly predictive of discomfort (r = -0.05, p = 0.395), effort (r = -0.02, p = 0.744), or boredom (r = -0.11, p = 0.075) during the task.

Relating trait mindfulness and meditation experience to post-SART ratings of emotional reactivity.

We used correlation analyses to understand how well both trait mindfulness and estimated total hours of meditation practice relate to post-task discomfort, boredom, and effort. We found that trait mindfulness was related to discomfort ($r = -0.16$, $p = 0.012$) and boredom ($r = -0.24$, $p < 0.001$), but not effort ($r = 0.02$, $p = 0.784$).

We found that when controlling for attentional control, the relationship between trait mindfulness and post-SART discomfort remained significant ($r = -0.17$, $p = 0.006$), as did the relationship between trait mindfulness and post-SART state boredom ($r = -0.24$, $p < 0.0001$). When controlling for experiential avoidance, however, the relationship between trait mindfulness and post-task discomfort was no longer significant ($r = -0.08$, $p = 0.199$), while the relationship between trait mindfulness and post-task state boredom remained significant ($r = -0.18$, $p = 0.005$). See Table 2 for a summary of the correlations between trait mindfulness, and meditation experience while controlling for trait measures.

Table 2

Correlations among Trait and State Variables

Variables	*M* (*SD*)	FFMQ	FFMQ: ACS controlled	FFMQ: AAQ controlled	FFMQ: BPS controlled	MedXP
During-task discomfort	4.31 (1.81)	-.16*	-.19*	-.08	-.58*	-.05
During-task boredom	4.95 (1.88)	.1	-.17*	-.17*	.13*	-.11
During-task effort	5.22 (1.7)	-.05	.01	.01	.05	-.02
Post-task discomfort	4.44 (1.87)	-.16*	-.17*	-.08	-.11	-.02
Post-task boredom	4.62 (1.41)	-.24*	-.24*	-.18*	-.13*	-.18*
Post-task effort	4.86 (1.65)	.02	.02	.008	.01	-.06

Notes. $N = 249$. FFMQ = Five Facet Mindfulness Questionnaire. AAQ = Acceptance and Action Questionnaire. ACS = Attentional Control Scale. BPS = Boredom Proneness Scale. MedXP = Total estimated hours of meditation practice. * $p < .05$.

For the most part our results did not replicate the findings of Hallard (2014). Specifically, contrary to Hallard, we found no difference between meditators and non-meditators, on post-task ratings of state boredom (t = 1.8, p = 0.08) or post-task ratings of frustration (t = 1.3, p = 0.2). Using estimated total hours of practice as a continuous measure, we did find that estimated total hours of practice was negatively correlated with post-task state boredom (r = -0.18, p = .005) but we failed to find significant correlations between estimated total hours of practice and other post-task ratings. In contrast, Hallard (2014) found that estimated total hours of practice was significantly correlated with a wide range of post-task workload measures (for a full correlation table, see Table 3).

Table 3

Correlations among Trait Mindfulness, Meditation Experience, and Task Load

Variables	*M* (*SD*)	MedXP	MD	PD	TD	SP	EF	FR
FFMQ	122.6 (18.5)	.39*	-.08	-.09	-.08	.01	-.02	-.17*
MedXP	1689 (6960)	1	-.09	-.05	-.07	-.02	-.07	-.11
MD	5.12 (1.76)		1	.44*	.34*	.13	.60*	.35*
PD	3.62 (2.09)			1	.22*	.11	.34*	.35*
TD	4.98 (1.67)				1	.23*	.32*	.34*
SP	4.57 (1.68)					1	.01	.31*
EF	4.87 (1.65)						1	.21*
FR	4.74 (1.98)							1

Notes. $N = 249$. FFMQ = Five Facet Mindfulness Questionnaire. MedXP = Total estimated hours of meditation practice. * $p < .05$. MD = How mentally demanding was the task? PD = How physically demanding was the task? TD = How hurried or rushed was the pace of the task? SP = How successful were you in accomplishing what you were asked to do? EF = How hard did you have to

work to accomplish your level of performance? FR = How insecure, discouraged, irritated, stressed, and annoyed were you?

Mediation models

Mediation models were run to disentangle the relevance of trait mindfulness for affect regulation. Specifically, the first model was run to see whether trait mindfulness is predictive of task accuracy independently of negative affect during the task, and the second model was run to see whether trait mindfulness is predictive of negative affect after the task independently of task performance. Indirect effects were tested using a bootstrap estimation approach with 1000 samples (Shrout & Bolger, 2002) in order to disentangle the direct relationships between trait mindfulness and SART accuracy, and trait mindfulness and post-task emotional reactivity. This kind of mediation model is powerful, as it simulates 1000 samples with similar distributions as the original sample, increasing the chances of identifying a skew in the mediated effect away from zero (i.e., a significant mediation).

During-task emotional reactivity as mediating the relationship between trait mindfulness and SART accuracy. Our results show that there was a non-significant direct effect of trait mindfulness on SART accuracy (ADE = 0.0007, p = .29) and a significant indirect effect of trait mindfulness on SART accuracy through during-task boredom (ACME = -.00002, p = .018; see Figure 1). Thus, there is some evidence that trait mindfulness is related to task accuracy, and that this relationship is mediated through during-task boredom. Similarly, there was a non-significant direct effect of trait mindfulness on SART accuracy (ADE = 0.0008, p = 0.051), and a significant indirect effect through during-task discomfort (ACME = -0.00001, p = 0.017), suggesting that the relationship between mindfulness and SART accuracy is also

mediated by during-task discomfort. There was no significant relationship between mindfulness and during-task effort (r = 0.05, p = 0.71), and so mediation was not tested.
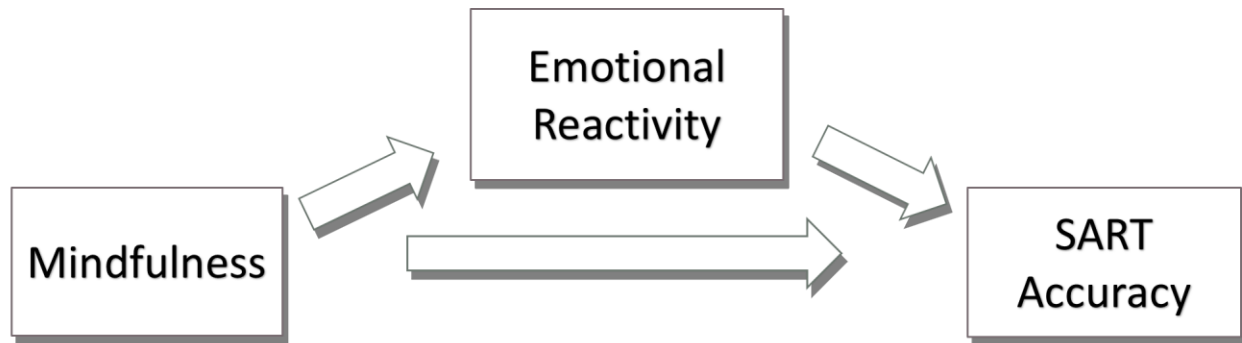

Figure 1. Mediation model including a direct pathway between trait mindfulness and SART accuracy, and an indirect pathway between trait mindfulness and SART accuracy which is mediated by emotional reactivity (i.e., boredom and discomfort) during the SART.

SART accuracy as mediating the relationship between trait mindfulness and post-task emotional reactivity. We found a significant direct effect of trait mindfulness on post-task state boredom (ADE = -0.0117, p = .0032) and a significant indirect effect of trait mindfulness on post-task state boredom through SART accuracy (ACME = 3.853, p = 0.004; see Figure 2). Thus, the relationship between trait mindfulness and post-SART state boredom is only partially mediated through SART accuracy. A similar trend occurred for post-task discomfort, where there was significant direct effect of mindfulness on post-task discomfort (ADE = -0.13, p = 0.048), and a significant indirect effect through SART accuracy (ACME = 0.052, p = 0.022), suggesting that the relationship between trait mindfulness and post-SART discomfort is only partially mediated by SART accuracy. There was no significant relationship between mindfulness and post-SART effort (r = 0.06, p = 0.82), and so mediation was not tested.
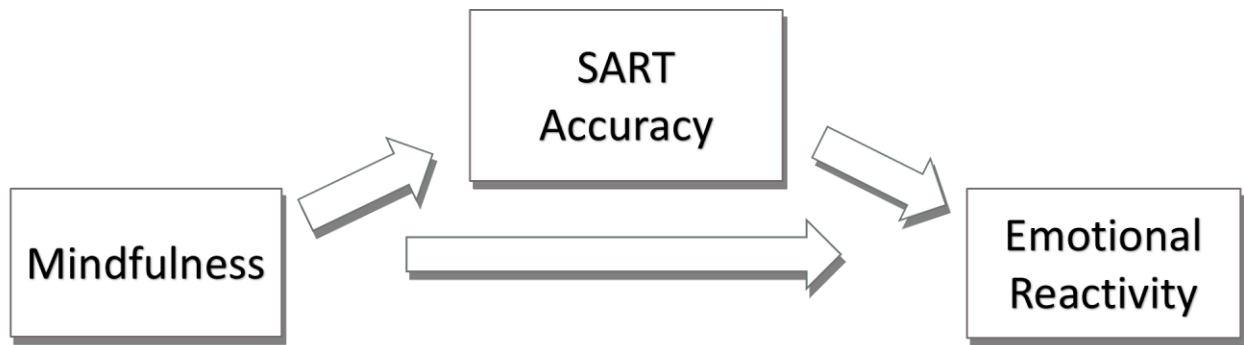
Figure 2. Mediation model including a direct pathway between trait mindfulness and post-task emotional reactivity, and an indirect pathway between trait mindfulness and post-task emotional reactivity (i.e., boredom and discomfort) which is mediated by SART accuracy.

Neuroticism as a moderator. Neuroticism did not moderate any of the hypothesized relationships: moderation for neuroticism on the relationship between trait mindfulness and SART accuracy was non-significant (b = 0.000001, p = 0.91); the same trend continued for the relationship between trait mindfulness and post-task state boredom (b = 0.0079, p = 0.51) and the relationship between trait mindfulness and post-task discomfort (b = 0.0015, p = 0.46).

Discussion

This study had three goals: replicating previous findings in the mindfulness and boredom literature; examining whether trait mindfulness is predictive of sustained attention accuracy; and if trait mindfulness is indeed predictive of sustained attention, understanding whether that is because mindfulness increases attention capacity directly, or if it is related to sustained attention by way of reducing emotional reactivity.

The relevance of affective regulation and attention ability for the relationship between mindfulness and sustained attention.

 Mindfulness retreats have been shown to be significantly correlated with sustained attention in some cases (MacLean et al. 2010) but this relationship does not extend to casual

mindfulness practice (MacCoon et al., 2014). These conflicting findings suggest that one way the

measurement of mindfulness can be further nuanced using individual difference measures. To

that end, we looked to the literature regarding the relationship between mindfulness and

attentional control – one's self-reported ability to consistently attend to a task, and experiential

avoidance – one's self-reported shirking away and attempt to change the content of difficult

emotional experience. Since attentional control measures a purely cognitive proxy for sustaining

attention and experiential avoidance measures the ability to regulate and manage affective

experience, we theorized that mindfulness is related to sustained attention through at least

through one of these constructs. Trait mindfulness has been shown to be positively correlated

with attentional control in several studies (Walsh, Balint, Smolira SJ, Fredericksen, & Madsen,

2009; Abasi, Mohammadkhani, Pourshahbaz, & Dolatshahi, 2017), and has also been shown to

be negatively correlated with experiential avoidance in others (Skinner, Roberton, Allison,

Dunlop, & Bucks, 2010). In this study, we wanted to further examine the relationship between

the affective and attentive aspects of mindfulness in relation to sustained attention, using

boredom as a prism that also includes both affective and attentive facets. Our main focus was on

understanding whether mindfulness is directly related to attentional control, or if the relationship

between mindfulness and sustained attention depends on affective regulation. This is particularly

pertinent since sustained attention involves an increasing task load and negative affect

(Chambers, Lo, & Allen, 2008; Szalma et al., 2004). Chambers et al. (2008) also found that an

intensive meditation retreat reduces overall negative affect while improving performance on

measures of sustained attention, adding more evidence for the role mindfulness plays in the

relationship between affective regulation and attentional control. We expected to find the same in

our data and hoped to be able to further illuminate the distinct parts of the relevance of

mindfulness to attentional control and affective regulation by sampling discomfort, boredom, and effort both during and after the task. Our plan was twofold: first, we aimed to substantiate whether or not mindfulness is related to sustained attention as measured by SART accuracy and replicate previous research on the coming together of mindfulness and boredom. Second, we aimed to gather converging evidence using different analyses so as to narrow down whether a difference in affective regulation or cognitive capacity is more likely to drive the correlation between trait mindfulness and sustained attention.

Replication of previous research

The finding that the task increased state boredom reassured us that the manipulation was effective. The small inverse relationship in our sample between neuroticism and trait mindfulness was smaller than the negative correlations normally reported in the literature (Giluk, 2009). The tenuousness of the relationship may account for our null findings for the predictive value of neuroticism in our mediation models. Our other trait variables were related in the expected directions, with trait mindfulness directly correlated with attentional control and total estimated hours of meditation, and inversely related with experiential avoidance. Having found that our core variables were all related in the directions we predicted, we turned to assess our replication of the existing literature regarding mindfulness and boredom.

We found that trait mindfulness was inversely correlated with trait boredom, in agreement with LePera (2011). While we were largely unable to conceptually replicate Koval and Todman's (2015) findings, there were a few exceptions. Koval and Todman found that state mindfulness was significantly lower for those who completed a boring task as compared to a control task, and that frequent meditators displayed higher state mindfulness than infrequent meditators. In our data, however, state mindfulness was not significantly lower following a

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boring task as compared to prior to the task, and frequency of meditation practice was not

predictive of post-task state mindfulness score. We did find a negative correlation between post-

task state mindfulness and state boredom, a finding conceptually consistent with Koval and

Todman's (2015) claim that boredom inhibits mindfulness. Our failure to find a significant

difference in state mindfulness following a boring task may be due to the difference in

experimental design: while Koval and Todman's (2015) design examined the difference between

control and experimental groups' state mindfulness, our study examined the difference in pre-

and post-task state mindfulness. In Koval and Todman (2015), participants were assigned either

to a control group or the experimental VCT condition, and group mean state mindfulness was

compared after the task. In our experiment, all participants went through the experimental –

boredom inducing – condition, and that condition was the SART rather than VCT. Thus, instead

of measuring the difference in post-task mindfulness between two different groups, one of which

performs a boring task, we measured state mindfulness before and after performing the SART to

complement Koval and Todman's (2015) design. Alternative explanations may be that Koval and

Todman's control condition, in which participants performed a reading task, increased state

mindfulness from baseline; or that the State Mindfulness Scale measures a relatively stable

characteristic rather than a highly transient state. We were able to replicate the finding that state

boredom and state mindfulness are inversely related, but this relationship was only significant

after performing the SART. These data suggest that the evidence for boredom directly

constraining mindfulness are still equivocal, and perhaps a more nuanced theory that takes into

account the type of boredom-eliciting task needs to be established.

We were only able to replicate some of Koval and Todman's (2015) and Hallard's (2014)

findings regarding relationships between meditation frequency, total hours of meditation

experience, and their correlations with a sustained attention task. For example, we were not able to replicate the finding that shows a significant difference on post-task state mindfulness between those who practice "weekly" or "almost every day" and those who practice less frequently. Similarly, we failed to replicate Hallard's (2014) findings that total estimated hours of meditation predict post-task state frustration and any retrospective measure of task load measured by the NASA-TLX. This may have been due to a difference in sample characteristics: Hallard's participants had 6209 mean estimated hours of meditation experience while our sample had 5301 mean estimated hours of meditation experience. Furthermore, most of Hallard's meditator sample was recruited from monasteries, while our sample was made up exclusively of university undergraduate students. The difference in our sample composition may contribute to our inability to replicate some of Hallard's findings. However, we were able to replicate Hallard's findings that long-term meditators experienced a sustained attention task as less boring.

Our finding that there is no significant difference on the performance decrement between meditators and nonmeditators fails to replicate the work of MacLean et al. (2010) and Sahdra et al. (2011) who found a difference in performance decrement before and after an intense three-month meditation retreat involving as many as ten hours of practice daily. It does, however, match the findings of Hallard (2014) who found no significant difference in performance decrement between meditators and nonmeditators, and MacCoon et al. (2014), who found no difference in performance decrement between participants who had completed an 8-week MBSR course and a control group. These findings suggest that while a long, intense meditation retreat may improve the performance decrement, individuals involved in a regular, but less intense practice may still experience normal vigilance decrements. It is possible that although trait mindfulness improves with increased meditation (Carmody & Baer, 2008), it is not the main

driver of the difference in performance decrement between these groups or that a less intense meditation course improves trait mindfulness below the threshold required for reduced performance decrement. This notion is corroborated in our dataset by the lack of predictive value for trait mindfulness on performance decrement: perhaps the increase in trait mindfulness was not the relevant aspect of intense meditation retreats when accounting for a reduction of vigilance decrement. Instead, it is possible that being away from high-intensity stimuli made low-demand stimuli easier to engage with, or that meditation practice improves overall performance but not the rate at which performance degrades.

The relationship between trait mindfulness, emotional reactivity, and sustained attention.

Since trait mindfulness is correlated with attentional control and inversely correlated with experiential avoidance, we hypothesized that trait mindfulness would be predictive of SART accuracy, either directly through improved attention ability or indirectly through improved affective regulation. Indeed, we found that trait mindfulness is predictive of SART accuracy, suggesting that mindfulness is related to the ability to sustain attention for extended periods of time. Next, we were interested in getting a more nuanced idea of the links between mindfulness and sustained attention. In order to do so we asked participants to describe their experience of boredom, discomfort, and effort both during and after the task. We hypothesized that these variables play a key role in performance on a sustained attention task, as participants invariably demonstrate a reduced accuracy and increased negative affect as the task goes on (Szalma et al., 2004). Our findings are described below.

In our sample, trait mindfulness was significantly inversely correlated with discomfort during the task, but not significantly related to during-task boredom or effort. Consistent with the findings of Szalma et al., (2004), who found that increased negative affect was inversely related

to sustained attention, we found that increased levels of emotional reactivity during the task were predictive of poorer performance.

Trait mindfulness was significantly inversely correlated with discomfort and state boredom after the task, but still not significantly correlated with how effortful the task felt. It is possible that mindfulness helped participants experience less discomfort during the task, which reflected how bored participants felt after the task. The correlation between mindfulness and emotional reactivity overall suggests that mindfulness made the emotional experience of undergoing the task less aversive. In light of the overall pattern of findings, this evidence broadly suggests that the mindfulness-related improved performance on the SART may stem from a less aversive emotional experience.

Accounting for attentive and affective regulation. As mentioned in the introduction, both attentional control and experiential avoidance are relevant for the relationship between mindfulness and task performance. In order to further disambiguate the contribution of both constructs to the relationship between trait mindfulness and sustained attention, we controlled for the variance accounted for by attentional control and experiential avoidance. If controlling for attentional control renders the relationship between trait mindfulness and task performance nonsignificant, we can infer that trait mindfulness is related to sustained attention through enhanced attentional control. If, however, the correlation between trait mindfulness and task performance becomes nonsignificant when controlling for experiential avoidance, affective regulation is implicated as a necessary part of the relationship between the two. In our data, the correlations between trait mindfulness and during-task discomfort, and trait mindfulness and SART accuracy remained significant when controlling for attentional control. In contrast, the correlations between trait mindfulness and during-task discomfort, and trait mindfulness and

SART accuracy became nonsignificant when controlling for experiential avoidance. In summary, the relationship between mindfulness and task performance is maintained when controlling for attentional control but becomes nonsignificant when controlling for experiential avoidance. We can subsequently conclude that attentional control is not a necessary part of the relationship between trait mindfulness and task performance, while experiential avoidance is a key factor in this relationship. This finding is in agreement with Warm et al. (1996), who found that individuals who are more error-prone and absent-minded experienced significantly higher task load, suggesting that they experienced more stress.

A similar trend was observed when controlling for attentional control and experiential avoidance in the relationships between trait mindfulness and post-task emotional reactivity. Both the correlation between trait mindfulness and post-task discomfort and the correlation between trait mindfulness and post-task boredom remained significant when controlling for attentional control. In contrast, only the relationship between trait mindfulness and post-task state boredom remained significant when controlling for experiential avoidance.

These data converge to suggest that the link between trait mindfulness and sustained attention is mainly via affective regulation. We subsequently ran a mediation analysis to further ascertain the contribution of the affective experience has for mediating the relationship between mindfulness and sustained attention.

Mediation of the relationship between trait mindfulness and SART accuracy

The first mediation analysis we ran aimed to disentangle the affective and attentive aspects of trait mindfulness when predicting SART accuracy. To do so, we tested the significance of during-task emotional reactivity (i.e., discomfort and boredom) as mediators of

the relationship between trait mindfulness and SART accuracy (see Figure 1). We were interested in seeing whether a model that includes emotional reactivity as a mediator renders the direct pathway between trait mindfulness and SART accuracy nonsignificant. Finding that only the direct pathway is significant would provide evidence that emotional reactivity does not play a significant role in predicting the relationship between trait mindfulness and task performance. Alternatively, if both indirect and direct pathways were significant, we could conclude that while emotional reactivity is relevant for the relationship between mindfulness and sustained attention, it does not entirely account for the relationship. What we found, however, is that only the indirect pathway – mediated by emotional reactivity during the task – was significant, while rendering the direct pathway nonsignificant. While our design was correlational, this result suggests a causal pathway: trait mindfulness leads to reduced negative affect during the task, which in turn leads to better task accuracy. Combined with the importance of experiential avoidance (but not attentional control) for SART accuracy, these findings suggest that affective regulation is the factor of interest in the relationship between mindfulness and sustained attention.

Mediation of the relationship between trait mindfulness and post-task emotional reactivity

Our second mediation model assessed to what extent the relationship between trait mindfulness and post-task emotional reactivity (discomfort and boredom) can be predicted by SART accuracy. The purpose of this analysis was to further establish the importance of trait mindfulness for affective regulation. Since better SART performance predicts lower post-task emotional reactivity (Warm, Dember & Hancock, 1996), we wanted to tease out how much of the relationship between post-task emotional reactivity could be explained by SART performance. To do so, we used task accuracy as a mediator for the relationship between trait

mindfulness and post-task reports of emotional reactivity (see Figure 2). Finding that only the direct pathway is significant would mean that mindful individuals experience less negative affect after the task, regardless of their performance. In contrast, finding that only the indirect pathway is significant would mean that trait mindfulness is only related to lower post-task emotional reactivity by enhancing SART accuracy. We found that both pathways were significant: mindfulness is partially related to post-task negative affect through improved performance on the task (which we know to be fully mediated through negative affect), but also predicts better post-task affect independently of performance. This means that trait mindfulness was predictive of post-task emotional reactivity independently of how well participants performed on the task. This finding lends more credence to the notion that trait mindfulness is tightly coupled with affective regulation.

These results suggest that affective regulation plays a larger role than an ostensible direct pathway to enhanced attention: emotional reactivity fully mediates the relationship between trait mindfulness and SART performance. Furthermore, when taken together with the non-significance of the relationship between mindfulness and discomfort when controlling for experiential avoidance, but not attentional control, our findings suggest that the relationship between mindfulness and sustained attention is driven by enhanced affective regulation. At the same time, we have been unable to uncover any evidence that trait mindfulness has a direct relationship with an increased attention ability.

Summary of findings. This study had three main aims. First, we wanted to verify that our instruments work properly, and that the foundation on which we build our research is sound. Second, we were intended to collect evidence for the predictability of sustained attention performance using trait mindfulness. Third, we aimed to add nuance to the existing literature

regarding the relationship between mindfulness, sustained attention, and boredom, and triangulated on the probable pathway through which the three constructs are related. We were able to replicate some of the findings in the literature, namely the inverse relationship between trait mindfulness and trait boredom, the inverse relationship between estimated total hours of meditation and post-task boredom. Most relationships involving state mindfulness, overall frequency of practice, and task load, however, failed to replicate. A systematic replication of the findings that failed to replicate is required in order to further disambiguate the relationships between state boredom and state mindfulness, ideally using a sample that is more similar to the one used in the original study.

Our extension of the literature suggested that trait mindfulness is indeed modestly predictive of accuracy on a sustained attention task. The relationship between trait mindfulness and sustained attention on low-demand stimuli can be mostly accounted for by mindfulness making the experience less aversive, rather than directly affecting attention ability. We found that the direct relationships between trait mindfulness, task accuracy, and emotional reactivity remained significant when controlling for the variance accounted for by attentional control. In contrast, almost all relationships between trait mindfulness, emotional reactivity, and task accuracy became nonsignificant when controlling for the variance accounted for by experiential avoidance. Furthermore, emotional reactivity during the task fully mediated the relationship between trait mindfulness and task accuracy. Our second meditation model further substantiated that post-task emotional reactivity is partially mediated by task performance (which is fully predicted by the relationship between trait mindfulness and emotional reactivity) and partially directly predicted by trait mindfulness.

Using these different correlational pieces of evidence to triangulate on the aspect of trait mindfulness that is relevant for sustained attention strongly suggests that it does so through an enhancement of affective regulation, and not through increasing attentional control. In order to fully test out this theory, however, a longitudinal lab study involving a mindfulness intervention and measurement of both attentional and affective variables before, during, and after the intervention is required. This design would include an experimental group and an active control group, and a validated mindfulness intervention. Trait mindfulness, task accuracy, personality variables, and negative affect related to the task will be assessed at five time points: pre-intervention, mid-intervention, immediately post-intervention, six months post-intervention, and one year post-intervention. Creating a design in which causal relationships can be established will buttress – or cast doubt – on the theory that mindfulness enhances sustained attention through improved affective regulation and not through enhanced attentional control. Furthermore, sampling personality variables and sustained attention accuracy at different time points will allow us to better understand the mechanism through which individual differences are related to sustained attention.

Limitations. It is possible that our sample did not have enough long-term meditators, and that our meditators did not have enough meditation experience to replicate findings from Hallard (2014). Furthermore, our design did not systematically replicate the design of Koval and Todman (2015). Future research should attempt to systematically replicate the work of Koval and Todman (2015) to further substantiate their findings that a boring task constrains state mindfulness.

In our data, the relationship between trait mindfulness and state boredom was trending towards significance (p = .1) during the task and significant after the task, suggesting an

incongruency between the two measures of boredom. This may have to do with the difference in measurement tool: while we measured during-task boredom using a one-item question which aims to directly assess boredom, post-task boredom was measured using the MSBS. It is possible that the one-item question lacked the nuance of the MSBS, or that participants were driven to report lower explicit boredom by social desirability.

Finally, the most constraining limitation of this study is that we can only infer correlations from it, and not causal relationships. While our data demonstrates a positive correlation between trait mindfulness and sustained attention, the question of whether a mindfulness-improving intervention would influence sustained attention. Subsequently, we cannot suggest any concrete clinical application of our findings. Instead, our research shows a promising research avenue which should be developed using an intervention study. Once causal evidence has been collected, the potential of mindfulness interventions for improving sustained attention will become clear.

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Table 4

Correlations among State Variables

Variables	*M* (*SD*)	PostSMS	PreMSBS	PostMSBS
	66.82	.18*	-.08	-.09
PreSMS	(16.60)			
	68.53		-.03	-.24*
PostSMS	(16.53)			
	33.08			.31*
PreMSBS	(11.95)			
	36.96			
PostMSBS	(11.31)			

Notes. N = 249. * p < .05.

Table 5

Correlations among Emotional Reactivity Variables

Variables	*M* (*SD*)	Effort	Boredom
Discomfort	4.30 (1.82)	.37*	.35*
Effort	5.24 (1.65)		-.12
Boredom	5.00 (1.84)		

Notes. N = 249. * p < .05.

Informed Consent Form Template

Study Name: Sustained Attention

Researchers: *Dr. John Eastwood, Dr. Doug McCann & Rotem Petranker, Room XXX, Phone* XXXXXXXXX

Purpose of the Research: To better understand what personality traits are associated with the ability to maintain attention and concentration over a period of time.

What You Will Be Asked to Do in the Research: You will be asked to fill out a few computerized questionnaires regarding your preferences and personality (approximately 20 minutes), and then complete a computerized task in which you will watch the computer screen and push a button every time you see a number displayed (approximately 20 minutes). The entire process should take no more than an hour.

Risks and Discomforts: There is minimal risk and discomfort involved in your participation, no more than you would otherwise incur by using a computer to answer questions about yourself or that you would experience by focusing your attention for 20 minutes. You might find it difficult to focus your attention for 20 minutes; but otherwise we do not foresee any significant risks or discomfort from your participation in the research.

Benefits of the Research and Benefits to You: You will have an educational experience that will enhance your coursework, and may provide insights into your own behaviour and experiences. This study will provide you with the opportunity to view, firsthand, the type of research conducted by experimental psychologists.

Voluntary Participation: Your participation in the study is completely voluntary and you may choose to stop participating at any time. Your decision not to volunteer will not influence your eligibility to receive credit for your participation or your relationship with any of the researchers involved in this project, nor the nature of your relationship with York University either now, or in the future.

Withdrawal from the Study: You can stop participating in the study at any time, for any reason, if you so decide. If you decide to stop participating, you will still be eligible to receive the promised credit or pay for agreeing to be in the project. Your decision to stop participating, or to refuse to answer particular questions, will not affect your relationship with the researchers, York University, or any other group associated with this project. In the event you withdraw from the study, all associated data collected will be immediately destroyed wherever possible.

Confidentiality: Your confidentiality will be provided to the fullest extent possible by law. All information you supply during the research will be held in confidence. Your name, or any other identifying information, will not appear in any report or publication of the research. The data will be collected electronically, and will be safely stored in a secure database and only research staff will have access to this information. This consent form will be stored securely in a locked cabinet in the researcher's lab separate from your

responses. Thus, your name will not be linked to any responses you provide. This hard copy consent form will be destroyed after 2 years. Anonymized electronic data (responses you give on the computer) will be kept indefinitely.

Subsequent use of the data you provide: The data collected in this research project may be used – in an anonymized form - by members of the research team in subsequent research investigations exploring similar lines of inquiry. Such projects will still undergo ethics review by the HPRC, our institutional research ethics board. Any secondary use of anonymized data by the research team will be treated with the same degree of confidentiality and anonymity as in the original research project.

We do not anticipate any third party or researchers external to York University using the anonymized data in any manner. However, in accordance with, and subject to the limitations of, the Canadian Tri-Council policies regarding digital data management and open access publication we will archive the anonymized data in a publicly available database. The anonymized data will not be made available to other investigators unless they have obtained appropriate ethical review and approval.

Questions About the Research? If you have questions about the research in general or about your role in the study, please feel free to contact Dr. John Eastwood either by telephone at (XXX) XXXXXXX, extension XXXXX or by e-mail (XXXXXXXXXX). This research has received ethics review and approval by the Human Participants Review Sub-Committee, York University's Ethics Review Board and conforms to the standards of the Canadian Tri-Council Research Ethics guidelines. If you have any questions about this process, or about your rights as a participant in the study, please contact the Sr. Manager & Policy Advisor for the Office of Research Ethics, 5th Floor, Kaneff Tower, York University (telephone XXXXXXXX or e-mail XXXXXXXX).

Legal Rights and Signatures:

I_____, consent to participate in _sustained attention_ conducted by Rotem Petranker, Dr. Doug McCann, and Dr. John Eastwood. I have understood the nature of this project and wish to participate. I am not waiving any of my legal rights by signing this form. My signature below indicates my consent.

Signature_____   **Date**_____
Participant

Signature_____   **Date**_____
Research Assistant

Boredom/effort/discomfort questionnaire

Please respond to the following questions:

1. How distressed or uncomfortable were you?
1 (Very low level) – 2 – 3 – 4 – 5 – 6 – 7 (Very high level)

2. How bored were you?
1 (Very low level) – 2 – 3 – 4 – 5 – 6 – 7 (Very high level)

3. How mentally fatigued were you?
1 (Very low level) – 2 – 3 – 4 – 5 – 6 – 7 (Very high level)

4. How much did you enjoy the task?
1 (Not at all) – 2 – 3 – 4 – 5 – 6 – 7 (A great deal)

5. How hard did you try to do your best?
1 (Very low level) – 2 – 3 – 4 – 5 – 6 – 7 (Very high level)

6. How satisfied are you with your performance?
1 (Not at all) – 2 – 3 – 4 – 5 – 6 – 7 (A great deal)

7. I seem to be forced to do thing that have no value to me.
1(Strongly disagree) – 2 – 3 – 4 – 5 – 6 – 7 (Strongly agree)

Meditation Practice Questionnaire

Please respond to the following questions:

1. At what age (in years) did you first learn meditation?
2. Did it cost money to learn meditation?
3. What is the name of the meditation with which you have the most experience? If you don't know the particular name or it does not have a specific name, what name would you give it?
4. "Please use the following space to describe how to practice meditation. Try to do this as if you were teaching someone the technique. As much as possible, please do so as if you were teaching someone who is learning to meditate for the very first time and is generally unfamiliar with meditation. In other words, be as specific as you can and please try to avoid technical terms a new meditator might not understand.

   If you do need to use technical terms, please define them for us."

5. How long (in minutes) is a single session of meditation?
6. Do you still practice meditation?
7. Approximately how long have you been practicing meditation at least monthly (in years)? If you stopped for a time and then started again do not count the time when you were not practicing at least monthly.
8. How many days per week (approximately) do you currently practice?
9. How much effort would you say it take to meditate? (slider question)
10. How important would you say it is to meditate regardless of outcome? (slider question)