THE EFFECT OF A BRIEF MINDFULNESS INTERVENTION ON NEGATIVE AFFECT DURING A SUSTAINED ATTENTION TASK: IS EMOTION REGULATION A MECHANISM OF ACTION?

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Abstract

Brief mindfulness-based interventions (BMBIs) have been associated with improvements in sustained attention and may support sustained attention by making it less aversive. More specifically, BMBIs may improve state emotion regulation, which in turn reduces negative affect and ultimately leads to better sustained attention performance. To test this, 191 undergraduate participants were randomized to a BMBI condition (10 minutes of mindfulness meditation) or a control condition (10 minutes of audiobook listening). They completed a 20-minute sustained attention task, with measures of state emotion regulation and negative affect administered between task blocks. Findings revealed that the BMBI was associated with fewer commission errors, offering evidence that BMBIs can support sustained attention. The BMBI condition was also associated with lower negative affect earlier on during the task. A serial mediation model testing the effect of condition on sustained attention performance through the path of state emotion regulation and negative affect was not supported.

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Table of Contents

Abstract ii
Acknowledgements iii
Table of Contents iv
Table of Figures vi
Table of Tables vii
Introduction 1
Hypotheses 6
1. The Effect of Condition on State Nonacceptance and Non-modulation of Emotions 6
During a Sustained Attention Task 6
2. The Effect of Condition on Negative Affect Immediately Following the Intervention 6
3. The Effect of Condition on the Slope of Negative Affect During a Sustained Attention Task 7
4. The Effect of Condition on Sustained Attention, Mediated by State Emotional Nonacceptance and Non-modulation and Negative Affect 7
Methods 9
Participants 9
Materials 11
Sustained Attention 11
Questionnaires 12
Treatment Material 15
Procedures 16
Results 17
Deviations from Proposed Analysis 18
Negative Suppression of Mindfulness Experience 18
Strong Autoregressive Effects of Negative Affect and CPT Performance 19
1. The Effect of Condition on State Emotional Nonacceptance and Non-modulation During a Sustained Attention Task 19
2. The Effect of Condition on Negative Affect Immediately Following the Intervention 22
3. The Effect of Condition on the Slope of Negative Affect During a Sustained Attention Task 24
4. The Effect of Condition on Sustained Attention, Mediated by State Emotional Nonacceptance and Non-Modulation and Negative Affect 26
4.1.1. The Effect of Condition on Commission Errors 27

4.1.2. The Mediating Effect of State Emotional Nonacceptance and Non-modulation and Negative Affect on the Relationship between Condition and Commission Errors 28
4.2. The Effect of Condition on HRT SD 32
Discussion 34
Limitations and Future Directions 43
Conclusion 44
References 46

Table of Figures

Figure 1. 8
Figure 2. 8
Figure 3. 17
Figure 4. 21
Figure 5. 23
Figure 6. 25
Figure 7. 25
Figure 8. 28
Figure 9. 30
Figure 10. 32
Figure 11. 33

Table of Tables

Table 1. 10
Table 2. 17
Table 3. 18
Table 4. 29
Table 5. 31

The Effect of a Brief Mindfulness Intervention on Negative Affect during a Sustained Attention Task: Is Emotion Regulation a Mechanism of Action?

Introduction

Over the past two decades, interest in mindfulness has increased exponentially, with 16,581 publications in scientific journals from 1996 to 2021 (Baminiwatta & Solangaarachchi, 2021). Mindfulness encompasses regulating attention and approaching one's experiences with openness, curiosity, and acceptance (Bishop et al., 2004). The context in which mindfulness is researched is varied. Mindfulness can be studied as a trait, in which individuals differ in their propensity toward a mindful stance, or by evaluating interventions designed to elicit state or trait mindfulness (Chiesa et al., 2013). This paper focuses on brief mindfulness interventions intended to elicit a mindful state.

Mindfulness-based interventions (MBIs) are, on average, 8-12 weeks long, with the most common being Mindfulness-based Stress Reduction (MBSR) and Mindfulness-based Cognitive Therapy (MBCT; Hofmann & Gómez, 2017). Participants are taught formal (i.e., meditation or guided practice) and informal mindfulness practices (i.e., deliberate, non-judgmental awareness in routine activities) designed to cultivate trait mindfulness and associated psychological benefits. Formal mindfulness practices can be further divided into focused attention meditation (sustaining attention on a single stimulus) and open monitoring meditation (noticing any experiences, thoughts, and emotions as they arise; Lutz et al., 2008). Both practices require acceptance and awareness to notice when the mind has wandered and to redirect attention.

Common benefits of MBIs are lower anxiety, stress and depression, and improved emotion regulation (Goyal et al., 2014; Guendelman et al., 2017). While often not an immediate goal of psychological interventions, mindfulness practice is also associated with improvements

in sustained attention, defined as the prolonged focus on a relatively low-demand stimulus (Verhaeghen, 2020; Petranker & Eastwood, 2021).

There are distinct theories on how outcomes associated with long-term mindfulness practice or MBIs arise. Yet, many of them consider the development of attentional control and emotion regulation skills at their core (Holzel et al., 2011). For example, the Liverpool model of mindfulness posits that mindfulness directly influences attentional control, with downstream cognitive and affective benefits (Malinowski, 2013). Similarly, Teper & Inzlicht (2013) place executive control, a facet of attentional control, as a core process by which mindfulness strengthens emotion regulation. Monitor and Acceptance Theory (MAT) identifies both attention monitoring and an attitude of acceptance, a facet of emotion regulation, as crucial ingredients of mindfulness practice (Lindsay & Creswell, 2017; Troy et al., 2018). While there is no clear consensus on *how* attentional control and emotion regulation act as mechanisms of action, there is strong evidence for both being core processes that contribute to the success of MBIs (Holzel, 2011; Guendelman et al., 2017).

It is important to note that findings for the benefits of mindfulness practice are mixed, and effect sizes are often small to moderate (Dawson et al., 2020; Anderson et al., 2007; Goyal et al., 2014; Mallya & Fiocco, 2016). In other words, the benefits of mindfulness practice must not be overstated. The most likely explanation for mixed findings is variability in intervention formats and outcome measures across studies. This underscores the importance of understanding mechanisms of action to inform targeted and effective interventions (Davidson, 2010). A second explanation is individual differences among participants in treatment motivation and personality factors (Tang & Braver, 2020). Moreover, the high commitment required for MBSR and MBCT, involving weekly 2-hour sessions and 45 minutes of daily home practice, can be demanding.

While not a substitute for extensive mindfulness training, brief mindfulness-based interventions (BMBIs) can be an accessible tool to induce a state of mindfulness in the moment. These interventions tend to be 5-30 minutes in length, ranging from a single session to two weeks, and involve a formal mindfulness practice, most commonly a mindfulness meditation (Schumer et al., 2018). Research on BMBIs is typically conducted with novice meditators (Howarth et al., 2019) and employs focused attention meditation (Lippelt et al., 2014). BMBIs have been shown to have immediate and short-term effects on cognition, with sustained attention of primary interest in the present study (Howarth et al., 2019; Ueberholz & Fiocco, 2022; Morrison et al., 2014; Mrazek et al., 2012).

Sustained attention is commonly measured through laboratory-based go/no-go paradigms. Participants must respond to frequent non-target stimuli and withhold a response to an infrequent target stimulus (e.g., Robertson et al., 1997; Conners, 1985). Commission errors occur when an individual fails to override a pattern of habitual responding and mistakenly responds to a no-go target stimulus. These errors are considered failures of sustained attention and are associated with real-world sustained attention failures (Smilek et al., 2010). Greater variability in reaction time (i.e., hit reaction time standard deviation; HRT SD) has been interpreted as lapses in sustained attention due to mind-wandering (Cheyne et al., 2009). Both commission errors and HRT SD have been studied in response to brief mindfulness interventions (Mrazek et al., 2012; Ueberholz & Fiocco, 2022; Banks et al., 2019).

Despite being misunderstood as a skill requiring little effort, sustained attention is aversive and associated with affective states of boredom, frustration, and discomfort (Warm et al., 2008; Malkovsky et al., 2012). Sustained attention is necessary for everyday activities, such as driving, and can carry catastrophic consequences when vigilance failures occur (Langner &

Eickhoff, 2013). Moreover, the avoidance of cognitively demanding tasks, including those that require sustained attention, is associated with lower levels of achievement and greater dissatisfaction (Nurmi et al., 2003). Given that BMBIs are highly accessible and could be effective for improving sustained attention in the moment, further research is needed to clarify the relationship between BMBIs and sustained attention. Of particular importance is investigating the mechanism of action to understand the contexts in which BMBIs are most effective.

The theories of how long-term mindfulness practice leads to cognitive and affective benefits may not be directly applicable, given that a single BMBI is likely insufficient for lasting effects. To date, the most likely mechanism of action is that BMBIs can elicit in-the-moment non-judgmental acceptance of emotions, a core feature of emotion regulation (Rahl et al., 2017). While emotion regulation is considered a trait, it is also a state variable. Emotion regulation can be made easier or more difficult under different conditions, for example, following a BMBI (Lavender et al., 2017)

Successful emotion regulation decreases the intensity and duration of negative affect (Gratz & Tull, 2010). There is abundant evidence to support that negative affect interferes with cognitive performance (Malkovsky et al., 2012; Hancock & Warm, 1989; Helton & Head, 2012). As such, facilitating state emotion regulation through BMBIs may reduce interference of negative affect during sustained attention, allowing for greater performance. Evidence for the path of BMBIs to greater state emotion regulation, lower negative affect and greater sustained attention lies in findings linking BMBIs to each outcome independently (Howarth et al., 2019; Schumer et al., 2018; Arch & Craske, 2006; Wu et al., 2019).

Only a small body of literature has empirically tested changes in state emotion regulation in response to brief mindfulness interventions, with mixed findings (Erisman & Roemer, 2010; Goodnight, 2016; Arch & Craske, 2006; Watford & Stafford, 2015). Across the four studies that have examined self-reported, state emotion regulation in response to BMBIs, a common finding is that BMBIs can change affective responses to negatively and positively valenced stimuli, with weaker evidence for BMBIs having a direct effect on state emotion regulation. However, a strong theoretical rationale suggests that BMBIs support facets of state emotion regulation that contribute to cognitive performance and reduced negative affect (Iani et al., 2019; Rahl et al., 2017; Arch & Craske, 2006).

There are some potential reasons for a lack of empirical support for the effect of BMBIs on state emotion regulation in the literature. The aspects of state emotion regulation most critical for observing benefits following BMBIs are not captured. The present version of the State Difficulties in Emotion Regulation Scale (S-DERS), the most popular measure of state emotion regulation, was not developed and validated until relatively recently (Lavender et al., 2017). Most of the literature was published before its creation, and more research is needed using this most up-to-date measure.

The majority of extant research has focused on facets of emotional clarity and awareness or the overall construct of emotion regulation following BMBIs (Erisman & Roemer, 2010; Goodnight, 2016). Acceptance and modulation of emotions may be most relevant in the context of BMBIs and cognitive performance. Acceptance is understood to be a critical ingredient for the effectiveness of mindfulness-based interventions (Rahl et al., 2017; Lindsay & Creswell, 2017). The ability to modulate emotional and behavioural responses is critical for the maintenance of

goal-directed behaviour (i.e., maintaining performance on a cognitive task; Linehan, 1993; Melnick & Hinshaw, 2000).

Hypotheses

The present study aims to provide empirical support for state emotional acceptance and modulation as a mechanism of action for BMBIs. As the scale administered in the present study measures nonacceptance of, and limited ability to modulate, emotions (i.e., non-modulation), these terms will be used moving forward. Specifically, we are interested in whether BMBIs contribute to less nonacceptance and non-modulation of emotions, leading to lower negative affect and better performance on a sustained attention task, relative to an audiobook control condition. From this aim, four hypotheses were generated. These hypotheses were pre-registered on the Open Science Framework and are available at https://osf.io/xs7d8/.

1. The Effect of Condition on State Nonacceptance and Non-modulation of Emotions During a Sustained Attention Task

The first hypothesis is that participants in a BMBI condition will experience less state emotional nonacceptance and non-modulation during a sustained attention task relative to an audiobook control condition. More specifically, the control condition will experience an increase in state nonacceptance and non-modulation of emotions from baseline to post-block one of a sustained attention task. Those in the BMBI condition will not experience an increase from baseline to post-block one of a sustained attention task; the BMBI will protect against difficulties with emotion regulation that are expected to arise during an aversive sustained attention task. This will address a gap in the literature related to whether BMBIs influence facets of state emotion regulation (acceptance and modulation) during sustained attention.

2. The Effect of Condition on Negative Affect Immediately Following the Intervention

The second hypothesis is that participants in the BMBI condition will experience less negative affect post-intervention, but before beginning the sustained attention task, relative to the control condition. Findings for lower negative affect following a BMBI have been consistently found in the literature (Ueberholz & Fiocco, 2022; Erisman & Roemer, 2010; Schumer et al., 2018).

3. The Effect of Condition on the Slope of Negative Affect During a Sustained Attention Task

The third hypothesis is that participants in the audiobook control condition will experience a steeper increase in negative affect throughout the sustained attention task relative to the BMBI condition. There is less direct evidence for this hypothesis, and thus it is based on findings that mindfulness has been found to reduce both negative affect and emotional reactivity (Arch & Craske, 2006; Creswell et al., 2014). It is anticipated that these effects will sustain throughout the sustained attention task**.**

4. The Effect of Condition on Sustained Attention, Mediated by State Emotional Nonacceptance and Non-modulation and Negative Affect

The final hypothesis is that individuals in the BMBI condition will make fewer commission errors and have lower HRT SD on a sustained attention task compared to the audiobook control condition. The effect of experimental condition on sustained attention will be mediated by state emotional non-modulation and nonacceptance, and negative affect. Specifically, those in the BMBI condition will experience less negative affect (after blocks two and three of the sustained attention task), mediated by nonacceptance and non-modulation (after block one). Those in the BMBI condition will experience fewer commission errors and lower HRT SD (blocks three and four), mediated by the path of state emotional non-modulation and nonacceptance, and negative affect. There will be two separate mediation models to represent

this hypothesis; the first will include negative affect and sustained attention performance measured at earlier time points, and the second, at later time points. See Figures 1 and 2 for a depiction of this model.

Figure 1.

Serial Mediation Model with Earlier Measures of Negative Affect and Sustained Attention Performance

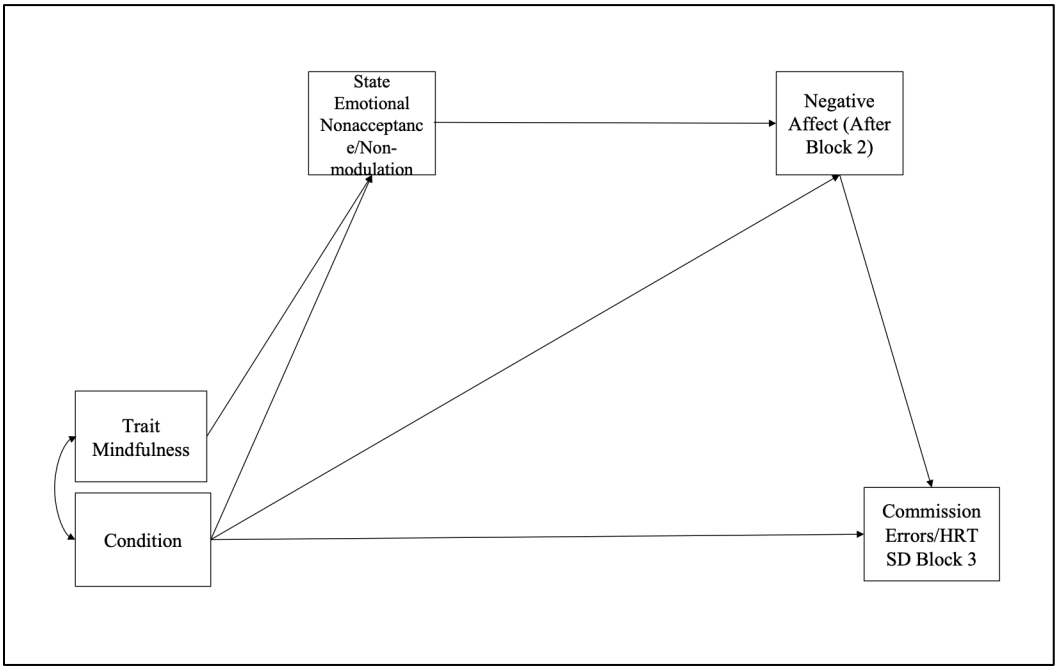
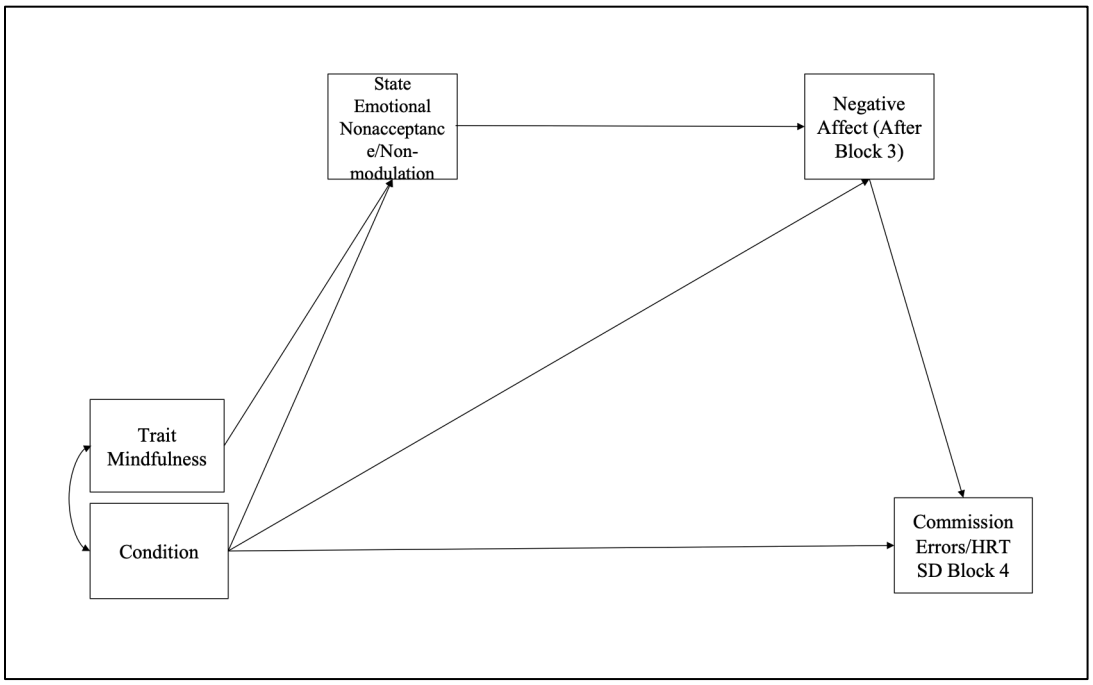


Figure 2.

Serial Mediation Model with Later Measures of Negative Affect and Sustained Attention Performance.



Methods

Participants

According to a priori power calculation using G*Power 3.1 for analysis of covariance (numerator df = 1, number of groups = 2, number of covariates = 2), a sample size of 171 participants was needed to achieve 90% power with an effect size of $\eta_p^2 = .07$ (Banks et al., 2019). Sample size requirements for structural equation modelling (SEM) were equally considered when deciding a target sample size (Bollen, 1989).

Participants were recruited from an undergraduate participant pool for a research study, which was described as examining how "relaxation exercises influence the experience of effort and performance on an attention test". They received partial course credit for their participation in the study. Data collection occurred between January and December 2025. Data were collected from 243 participants. Fifty-two participants were removed from the dataset for non-compliance with the experimental procedure (e.g, not following instructions to close eyes/soften gaze during mindfulness practice; $n = 24$), coding errors that resulted in missing data ($n = 2$), having >50%

omission errors on the CPT (n = 9), or technological difficulties (e.g., Inquisit experiment freezing or being incompatible with participants' device; n = 17).

The distribution of demographic variables for the sample is presented in Table 1. There were no significant differences in demographic variables between conditions. Two-way chi-square difference tests were used to test differences between conditions, with p-values ranging from .16 (sex) to .66 (education). A Welch's two-sample t-test was used to test differences in age between conditions and was non-significant (p = .470).

Table 1.

Demographic Statistics for the Sample

Measure **Count (%)**	**Control** ***n* = 107**	**BMBI** **n = 84**	**Total** ***N* = 191**
Gender			
Women	77 (72.0%)	69 (82.1%)	146 (76.4%)
Men	27 (25.2%)	14 (16.7%)	41 (21.5%)
Gender Fluid	1 (0.9%)	0 (0.0%)	1 (0.5%)
Nonbinary	0 (0.0%)	1 (1.2%)	1 (0.5%)
Transgender Man	1 (0.9%)	0 (0.0%)	1 (0.5%)
Transgender Woman	1 (0.9%)	0 (0.0%)	1 (0.5%)
Sex			
Female	79 (73.8%)	70 (83.3%)	149 (78.0%)
Male	28 (26.2%)	14 (16.7%)	42 (22.0%)
Age *M(SD)*	22.61 (5.28)	23.25 (6.62)	22.89 (5.90)
Education			
Grade 11	0 (0.0%)	1 (1.2%)	1 (0.5%)
Grade 12 / High School Graduate	34 (31.8%)	26 (31.0%)	60 (31.4%)
Partial College/University	55 (51.4%)	47 (56.0%)	102 (53.4%)
Completed College/University	14 (13.1%)	7 (8.3%)	21 (10.9%)
Completed Graduate/Post-Secondary	4 (3.7%)	3 (3.6%)	7 (3.7%)

Ethnicity			
Indigenous Peoples in Canada	1 (0.9%)	0 (0.0%)	1 (0.5%)
Chinese Canadian	5 (4.7%)	3 (3.6%)	8 (4.2%)
Black Canadian	17 (15.9%)	15 (17.9%)	32 (16.8%)
English Canadian	10 (9.3%)	6 (7.1%)	16 (8.4%)
European Canadian	10 (9.3%)	4 (4.8%)	14 (7.3%)
South Asian Canadian	21 (19.6%)	20 (23.8%)	41 (21.5%)
West Asian Canadian	7 (6.5%)	3 (3.6%)	10 (5.2%)
Other Asian Canadian	9 (8.4%)	3 (3.6%)	12 (6.3%)
Other	25 (23.4%)	29 (34.5%)	54 (28.3%)
Prefer not to say	2 (1.9%)	1 (1.2%)	3 (1.6%)

Materials

Sustained Attention

Continuous Performance Task. Sustained attention was assessed using a modified Conners' Continuous Performance Task-III (CPT), a Go/No-Go task wherein participants continually monitor for a target stimulus among a proportion of non-target stimuli (Conners, 1985). In this task, participants were presented with a sequence of white letters in a sans-serif font against a black screen. They were instructed to press the spacebar when they saw any letter other than the letter X and withhold a response when they saw the letter X. Non-target trials appeared 90% of the time, and target trials (i.e. the letter X) appeared 10% of the time. The letters were presented on the screen for 250 ms each with a 1000 ms interstimulus interval, during which a fixation cross appeared. Participants had 1250 ms to respond to a stimulus.

Before the intervention, participants completed a brief practice CPT of 30 trials for 38 seconds to prepare them for the task. There were 960 trials in the experimental task, lasting a total of 20 minutes. The sustained attention task was split into four blocks, with a brief questionnaire administered between each block. Each experimental block consisted of 240 trials,

lasting approximately five minutes. This duration has been shown to induce negative affect and boredom (Hunter & Eastwood, 2018; Scerbo, 1998).

The CPT offers various performance metrics. In this study, the primary CPT outcomes were the number of commission errors and HRT SD. Participants with non-target trial accuracy below 50% in a given block were excluded from the analyses. Given the high proportion of non-target trials, participants who failed to meet this threshold likely did not adequately engage in the task.

Questionnaires

Demographic Questionnaire. To describe the sample, ensure diversity, and check for any differences in the between-subject conditions, participants provided their age, sex, gender, level of education, and ethnic identity.

Mindfulness Experience Questionnaire. A Mindfulness Experience Questionnaire was administered to measure differences in mindfulness practice across participants. It was a pre-registered covariate in all analyses. Participants were asked: *Over the past three months, have you regularly engaged in mindfulness or contemplative practice?* If they responded in the affirmative, they were prompted to provide information on how many minutes per week, on average, they practice mindfulness.

Five-Facet Mindfulness Questionnaire Short Form (FFMQ; Bohlmeijer et al., 2011). The Five-Facet Mindfulness Questionnaire Short Form (FFMQ) was used to assess differences in trait mindfulness among participants and was included as a covariate in all analyses. The FFMQ is a 24-item self-report measure that assesses five facets of trait mindfulness: *observing, describing, acting with awareness, non-judging* and *non-reactivity*, adapted from the original 39-item FFMQ (Baer et al., 2006). Respondents rate the degree to which each statement is true for

them on a 5-point Likert scale ranging from 1 (*never or very rarely true)* to 5 (*very or often always true).* Higher scores indicate higher trait mindfulness. The FFMQ has a five-factor structure, or higher-order factor structure, with all five factors loading onto a single, "mindfulness" factor (Bohlmeijer et al., 2011). As such, it is acceptable to compute individual scores for each subscale and an overall score for the entire scale (Reise et al., 2013). Subscale scores on the FFMQ are inversely related to scores on the *neuroticism* scale of the NEO Five-Factor Inventory and the Hospital Anxiety and Depression Scale, suggesting strong validity (Bohlmeijer et al., 2011). In the present study, the FFMQ total score was found to have good internal consistency ($\omega = 0.93$).

Prior literature suggests that individuals high in trait mindfulness tend to perform well on sustained attention tasks and have fewer difficulties regulating their emotions (Petranker & Eastwood, 2021; Laurent et al., 2015). Including the FFMQ as a covariate helps to ensure that findings are attributed to the intervention. See Appendix A for the full FFMQ.

State Difficulties with Emotion Regulation Scale (S-DERS; Lavender et al., 2017). The S-DERS is used to capture fluctuating ability to regulate emotions (Lavender et al., 2017). It is a 21-item scale adapted from the Difficulties in Emotion Regulation Scale (DERS; Gratz & Roemer, 2004), adopting a momentary approach to measuring emotion regulation difficulties. It consists of four subscales: *nonacceptance* of current emotions, limited ability to modulate current emotional and behavioural responses (i.e., *non-modulation*), lack of *awareness* of current emotions, and lack of *clarity* about current emotions. Respondents are instructed to indicate how much each item applies to their emotions right now on a scale ranging from 1 (*not at all*) to 5 (*completely*).

The entire scale was administered, but only the non-modulation and nonacceptance subscales were used in the present study, as they were postulated to be the most relevant. A four-factor structure has been found for the S-DERS, suggesting each subscale represents a distinct construct (Sicorello et al., 2025; Lavender et al., 2017). All analyses were conducted with the relevant subscales (nonacceptance and non-modulation) independently, consistent with the four-factor structure, and as a composite score of both subscales, for simplicity. There were no differences in the results when using independent subscales or a composite score. Therefore, the composite score was used in the main analysis to represent state emotion nonacceptance and non-modulation, consistent with the pre-registration. See supplemental materials for analyses with independent subscales.

In the present sample, the internal consistency of the non-modulation ($\omega = 0.89$) and nonacceptance subscales was excellent ($\omega = 0.93$). In the initial validation, the S-DERS demonstrated good convergent validity, with the non-modulation and nonacceptance subscales being moderately correlated with the corresponding subscales on the DERS ($r = .44$ for nonacceptance and $r = .35$ for non-modulation) and a composite of the Negative Intensity/Reactivity subscales of the Affect Intensity Measure ($r = .36$ for nonacceptance and $r = .35$ for non-modulation; Lavender et al., 2017).

Participants completed the S-DERS at two time points: once before the intervention to measure baseline differences, and a second time to measure changes following the intervention and after five minutes of the CPT. After five minutes of the CPT, participants may begin to experience negative affectivity typical of monotonous sustained attention tasks that require emotion regulation (Langner & Eickhoff, 2013; Scerbo, 1998; Hunter & Eastwood, 2018). Thus,

any effects of condition on state nonacceptance and non-modulation of emotions were expected to be apparent at this stage of the experiment. See Appendix B for the full S-DERS.

State Discomfort Questionnaire (SDQ). A state discomfort questionnaire (SDQ), developed by the researchers, was administered to measure negative affect. The items were: 1) *I am distressed*, 2) *I am uncomfortable*, 3) *I am upset*, 4) *I am relaxed* [reverse coded], 5) *I am having negative feelings*. Participants were instructed to rate how much each statement applied to them in the present moment on a scale ranging from 0 (not at all) to 10 (extremely). Confirmatory factor analysis (CFA) revealed that a one-factor model representing a unitary construct of negative affect fit the data. The CFA was conducted on SDQ values collected at baseline. The model fit was good, with robust CFI = 1.00, robust TLI = 0.99, robust RMSEA = 0.045 (90% CI: 0.00, 0.12), and SRMR = 0.023. Factor loadings ranged from .50 to .87. The internal consistency of the SDQ was good ($\omega = 0.85$).

The SDQ was administered at multiple time points to measure changes in negative affect throughout the experiment: pre-intervention, post-intervention, and after blocks two, three, and four of the CPT.

Treatment Material

Brief Mindfulness-Based Intervention (BMBI) Condition. Those in the BMBI condition were instructed to listen and follow along for ten minutes to a guided focused attention meditation practice (narrated by RU), adapted from Ueberholz and Fiocco (2022). The meditation focused on sensations in the body and the breath, and encouraged both focused attention and an attitude of acceptance and curiosity. See Appendix C for the full meditation script.

Control Condition. Those in the control condition listened to an audiobook for ten minutes. *The Hobbit* by J.R.R. Tolkien (narrated by Rob Inglis) was selected as it has been used previously in similar studies (e.g., Eisenbeck et al., 2018; Johnson et al., 2015; Zeidan, 2010). Participants listened to a portion of chapter one to match the duration of the mindfulness meditation recording.

Procedures

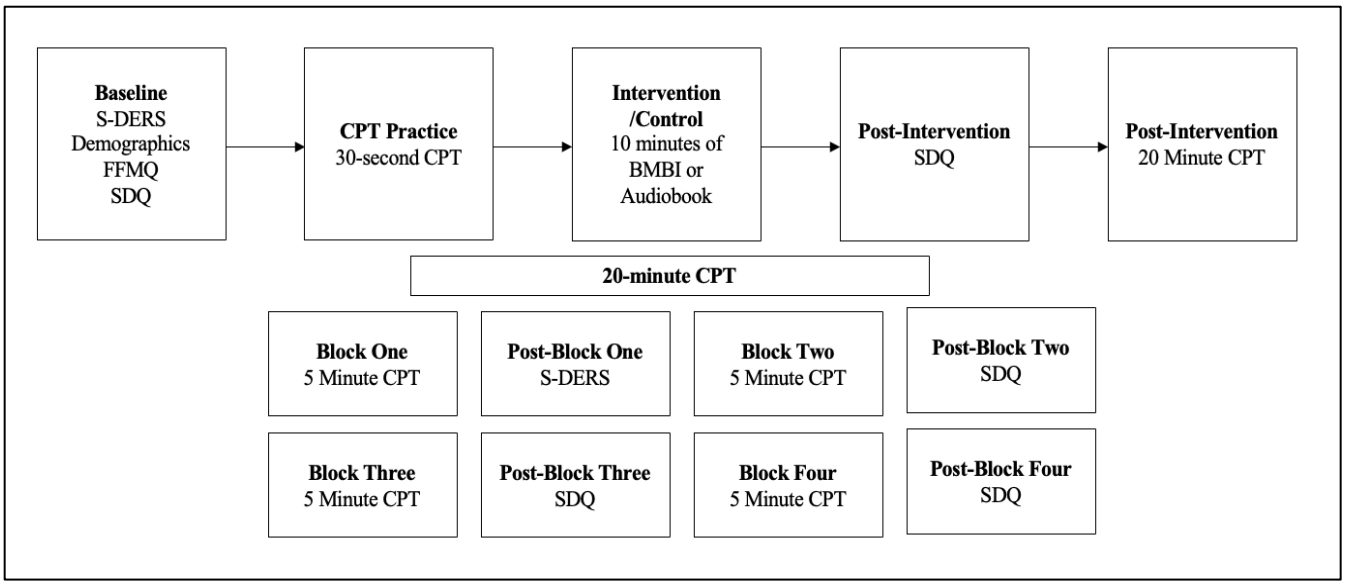
Participants met with a research assistant over Zoom to complete the experiment, with the requirement that their web camera be on for the duration of the study to allow for adherence monitoring. Following provision of consent (See Appendix D), participants were randomly assigned to one of two conditions: ten minutes of audio-guided mindfulness meditation (BMBI condition) or ten minutes of audiobook listening (control condition). Participants completed questionnaires to measure demographic variables, mindfulness experience, trait mindfulness (FFMQ), baseline state emotional nonacceptance and non-modulation (S-DERS) and baseline state negative affect (SDQ), all of which were administered on QuestionPro (https://www.questionpro.com). Participants were prompted to download Inquisit 6 Player onto their personal computer. They completed a 38-second practice round of the CPT, administered using Inquisit, before completing their assigned intervention for 10 minutes and rating their state negative affect using the SDQ.

Participants then completed a 20-minute CPT, which was divided into four five-minute blocks. After each block, participants completed a questionnaire. After block one, participants completed the S-DERS, and after each subsequent three blocks, they completed the SDQ. The final block of the CPT and associated questionnaires concluded the experiment, and participants

were debriefed on the nature and hypotheses of the research study. See Figure 3 for a breakdown of the study procedure.

Figure 3.

Breakdown of Study Procedure



Results

See Table 1 for descriptive statistics of baseline measures.

Table 2.

Descriptive Statistics of Baseline Variables

Measures	Control Condition ***n* = 107**	BMBI Condition ***n* = 84**	Total ***N* = 191**	Welch's t-test
Baseline Measures		Mean or Frequency (SD or %)		
Trait Mindfulness (FFMQ)	76.75 (10.74)	75.92 (11.32)	76.38 (10.98)	t(174) = 0.52, *p* = .61
Nonacceptance (S-DERS)	11.41 (6.02)	12.50 (6.78)	11.89 (6.37)	t(168) = -1.16, *p* = .25
Non-Modulation (S-DERS)	12.47 (5.65)	13.82 (6.62)	13.06 (6.12)	t(163) = -1.49, *p* = .14
Combined (S-DERS)	23.88 (10.64)	26.32 (12.12)	24.95 (11.35)	t(166) = -1.46, *p* = .15

Negative Affect	12.14 (8.25)	14.01 (10.91)	12.96 (9.53)	$t(150) = -1.31$, $p = .19$
Mindfulness Experience				
0 Mins	70 (65.4%)	47 (56.0%)	117 (61.3%)	
0–10 Mins	11 (10.3%)	13 (15.5%)	24 (12.6%)	
11–30 Mins	14 (13.1%)	16 (19.0%)	30 (15.7%)	
31–60 Mins	6 (5.6%)	5 (6.0%)	11 (5.8%)	
60+ Mins	6 (5.6%)	3 (3.6%)	9 (4.7%)	

Table 3.

Pearson Intercorrelations Between Baseline Variables

	Combined (S-DERS)	Nonacceptance (S-DERS)	Non-modulation (S-DERS)	Negative Affect	Mindfulness Experience
Combined (S-DERS)	-				
Nonacceptance (S-DERS)	0.91	-			
Non-modulation (S-DERS)	0.90	0.65	-		
Negative Affect	0.45	0.37	0.44	-	
Mindfulness Experience	-0.13	-0.13	-0.11	-0.01	-
Trait Mindfulness	-0.51	-0.48	-0.46	-0.34	0.40

Deviations from Proposed Analysis

Negative Suppression of Mindfulness Experience

Mindfulness experience was initially intended to be included as a covariate in all analyses with trait mindfulness. During the statistical analysis, it was uncovered that trait mindfulness exerted a negative suppression effect on the mindfulness experience variable. When both were included in a model, mindfulness experience was associated with poorer psychological outcomes (i.e., greater negative affect and state emotional nonacceptance and non-modulation). When it was the sole covariate, mindfulness experience was associated with better psychological outcomes, as expected. VIF values for trait mindfulness and mindfulness experience across

models were <5, and the correlation between the two variables was .40, suggesting that the suppression effect is not solely attributed to multicollinearity. It could be that when controlling for trait mindfulness, the mindfulness experience variable captures the need for a self-regulation exercise rather than the positive effects of mindfulness meditation. The intention for including both was to isolate the benefits of brief mindfulness practice by controlling for variables that would be expected to have additive positive effects.

Given that the mindfulness experience variable was weakly correlated with state emotional nonacceptance and non-modulation, negative affect and sustained attention performance (ranging from -.11 to -.04) relative to trait mindfulness (ranging from .08 to .50), mindfulness experience was seen as unnecessary and dropped as a covariate across models. The results did not change significantly when mindfulness experience was included (see supplemental materials for analyses conducted including mindfulness experience).

Strong Autoregressive Effects of Negative Affect and CPT Performance

The proposed serial mediation model was pre-registered as one model, with repeated measures of negative affect and CPT performance. However, the high correlations between repeated measures accounted for a substantial proportion of the variance and influenced model estimation. As the intention was not to test the stability of the measures over time, each model was split into two, containing a single measure of negative affect and the subsequent measure of CPT performance. See supplemental materials for the repeated measures model and Appendix E for an overview of the original statistical plan and the revised statistical methods.

1. The Effect of Condition on State Emotional Nonacceptance and Non-modulation During a Sustained Attention Task

It was hypothesized that participants in the control condition would experience an increase in state emotional nonacceptance and non-modulation from baseline to post-block one of a sustained attention task. Whereas those in the BMBI condition would experience no such increase. To test this hypothesis, a linear mixed-effects model was estimated using the lme4, lmerTest, and emmeans packages in R (Bates et al., 2015; Kuznetsova et al., 2017; Lenth & Piaskowski, 2026). The linear mixed-effects model was fit using Restricted Residual Maximum Likelihood, and t-tests for pairwise comparisons were conducted using Kenward-Roger's method. These model specifications were used for all subsequent linear mixed-effects models.

The main effects and interaction of condition and time, and centered trait mindfulness were entered as predictors, with random intercepts for participant ID. A combined S-DERS nonacceptance and non-modulation subscale score was entered as the dependent variable. Normality assumptions were assessed by visual analysis of the Q-Q plot, and were deemed acceptable. There was some heteroscedasticity, as evidenced by a residuals v. fitted plot, that was not of major concern given the large sample size and robust estimation methods. Outliers were assessed using Cook's Distance with a threshold of $> 4/n$ on a participant, rather than on a case-by-case basis. Thirteen outliers were detected using Cook's Distance with a threshold of $> 4/n$ on a participant, rather than on a case-by-case basis (this method was applied for outlier detection throughout). All models are reported with outliers, except where noted.

Controlling for trait mindfulness and condition, there was a significant main effect of time, $F(1, 189) = 11.73$, $p < .001$, $\eta p^2 = .06$, such that state emotional nonacceptance and non-modulation were generally lower post-intervention during block one of the CPT compared to pre-intervention baseline. Controlling for trait mindfulness and time, there was no main effect of condition $F(1, 188) = 0.54$, $p = .463$, $\eta p^2 = .00$. However, controlling for trait mindfulness, the

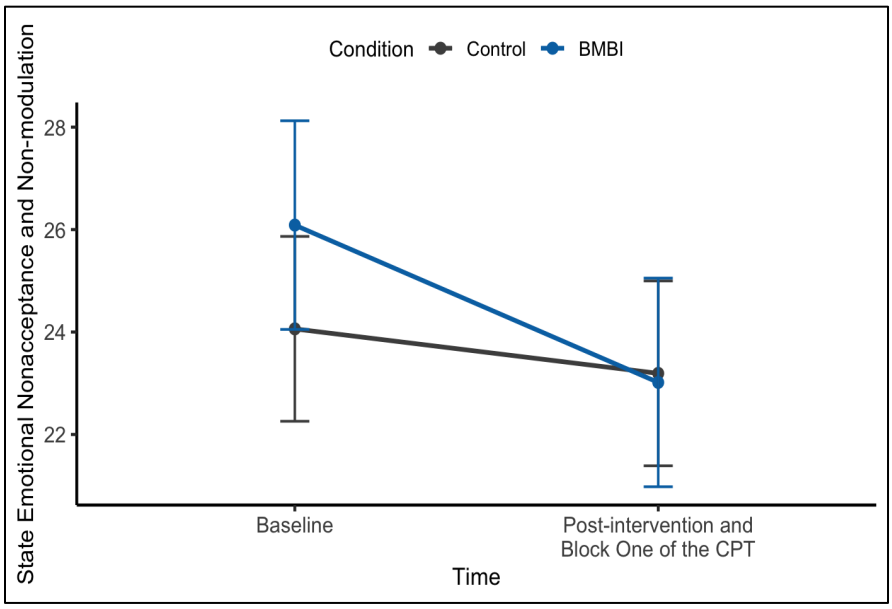
interaction between condition and time was approaching significance, $F(1, 189) = 3.66$, $p = .057$, $\eta p^2 = .02$. Removal of outliers led to the interaction effect becoming significant, $F(1,176) = 4.27$, $p = .027$, $\eta p^2 = .03$. Controlling for condition and time, trait mindfulness was a significant covariate, $F(1, 188) = 77.73$, $p < .001$, $\eta p^2 = .29$.

Pairwise comparisons revealed that those in the BMBI condition experienced a significant decrease in state emotional nonacceptance and non-modulation from baseline to post-block one of the CPT, $B = 3.07$, SE = 0.86, $t(189) = 3.57$, $p < .001$, $d = .55$, whereas the control condition did not, $B = 0.87$, SE = 0.76, $t(189) = 1.14$, $p = .256$, $d = .16$. There were no significant differences between conditions at baseline, $B = -2.03$, SE = 1.38, $t(264) = -1.47$, $p = .144$, $d = -.36$. or after the first, post-intervention, block of the CPT, $B = 0.18$, SE = 1.38, $t(264) = 0.13$, $p = .898$, $d = .03$.

These findings fail to support the hypothesis that those in the BMBI condition would experience less state emotional nonacceptance and non-modulation post-intervention, after block one of the CPT, relative to participants in the audiobook control condition.

Figure 4.

The Effect of Condition and Time on State Emotional Nonacceptance and Non-Modulation



2. The Effect of Condition on Negative Affect Immediately Following the Intervention

It was hypothesized that the BMBI condition would experience less negative affect after the intervention, but before beginning the CPT, relative to the control condition. A linear mixed-effect model was estimated with the main effects and interaction of condition and time, and centered trait mindfulness entered as predictors. Negative affect (SDQ score) was entered as the dependent variable. Normality assumptions were assessed by visual analysis of the Q-Q plot, and were deemed acceptable. There was some heteroscedasticity, as evidenced by a residuals v. fitted plot, that was not of major concern given the robustness of the model and large sample size. Outliers were assessed using Cook's Distance with a threshold of $> 4/n$ on a participant, rather than on a case-by-case basis. Twelve outliers were detected; results are reported with outliers included, except where noted.

Controlling for trait mindfulness and condition, there was a significant main effect of time, $F(1, 189) = 75.96$, $p < .001$, $\eta p^2 = .29$, such that negative affect decreased from baseline to post-intervention. Controlling for trait mindfulness and time, there was no significant main effect of condition, $F(1, 188) = 0.87$, $p = .35$, $\eta p^2 = .00$ when outliers were included in the model.

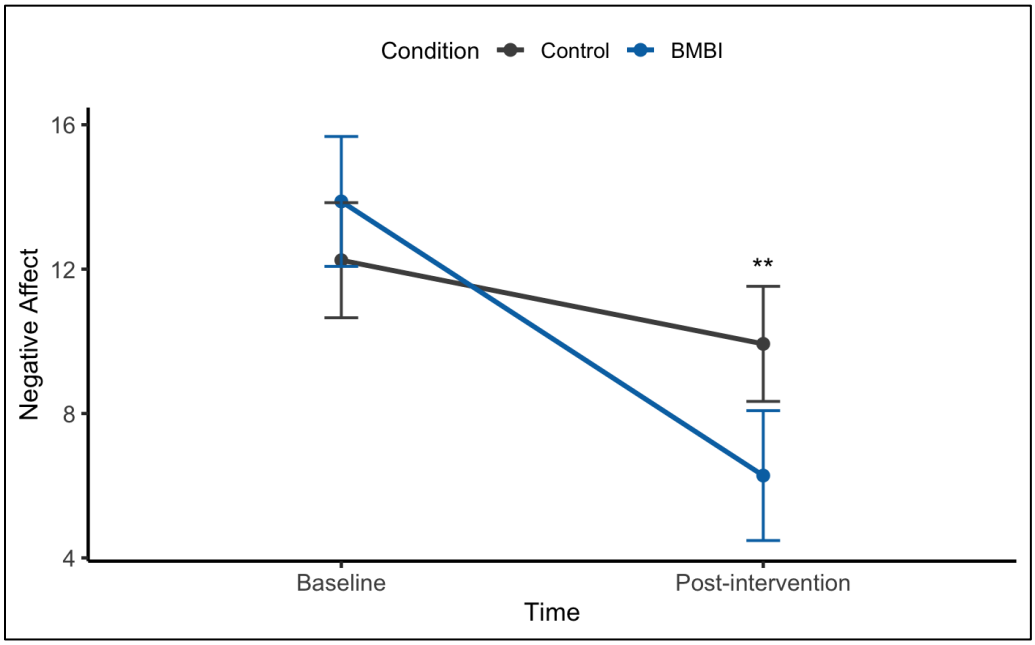
When they were removed, the effect of condition was significant $F(1, 176) = 3.97$, $p = .048$, $\eta p^2 = .02$. There was a significant Time X Condition interaction, $F(1, 189) = 21.53$, $p < .001$, $\eta p^2 = .10$. Controlling for condition and time, trait mindfulness was a significant covariate, $F(1, 188) = 35.72$, $p < .001$, $\eta p^2 = .16$.

Pairwise comparisons revealed significant decreases in negative affect from baseline to post-intervention in the BMBI, $B = 7.60$, $SE = 0.85$, $t(189) = 8.92$, $p < .001$, $d = 1.38$, and control condition, $B = 2.32$, $SE = 0.75$, $t(189) = 3.07$, $p = .002$, $d = 0.42$. At post-intervention, the BMBI condition had significantly lower negative affect relative to the control condition, $B = 3.65$, $SE = 1.22$, $t(285) = 2.99$, $p = .003$, $d = 0.66$.

These findings support the hypothesis that those in the BMBI condition would experience less negative affect immediately following the intervention, and before starting the CPT, relative to the control condition.

Figure 5.

Linear Mixed Effects Model of the Effect of Condition and Time on Negative Affect



3. The Effect of Condition on the Slope of Negative Affect During a Sustained Attention Task

It was hypothesized that participants in the audiobook control condition would experience a steeper increase in negative affect throughout the sustained attention task relative to the BMBI condition. Negative affect was measured at three time points during the CPT: after 10 minutes (after block 2), 15 minutes (after block 3), and after 20 minutes (after block 4).

A latent growth curve model was used to test this hypothesis, and the lavaan package in R was used to estimate the model (Rosseel et al., 2025). Robust maximum likelihood was the estimation method. The intercept factor was set to 1, and the slope factor was created by fixing the time points to 0 (after block 2), 1 (after block 3), and 2 (after block 4). The intercept and slope of negative affect were regressed onto condition and trait mindfulness, which was included as a covariate. The model fit was good, with robust TLI = 1.00, robust CFI = 1.00, robust RMSEA = .00 (90% CI: .00, .11), and SRMR = .011.

Controlling for trait mindfulness, the effect of condition on the latent intercept of negative affect was approaching significance, such that those in the mindfulness condition had a latent intercept that was 2.75 points lower than those in the control condition, $B = -2.75$, $SE = 1.46$, $z = -1.89$, $p = .059$. Condition did not significantly affect the latent slope of negative affect, $B = 0.29$, $SE = 0.73$, $z = 0.40$, $p = .69$.

Trait mindfulness was a significant predictor of the latent intercept of negative affect, $B = -0.34$, $SE = 0.07$, $z = -5.16$, $p < .001$, but not the latent slope of negative affect, $b = 0.01$, $SE = 0.03$, $z = 0.26$, $p = .80$.

These findings fail to support the hypothesis that condition influences the slope of negative affect over the course of the CPT. There was a trend in the data, such that the BMBI

may have influenced negative affect during block 2 of the CPT (i.e., a lower latent intercept of negative affect in the BMBI condition) rather than its trajectory throughout the task. However, the effect was non-significant.

Figure 6.

Plotted Means of Negative Affect by Condition

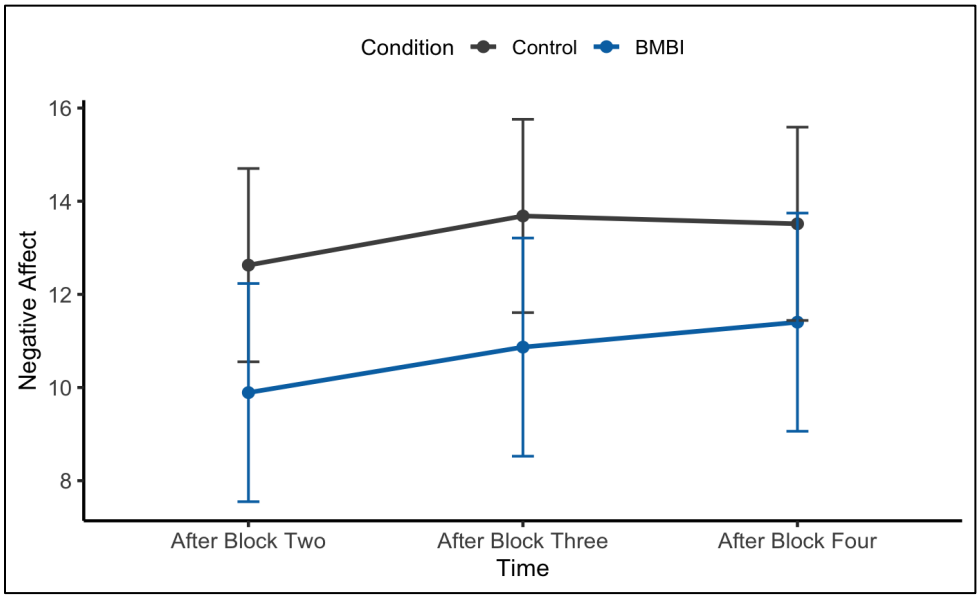
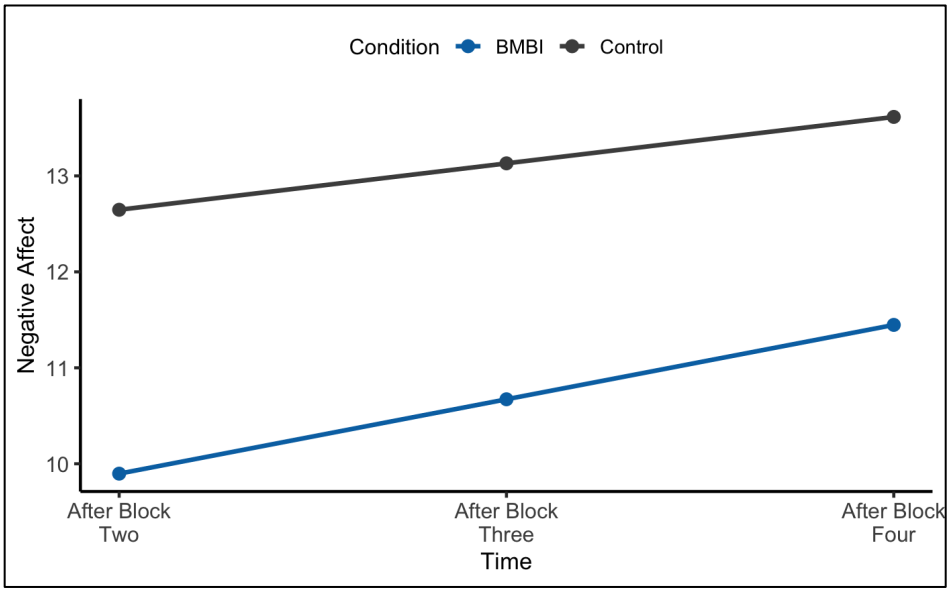


Figure 7.

Latent Slope and Intercept of Negative Affect by Condition



4. The Effect of Condition on Sustained Attention, Mediated by State Emotional Nonacceptance and Non-Modulation and Negative Affect

It was hypothesized that individuals in the BMBI condition would perform better on the CPT (i.e., fewer commission errors and lower HRT SD) relative to individuals in the control condition. More specifically, it was hypothesized that the BMBI condition would experience less state emotional nonacceptance and non-modulation, leading to lower levels of negative affect and, ultimately, better performance.

Before testing the full hypothesis, the direct effect of condition on CPT performance was tested by running two linear mixed effects models—one for each performance metric (commission errors and HRT SD) across all blocks of the CPT. If condition predicted performance, the full model was tested.

To test the full model, two serial mediation models were run per performance metric. In model one, condition and trait mindfulness predicted state emotional nonacceptance and non-modulation (after block one of the CPT); condition and state emotional nonacceptance and non-modulation (after block one of the CPT) predicted negative affect (after block two of the CPT); condition and negative affect (after block two of the CPT) predicted performance (block three of the CPT). See Figure 1 above for a depiction of the model.

In model two, condition and trait mindfulness predicted state emotional nonacceptance and non-modulation (after block one of the CPT); condition and state emotional nonacceptance and non-modulation (after block one of the CPT) predicted negative affect (after block 3 of the CPT); negative affect (after block three of the CPT) and condition predicted performance (block four of the CPT). See Figure 2 above for a depiction of the model. If any pathway from predictor to mediator and mediator to dependent variable were significant, the indirect and total effects

were calculated, with 95% bootstrap confidence intervals used to detect a significant mediation effect.

4.1.1. The Effect of Condition on Commission Errors

To test the effect of condition on commission errors, a linear mixed-effects model was estimated, with random intercepts specified for participants. The main effects and interaction of condition and time (four blocks of the CPT) and centered trait mindfulness were entered as predictors. The number of commission errors was entered as the dependent variable. There were no violations of normality or heteroscedasticity based on visual analysis of a Q-Q Plot and fitted v. residuals, respectively. Outliers were assessed using Cook's Distance with a threshold of $> 4/n$ on a participant, rather than on a case-by-case basis. No outliers were detected.

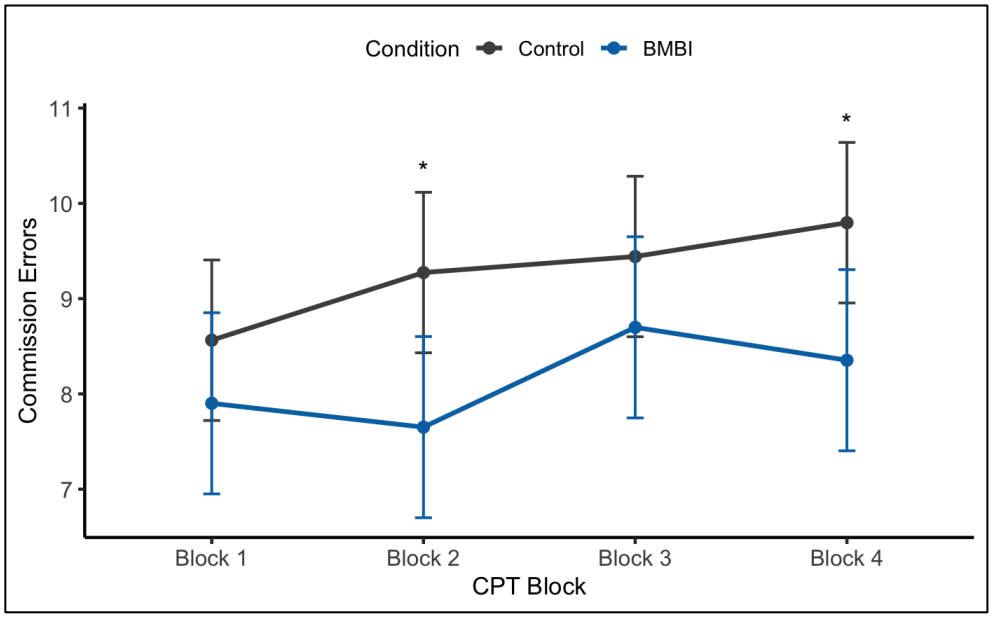
Controlling for condition and trait mindfulness, there was a significant main effect of time, $F(3, 567) = 4.71$, $p = .003$, $\eta p^2 = .02$, such that commission errors were higher in block three, $B = 0.88$, $SE = 0.37$, $t = 2.37$, $p = .018$, and block four of the CPT, $B = 1.23$, $SE = 0.37$, $t = 3.33$, $p < .001$, compared to block one. Controlling for time and trait mindfulness, there was a significant main effect of condition, $F(1, 188) = 4.17$, $p = .043$, $\eta p^2 = .02$, such that the mindfulness condition had fewer commission errors overall. The condition x time interaction was not significant, $F(3, 567) = 1.51$, $p = .211$, $\eta p^2 = .01$; the changes in commission errors did not differ significantly across conditions. Controlling for condition and time, trait mindfulness was a significant covariate, $F(1, 188) = 5.63$, $p = .018$, $\eta p^2 = .03$.

Pairwise analyses revealed that commission errors were significantly higher in the control condition than the mindfulness condition during block two, $B = 1.62$, $SE = 0.65$, $t = 2.51$, $p = .013$, $d = 0.60$, and block four of the CPT, $B = 1.44$, $SE = 0.65$, $t = 2.24$, $p = .026$, $d = 0.53$.

As there was a significant main effect of condition on commission errors, supporting the hypothesis that the BMBI would influence performance, the serial mediation models were estimated.

Figure 8.

Linear Mixed Effects Model of the Effect of Condition and Time on Commission Errors



4.1.2. The Mediating Effect of State Emotional Nonacceptance and Non-modulation and Negative Affect on the Relationship between Condition and Commission Errors

4.1.2.1. Model One: Negative Affect After Block Two and Commission Errors During Block Three. Model one was fit using robust maximum likelihood estimation. The model fit was adequate, with robust TLI = .94, robust CFI = .98, robust RMSEA = .076, and SRMR = .038.

Controlling for trait mindfulness, condition did not have a significant effect on state emotional nonacceptance and non-modulation, and neither condition nor earlier negative affect predicted commission errors. See Table 4 for regression output and Figure 9 for the path diagram.

With respect to the regression pathways that were significant, a one unit increase in state emotional nonacceptance and non-modulation was associated with a .69 unit increase in negative affect ($p < .001$, 95% CI = 0.57, 0.81). Controlling for state emotional nonacceptance and non-modulation, the BMBI condition had a negative affect (after block 2) score that was, on average, 2.63 points lower than those in the control condition ($p = .020$, 95% CI = −4.84, −0.41). This suggests that condition and state emotional nonacceptance and non-modulation independently influenced negative affect.

While not a focus of the thesis, the paths between trait mindfulness and state emotional nonacceptance and non-modulation, and from state emotional nonacceptance and non-modulation to negative affect were significant. Therefore, the full mediating effect of state emotional nonacceptance and non-modulation in the relationship between trait mindfulness and negative affect was tested as exploratory. The unstandardized estimate for the indirect mediation effect was -0.33, with bootstrap 95% confidence intervals (CI) falling between [−0.42, −0.23]. As the CI does not overlap zero, this suggests a significant mediation effect, such that higher trait mindfulness predicts lower negative affect through less state emotional nonacceptance and non-modulation.

Table 4.

Structural Model Results for Model One: Negative Affect (After Block Two) and Commission Errors (Block Three)

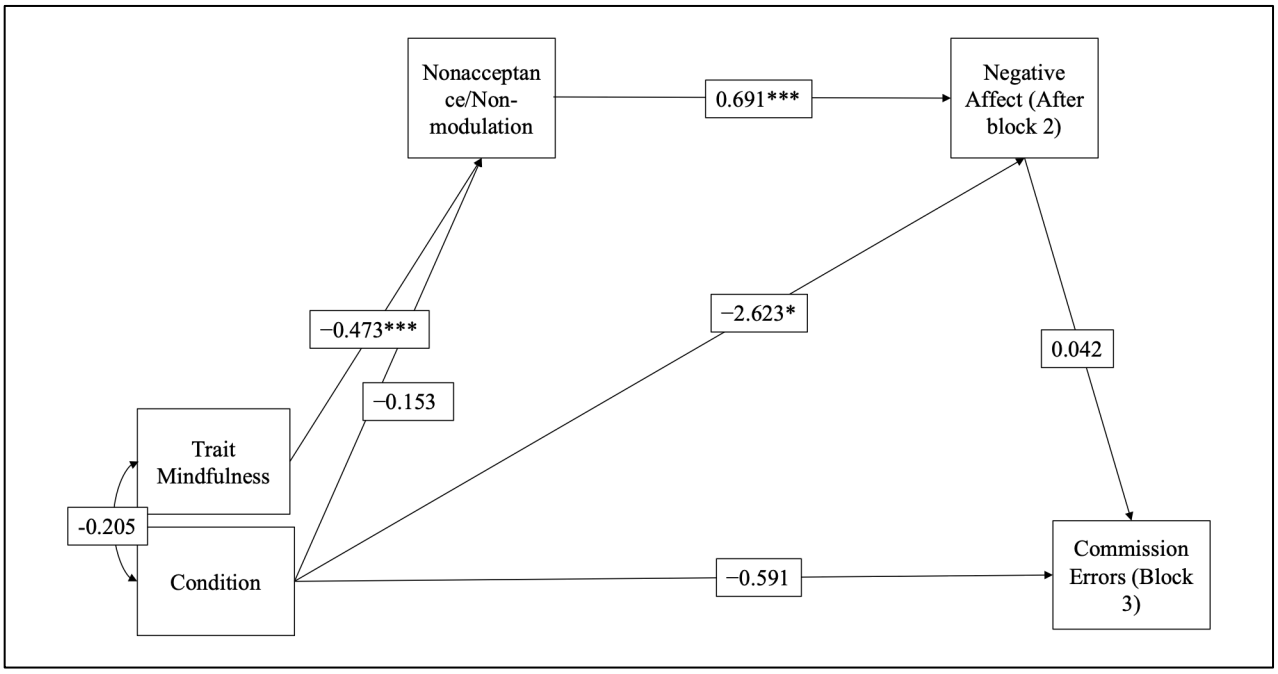
Path	Estimate	SE	Z	p	95% CI	Standardized Estimate
Condition → Non-acceptance/Nonmodulation	−0.153	1.354	−0.113	0.91	[−2.806, 2.500]	−0.007
Trait Mindfulness → Non-acceptance/Nonmodulation	−0.473	0.058	−8.097	< .001	[−0.588, −0.359]	−0.493

Non-acceptance/Nonmodulation → Negative affect (After block 2)	0.691	0.062	11.174	< .001	[0.570, 0.813]	0.680
Condition → Negative affect (After block 2)	−2.623	1.129	−2.323	0.02	[−4.837, −0.410]	−0.122
Negative affect (After block 2) → Commission errors (Block 3)	0.042	0.032	1.292	0.196	[−0.022, 0.106]	0.093
Condition → Commission errors (Block 3)	−0.591	0.704	−0.840	0.401	[−1.971, 0.788]	−0.061

Note. N = 191, SE = robust standard error.

Figure 9.

Path Diagram of Model One: Negative Affect (After Block Two) and Commission Errors (Block Three)



4.1.2.2. Model Two: Negative Affect After Block Three and Commission Errors During Block Four.

Model two was fit using robust maximum likelihood estimation. The model fit was adequate, with robust TLI = .89, robust CFI = .97, robust RMSEA = .084 (90% CI: [.00, .165]), and SRMR = .035.

The paths of condition and trait mindfulness to state emotional nonacceptance and non-modulation are unchanged from the previous model. Negative affect after block three or condition did not predict commission errors during block four. See Table 5 for the full regression output and Figure 10 for the path diagram.

With respect to the significant regression pathways, a one unit increase in state nonacceptance and non-modulation was associated with a 0.58 unit increase in negative affect ($p < .001$, 95% CI = 0.44, 0.72). Controlling for state difficulties with emotion regulation, the BMBI condition had a negative affect score that was, on average, 2.68 points lower than those in the control condition, but the effect was marginally significant ($p = .052$, 95% CI = −5.38, 0.03).

Table 5.

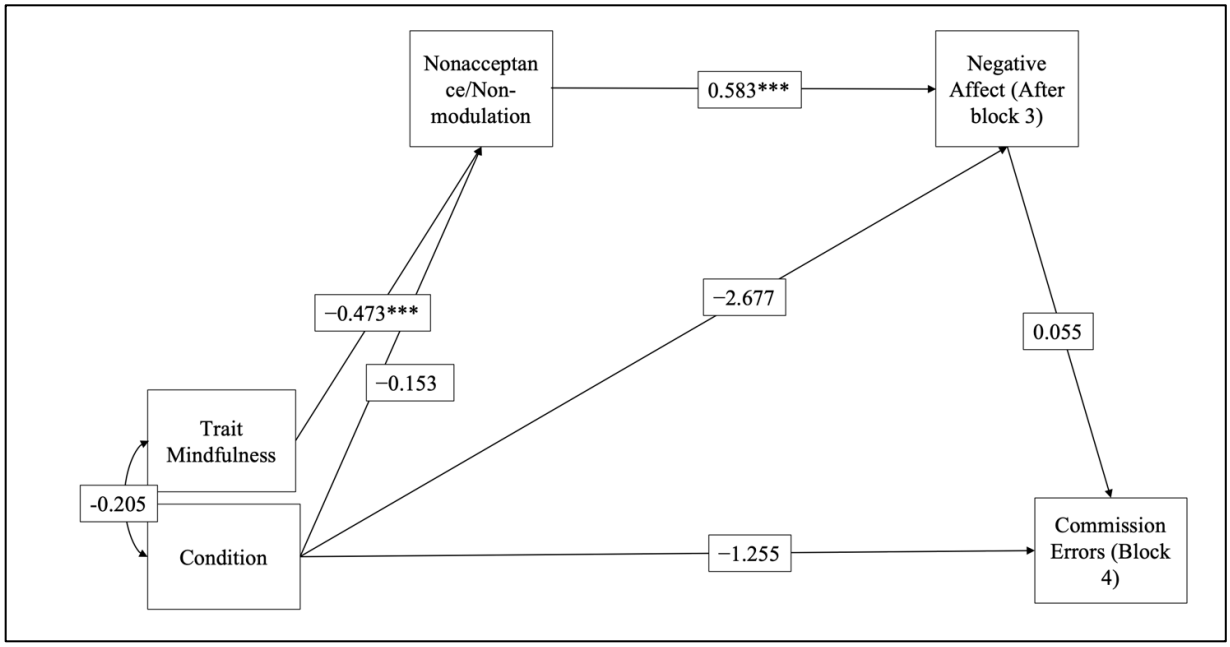
Structural Model Results from Model Two: Negative Affect (After Block Three) and Commission Errors (Block Four)

Path	Estimate	SE	Z	*p*	95% CI	Standardized Estimate
Condition → Nonacceptance/Non-modulation	−0.153	1.354	−0.113	0.91	[−2.806, 2.500]	−0.007
Trait Mindfulness → Nonacceptance/Non-modulation	−0.473	0.058	−8.097	< .001	[−0.588, −0.359]	−0.493
Nonacceptance/Non-modulation → Negative Affect (After block 3)	0.583	0.071	8.231	< .001	[0.444, 0.722]	0.539
Condition → Negative Affect (After block 3)	−2.677	1.38	−1.940	0.052	[−5.383, 0.028]	−0.117
Negative Affect (After block 3)→ Commission errors (Block 4)	0.055	0.031	1.771	0.077	[−0.006, 0.116]	0.135
Condition → Commission errors (Block 4)	−1.255	0.686	−1.829	0.067	[−2.600, 0.090]	−0.134

Note. $N = 191$, SE = robust standard error.

Figure 10.

Path Diagram of Model Two: Negative Affect (After Block Three) and Commission Errors (Block Four)



4.1.2.3. Summary of Findings from Models One and Two (Commission Errors). As condition did not predict state emotional nonacceptance and non-modulation, and negative affect did not predict commission errors, the hypothesis that condition would influence commission errors through the path of state nonacceptance and non-modulation and negative affect was not supported.

4.2. The Effect of Condition on HRT SD

To test the effect of condition on HRT SD, a linear mixed-effects model was estimated, with random intercepts specified for participants. The main effects and interaction of condition and time (four blocks of the CPT) and centered trait mindfulness were entered as predictors. The standard deviation of reaction time for correct hits was entered as the dependent variable. There were no violations of normality based on visual analysis of a Q-Q Plot. There was evidence of

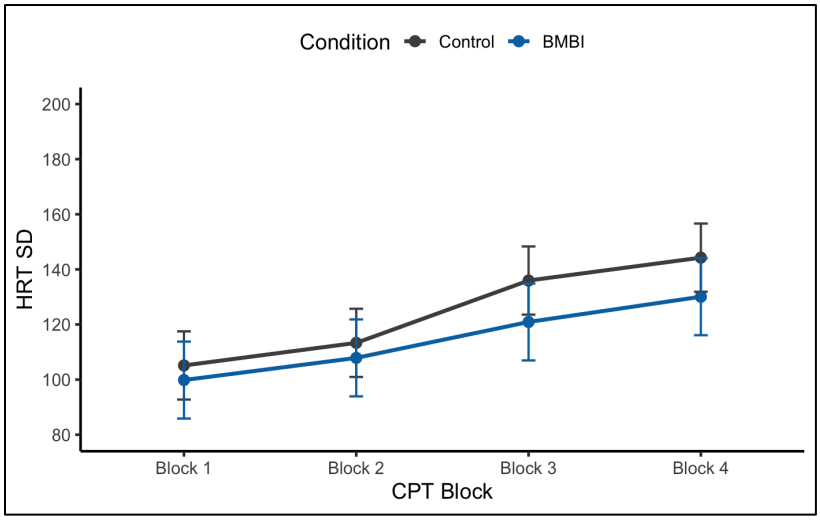
heteroscedasticity based on visual analysis of the fitted v. residual plot, but this was not of concern given the robust estimation methods and large sample size. Outliers were assessed using Cook's Distance with a threshold of > 4/*n* on a participant, rather than on a case-by-case basis. Based on this criterion, nine outliers were detected. However, their removal did not meaningfully change the results, so they were retained.

Controlling for condition and trait mindfulness, there was a significant main effect of time, $F(3, 567) = 31.16$, $p < .001$, $\eta p^2 = .14$, such that HRT SD was higher in block three, $B = 30.82$, $SE = 5.35$, $t = 5.76$, $p < .001$, and block four of the CPT, $B = 39.13$, SE = 5.35, $t(567) = 7.31$, $p < .001$, compared to block one. There was no significant main effect of condition, $F(1, 188) = 1.87$, $p = .173$, $\eta p^2 = .01$, or condition x time interaction, $F(3, 567) = 0.88$, $p = .453$, $\eta p^2 = .00$. Controlling for condition and time, trait mindfulness was not a significant covariate, $F(1, 188) = 2.53$, $p = .113$, $\eta p^2 = .01$.

As there was no significant effect of condition or condition x time interaction on HRT SD, the complete path analysis model was not conducted for this variable.

Figure 11.

Linear Mixed Effects Model of the Effect of Condition and Time on HRT SD.



Discussion

Sustained attention is difficult, aversive, and crucial for everyday life (Warm et al., 2008; Malkovsky et al., 2012; Langner & Eickhoff, 2013). BMBIs have been associated with short-term improvements in sustained attention (Ueberholz & Fiocco, 2022; Morrison et al., 2014; Mrazek et al., 2012). However, there is no clear mechanism of action for how BMBIs support sustained attention. It is important to understand the mechanisms of action to leverage these practices most effectively. Drawing on theories for how trait mindfulness and longer MBIs (e.g., a minimum of eight weeks) influence sustained attention (Iani et al., 2019; Malinowski, 2013), the present study sought to explore whether state emotional modulation and acceptance are a mechanism of action for BMBIs that lead to improvements in negative affect and performance during a sustained attention task.

The Effect of BMBIs on Emotional Nonacceptance and Non-modulation

We first hypothesized that those in the BMBI condition would experience less state emotional nonacceptance and non-modulation compared to the control condition. More specifically, we anticipated that those in the control condition would experience an increase in nonacceptance and non-modulation from baseline to five minutes into the sustained attention task. Five minutes of the task was expected to elicit sufficient negative affect to require effective emotional modulation and acceptance (Langner & Eickhoff, 2013; Scerbo, 1998; Hunter & Eastwood, 2018). As the BMBI was expected to support modulation and acceptance of emotions, it was predicted that the BMBI condition would experience no such increase.

This hypothesis was not supported. By chance, the BMBI condition was trending towards higher state emotional nonacceptance and non-modulation relative to the control condition at

baseline. The BMBI condition experienced a significant decline in state emotional non-modulation and nonacceptance from baseline to five minutes into the sustained attention task, which was not expected. It could be that the BMBI influenced emotional nonacceptance and non-modulation, but differently than hypothesized. Rather than supporting state emotional acceptance and modulation during the CPT, the BMBI helped participants to regulate difficult emotions that they were experiencing before the intervention. However, the BMBI condition having a higher, albeit non-significant, level of baseline state emotional nonacceptance and non-modulation suggests that the decrease could also be a regression to the mean.

This was the first study testing the effect of a BMBI on state emotional nonacceptance and non-modulation during a cognitive task. There are a few possible explanations for the lack of support for this hypothesis. First, it may have been that negative affect was not sufficiently high to observe differences in state emotional non-modulation and nonacceptance. Previous studies have included a stronger induction of negative affect before administering a state emotion regulation measure, such as a stressful cognitive test or distressing visual stimuli (Lavender et al., 2017; Erisman & Roemer, 2010). It was surmised that participants would experience increases in negative affect five minutes into completing a sustained attention task that would necessitate emotion regulation (Scerbo, 1998; Hunter & Eastwood, 2018). However, negative affect was not assessed at the same time as state emotional non-acceptance and non-modulation. It is unknown whether negative affect reached a degree that state emotional nonacceptance and non-modulation would feel effortful and could benefit from a BMBI.

Levels of negative affect were also relatively low throughout the course of the task. The highest mean rating of negative affect was in the control condition at block three and was 13.56, out of a possible highest score of 50. This is lower than other work using a similar task. For

example, average discomfort ratings for within-task sustained attention were 4.31 out of seven in Petranker & Eastwood (2021) and 4.22 out of seven in Bambrah et al. (2019). Ultimately, it may have been that the negative affect induced by the task was not sufficient to elicit differences in state emotional nonacceptance and non-modulation that typically arise at higher levels of negative affect (Lavender et al., 2017; Dixon-Gordon et al., 2015; Barrett et al., 2001).

Second, the intervention may not have been well-suited to see an effect on state emotion regulation. Despite a strong theoretical rationale, no studies to date have provided direct evidence for the effect of single-session BMBIs on state emotion regulation (Erisman & Roemer, 2010; Goodnight, 2016; Arch & Craske, 2006; Watford & Stafford, 2015). As trait emotion regulation reflects a habitual way of responding to one's emotional experience, it may be that a single, 10-minute meditation was not sufficient to influence a different way of responding. Ford & Troy (2019) found that one's skill and experience with an emotion regulation strategy is a determinant of its effectiveness. Guendelman et al. (2017) proposed that those with more mindfulness experience apply mindfulness as an automatic, bottom-up process of emotion regulation. Meanwhile, novices experience mindfulness as a deliberate, top-down process (i.e., an emotion is experienced, and a mindfulness-based strategy is deliberately applied in response). As such, more practice with mindfulness (i.e., longer interventions) may be needed to influence emotion regulation. Counterintuitively, Watford & Stafford (2015) found that those who engaged in a 15-minute mindfulness meditation experienced greater self-reported state emotion dysregulation. They suggested that the introduction of being mindfully open, accepting and aware of negative experiences may be overwhelming for novices, and emotion regulation skills may need to be developed over time. As such, a BMBIs of varying durations should be examined to better understand the trajectory of changes in emotion regulation.

Third, there are few studies which measure or detect changes in S-DERS scores following an intervention or stressor (Lavender et al., 2017; Sicorello et al., 2025; Herzog et al., 2022). Therefore, more research may be needed to understand the sensitivity of the S-DERS for capturing changes following a brief intervention, including BMBIs. Moreover, it could be beneficial to measure state emotional nonacceptance and non-modulation at multiple time points, so that the measure is more proximal to subsequent measures of negative affect. However, there is no known brief measure of state emotional nonacceptance and non-modulation, posing further challenges for multiple administrations during a sustained attention task. Though, there is a validated three-item measure of state distress tolerance (i.e., the ability to tolerate negative affect; Veilleux et al., 2018). State distress tolerance is a different, but related construct to state emotional nonacceptance and non-modulation (Iverson et al., 2012). State distress tolerance describes the ability to endure intense, uncomfortable feelings (Veilleux et al., 2018), while state emotional acceptance and modulation capture the acceptance of emotional experiences and the ability to modulate emotional and behavioural responses to act in line with goals (Gratz & Tull, 2010; Lavender et al., 2017). The three-item distress tolerance measure would be feasible to administer multiple times during a sustained attention task. It could still provide information on how one's relation to negative emotions influences affect and performance during sustained attention.

To address these limitations of the present study, it is recommended to modify the task to elicit greater negative affect, examine a dose-response effect of BMBIs on emotion regulation, or measure state distress tolerance, which may be easier to administer at multiple time points.

The Effect of BMBIs on Negative Affect

We also made predictions about the effect of BMBIs on negative affect independent of state emotional nonacceptance and non-modulation, to ensure our manipulation was in line with previous studies that found reduced negative affect following a BMBI (Schumer et al., 2018). Negative affect was measured pre- and post-manipulation (i.e., BMBI or audiobook), before the administration of the sustained attention task. It was hypothesized that the BMBI condition would experience significantly lower negative affect post-intervention, relative to the control condition. This hypothesis was supported. Both the control and BMBI conditions showed a significant decrease in negative affect immediately after the intervention, but the decrease was much steeper in the BMBI condition.

The findings that BMBIs reduce self-reported negative affect are well-supported in the literature. Reductions in negative affect are suspected to arise because mindfulness can temporarily reduce perceived stress and rumination (Schumer et al., 2018; Broderick, 2005; Creswell et al., 2014), and may have helped individuals in the present sample decenter from any daily stressors they were experiencing. It is also well-known that mindfulness meditation is an exercise to support mental well-being. While participants were not informed that they engaged in a mindfulness meditation, they may have recognized the practice, and expectancy effects may have also contributed to the lower ratings of negative affect. Ultimately, this finding adds to a robust body of literature that BMBIs can be a powerful tool to decrease negative affect in the moment (Schumer et al., 2018).

It was also hypothesized that those in the control condition would experience increasing negative affect, while those in the BMBI condition would experience steady levels of negative affect throughout the sustained attention task. There is strong evidence to suggest that negative affect increases over the course of sustained attention tasks due to the boring nature of the task

(Scerbo, 1998; Hunter & Eastwood, 2018). Moreover, negative affect and sustained attention failures are often correlated (Smallwood et al., 2009). It was believed that the BMBI would help participants regulate negative affect over the course of the task, thus protecting against increases in negative affect that lead to lapses in attention.

However, this hypothesis was not supported. There was no difference in the trajectory of negative affect between the BMBI and control conditions over the course of the sustained attention task. Interestingly, trait mindfulness did not predict the slope of negative affect either. This suggests that mindfulness, generally, may not be protective against the rise in negative affect commonly associated with sustained attention tasks. While the effect was only trending toward significance, those in the BMBI condition had a lower latent intercept of negative affect. In the repeated measures mediation model (see supplemental materials), where negative affect measures at blocks three and four were included, earlier negative affect was a strong predictor of later negative affect. Therefore, BMBIs may influence initial levels of negative affect, and as the task progresses, later negative affect ratings are dependent on earlier negative affect ratings.

While the BMBI was not exactly a mood induction, it has been found that the effects of a mood induction before a sustained attention task decrease over time. Nayda & Takarangi (2025) found that when negative affect was induced before a sustained attention task, negative affect decreased throughout the task, and when positive affect was induced, positive affect decreased. This may have been the case in the present study, such that the effects of the BMBI began to wear off over the course of the sustained attention task.

Trait mindfulness seemed to act in a similar way. Trait mindfulness was a significant predictor of the latent intercept, but not the latent slope of negative affect, such that those higher on trait mindfulness had lower levels of negative affect 10 minutes into the task, when negative

affect was first measured. This is the first study to explore how mindfulness influences the trajectory of negative affect over the course of the sustained attention task, and therefore, further replication is warranted to understand both state and trait effects of mindfulness on negative affect during a sustained attention task.

While not a focus of the present study, lower levels of negative affect have been associated with greater persistence, and brief mindfulness practices have been shown to increase persistence for painful stimuli (Carpenter et al., 2019; Nagy et al., 2023; Arch & Craske, 2006). Given the current evidence that BMBIs could reduce negative affect, there is a rationale for investigating whether BMBIs could help individuals persist with a sustained attention task by making the task more tolerable. This could be of benefit for those who tend to avoid cognitively demanding tasks because of their aversive nature; however, this is speculative, and research is needed to assess the effects of BMBIs on sustained attention persistence.

The Effect of BMBIs on Sustained Attention Task Performance

The findings partially supported the hypothesis that BMBIs could improve performance on a sustained attention task, reflected by fewer commission errors in blocks two and four of the CPT. However, it is important not to overstate the effects of the BMBI on sustained attention performance. While the effect was significant for commission errors, the effect size was small, and differences between conditions were only present in two of the four blocks. Furthermore, in the final mediation model, neither negative affect nor condition associated with commission errors when both were included as predictors. Nonetheless, the findings are consistent with previous studies that have found lower levels of commission errors following a BMBI (Mrazek et al., 2012; Rahl et al., 2017).

Commission errors are a consequence of sustained attention failures, as participants fail to detect the target letter and inhibit a response (Smilek et al., 2010). They have also been associated with failures of attention in daily life (Smilek et al., 2010; Schepers et al., 2023), suggesting that BMBIs could be used to support day-to-day sustained attention. Alternatively, fewer commission errors can reflect a deliberate strategy to reduce errors at the detriment of a quick reaction time, rather than tangible improvements in sustained attention (Seli et al., 2013), known as the speed-accuracy trade-off. An alternative explanation of the findings may be that the BMBI motivated participants to adopt a slower, more deliberate approach to the sustained attention task. Though given that there were no significant differences between conditions on hit reaction time (see supplemental materials), it is more likely that the differences in commission errors arose from fewer attention failures.

There was no significant between-condition effect on HRT SD. Fluctuations in reaction time are said to represent mind-wandering that can contribute to sustained attention failures, and are a more specific measure (Cheyne et al., 2009). The findings related to HRT SD are mixed, with one study reporting lower variability following a BMBI (Mrazek et al., 2012) and others failing to find an effect (Ueberholz & Fiocco., 2022; Banks et al., 2019). Banks et al. (2019) did find that a BMBI was protective against the detrimental effect of negative task-unrelated thoughts on HRT SD. This suggests that BMBIs may only influence HRT SD under very specific conditions that were not captured in the present study.

The Mediating Role of State Emotional Nonacceptance, Non-modulation and Negative Affect on Performance

Finally, the proposed model that BMBIs would reduce state emotional nonacceptance and non-modulation, which would lead to lower levels of negative affect and better performance on

the sustained attention task, was not supported. First, because there was no significant effect of condition on state emotional nonacceptance and non-modulation. A second way that the findings fail to provide support for the model was that neither negative affect nor condition predicted performance when both were included as predictors. In the present study, performance on the CPT was quite good relative to similar tests in previous studies (see Welhaf & Banks, 2025 for a review). Across blocks and conditions, accuracy ranged from 59-68% for target (i.e., no-go) trials. Again, it may have been that negative affect was not sufficiently high as to interfere with performance, or that the demands of the task were not sufficient for negative affect to interfere. In other words, participants could still maintain their performance on the task while experiencing a mild degree of negative affect. Moreover, the model that was tested included both condition and negative affect as predictors of sustained attention performance. This likely made it more difficult to detect an effect due to competition for variance (Bainter et al., 2020). As negative affect and failures of sustained attention are commonly associated (Malkovsky et al., 2012), it is most likely that the conditions of the experiment made it more difficult to detect an effect.

One surprising finding was that the BMBI condition and trait mindfulness both influenced negative affect but through distinct pathways. Trait mindfulness predicted lower state emotional nonacceptance and non-modulation five minutes into the sustained attention task, which in turn predicted lower negative affect 10 and 15 minutes into the sustained attention task. As trait mindfulness captures a dispositional, adaptive way of regulating emotions, it tends to be associated with less emotional nonacceptance and non-modulation, which is associated with lower levels of negative affect (Lavender et al., 2017; Daros et al., 2020). State emotional nonacceptance and non-modulation mediated the relationship between trait mindfulness and negative affect during the sustained attention task. This is in line with previous studies that

suggest that trait mindfulness improves sustained attention through greater emotion regulation (Petranker & Eastwood, 2021).

Meanwhile, the BMBI condition directly predicted lower levels of negative affect 10 minutes into the sustained attention task, which, in the full repeated measures mediation model, predicted negative affect 15 minutes into the sustained attention task. Condition assignment did not predict differences in negative affect through state emotional nonacceptance and non-modulation as expected. Because of the previously mentioned limitations, it is hard to know if condition assignment would have predicted state emotional nonacceptance or non-modulation under different conditions, or if BMBIs simply exert their effects on negative affect more directly. Nonetheless, these findings indicate that trait mindfulness and BMBIs both improve the experience of completing a sustained attention task.

Limitations and Future Directions

First, it was difficult to interpret findings related to state emotional nonacceptance and non-modulation, with the BMBI condition trending toward higher state emotional nonacceptance and non-modulation at baseline. Second, the BMBI may not have been sufficient to elicit changes in state emotional nonacceptance and non-modulation. Manipulating the length of brief mindfulness training may help to elucidate the point at which changes in state emotion regulation emerge.

Third, the demands of the sustained attention task may not have been sufficient to observe a strong relationship between negative affect and performance. As such, it is recommended that the study be replicated with a more demanding attention test. For example, dual task paradigms that divide attention are considered more demanding and resource-intensive (Matthews & Davies, 2001). Alternatively, Wagner & Eastwood (2025) found that a sustained

attention task with a longer ISI (6000 ms) was perceived as more cognitively burdensome. Under these conditions, negative affect, even at milder levels, may interfere with task performance to a greater extent than in the present study. Alternatively, these tasks may elicit higher levels of negative affect that could better test the proposed model.

Finally, a future direction is to explore the effect of BMBIs on the persistence with cognitively demanding tasks. As the findings of the present study suggest that BMBIs may improve the experience of engaging sustained attention by reducing negative affect, future research may find that they support the willingness to engage sustained attention for longer periods. Persistence could be tested by allowing participants the option to stop doing the sustained attention task at any time, or by providing the option to do an additional sustained attention task. Persistence on tasks is associated with a wide range of positive functional outcomes, while avoidance of cognitively demanding tasks is associated with lower achievement and poorer mental health outcomes (Orhan et al., 2023; Patzelt et al., 2019). With future research in this area, BMBIs may be a possible intervention for those with difficulties persisting with tasks that require sustained attention.

Conclusion

BMBIs have been found to improve sustained attention, and the present study aimed to understand how BMBIs influence sustained attention by exploring state difficulties with emotion regulation (modulation and acceptance) and negative affect as mechanisms of action. Findings suggest BMBIs may improve the experience of performing a sustained attention task by reducing negative affect early in the task. In line with previous studies, the BMBI was associated with fewer commission errors, but not lower HRT SD. The effect sizes for commission errors were also small, and disappeared when negative affect and condition were both included as predictors.

A clearer relationship between BMBIs and performance, mediated by negative affect, may emerge with a more demanding attention task. Moreover, there was no effect of condition on state emotional nonacceptance and non-modulation. It may have been that the demands of the task were not sufficient to require effortful emotion regulation or that the BMBI was not powerful enough to elicit changes in state emotion regulation. Overall, BMBIs may offer a way to improve the experience of cognitively demanding tasks, like sustained attention, by reducing negative affect associated with these tasks. However, the mechanism of action remains unclear and future research is needed to continue developing this model.

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Appendix A: FFMQ

5 facet questionnaire: short form (ffmq-sf)

Below is a collection of statements about your everyday experience. Using the 1–5 scale below, please indicate, in the box to the right of each statement, how frequently or infrequently you have had each experience in the last month (or other agreed time period). Please answer according to what really reflects your experience rather than what you think your experience should be.

never or very rarely true	***not often true***	***sometimes true sometimes not true***	***often true***	***very often or always true***
1	***2***	***3***	***4***	***5***

1	I'm good at finding the words to describe my feelings	*DS*	
2	I can easily put my beliefs, opinions, and expectations into words	*DS*	
3	I watch my feelings without getting carried away by them	*NR*	
4	I tell myself that I shouldn't be feeling the way I'm feeling	*/NJ*	
5	it's hard for me to find the words to describe what I'm thinking	*/DS*	
6	I pay attention to physical experiences, such as the wind in my hair or sun on my face	*OB*	
7	I make judgments about whether my thoughts are good or bad.	*/NJ*	
8	I find it difficult to stay focused on what's happening in the present moment	*/AA*	
9	when I have distressing thoughts or images, I don't let myself be carried away by them	*NR*	
10	generally, I pay attention to sounds, such as clocks ticking, birds chirping, or cars passing	*OB*	
11	when I feel something in my body, it's hard for me to find the right words to describe it	*/DS*	
12	it seems I am "running on automatic" without much awareness of what I'm doing	*/AA*	
13	when I have distressing thoughts or images, I feel calm soon after	*NR*	
14	I tell myself I shouldn't be thinking the way I'm thinking	*/NJ*	
15	I notice the smells and aromas of things	*OB*	
16	even when I'm feeling terribly upset, I can find a way to put it into words	*DS*	
17	I rush through activities without being really attentive to them	*/AA*	
18	usually when I have distressing thoughts or images I can just notice them without reacting	*NR*	

PTO.

never or very rarely true 1	***not often true 2***	***sometimes true sometimes not true 3***	***often true 4***	***very often or always true 5***

19	I think some of my emotions are bad or inappropriate and I shouldn't feel them	*/NJ*	
20	I notice visual elements in art or nature, such as colors, shapes, textures, or patterns of light and shadow	*OB*	
21	when I have distressing thoughts or images, I just notice them and let them go	*NR*	
22	I do jobs or tasks automatically without being aware of what I'm doing	*/AA*	
23	I find myself doing things without paying attention	*/AA*	
24	I disapprove of myself when I have illogical ideas	*/NJ*	

correct scores for items preceded by a slash (/NJ, /AA, etc) by subtracting from 6

non react = ; observe = ; act aware = ; describe = ; non judge =

In the research study where the short form of the FFMQ was developed (see Bohlmeijer et al. below), most of the 376 participants were educated women with "clinically relevant symptoms of depression and anxiety". They were randomized to a nine week clinical intervention involving an *Acceptance & Commitment Therapy (ACT)* self-help book *"Living life to the full"*, plus 10 to 15 minutes per day of *Mindfulness-Based Stress Reduction* meditation exercises, plus some email support. Mean (and Standard Deviation) scores pre- and post- intervention were:

	non react	***observe***	***act aware***	***describe***	***non judge***
pre- mean (sd)	*13.47 (3.07)*	*13.86 (3.21)*	*13.19 (3.32)*	*16.28 (3.91)*	*14.09 (3.63)*
~70%	*10.4–16.5*	*10.6–17.0*	*9.9–16.6*	*12.4–20.2*	*10.5–17.7*
~95%	*7.3–19.6*	*7.4–20.3*	*6.5–19.8*	*8.5–24.1*	*6.8–21.3*
post- intervention	*16.90*	*15.22*	*15.98*	*18.46*	*18.14*

Bohlmeijer, E., P. M. ten Klooster, et al. (2011). *"Psychometric properties of the five facet mindfulness questionnaire in depressed adults and development of a short form."* Assessment 18(3): 308-320. In recent years, there has been a growing interest in therapies that include the learning of mindfulness skills. The 39-item Five Facet Mindfulness Questionnaire (FFMQ) has been developed as a reliable and valid comprehensive instrument for assessing different aspects of mindfulness in community and student samples. In this study, the psychometric properties of the Dutch FFMQ were assessed in a sample of 376 adults with clinically relevant symptoms of depression and anxiety. Construct validity was examined with confirmatory factor analyses and by relating the FFMQ to measures of psychological symptoms, well-being, experiential avoidance, and the personality factors neuroticism and openness to experience. In addition, a 24-item short form of the FFMQ (FFMQ-SF) was developed and assessed in the same sample and cross-validated in an independent sample of patients with fibromyalgia. Confirmatory factor analyses showed acceptable model fit for a correlated five-factor structure of the FFMQ and good model fit for the structure of the FFMQ-SF. The replicability of the five-factor structure of the FFMQ-SF was confirmed in the fibromyalgia sample. Both instruments proved highly sensitive to change. It is concluded that both the FFMQ and the FFMQ-SF are reliable and valid instruments for use in adults with clinically relevant symptoms of depression and anxiety.

Appendix B: S-DERS

PsycTESTS®

doi: http://dx.doi.org/10.1037/t60317-000

State Difficulties in Emotion Regulation Scale
S-DERS

Items

Factor 1: Nonacceptance of Current Emotions (NONACCEPTANCE)

1. I feel ashamed with myself for feeling this way.
2. I am embarrassed for feeling this way.
3. I feel guilty for feeling this way.
4. I am feeling very bad about myself.
5. I am angry with myself for feeling this way.
6. I feel like I'm a weak person for feeling this way.
7. I am irritated with myself for feeling this way.

Factor 2: Limited Ability to Modulate Current Emotional and Behavioral Responses (MODULATE)

8. I am having difficulty controlling my behaviors.
9. My emotions feel out of control.
10. I believe that I will continue feeling this way for a long time.
11. I feel out of control.
12. I believe that I am going to end up feeling very depressed.
13. My emotions feel overwhelming.
14. I am having difficulty doing the things I need to do right now.

Factor 3: Lack of Awareness of Current Emotions (AWARENESS)

15. I am acknowledging my emotions. (r)
16. I care about what I am feeling. (r)
17. I am paying attention to how I feel. (r)
18. I believe that my feelings are valid and important. (r)
19. I am taking time to figure out what I am really feeling. (r)

Factor 4: Lack of Clarity About Current Emotions (CLARITY)

20. I am confused about how I feel.
21. I have no idea how I am feeling.

Note. For each S-DERS item, participants were asked to read the statement and "indicate how much it applies to your emotions right now," with response options ranging from 1 (not at all) to 5 (completely).

PsycTESTS™ is a database of the American Psychological Association

Appendix C: BMBI Script

10-minute mindfulness meditation script:

"Welcome to this body scan meditation. This will be a brief, 10-minute practice, allowing you to take some time to relax and attend to sensations in the body…

I invite you to find a seating position that enables wakefulness, with your feet on the floor and sit bones planted in your chair or on the ground, depending where choose to do this practice. Allowing the upper body to be straight, but relaxed. Now slowly beginning to close your eyes, or if you do not wish to close your eyes, allowing the eyelids to soften, the gaze unfocused… And at any point during this practice, if you feel discomfort to the point of interfering with your well-being you may stop and take some time to check in with yourself and how you are feeling…

Now bringing your attention to the fact that you are breathing…Not trying to control the breath in any way… allowing the breath to naturally flow in and out of the body… experiencing it as the air moves in and out… noticing how belly moves up and down with every in breath and outbreath. If your mind begins to wander during this practice, as it may, simply noting where your attention has been drawn to and without judgment, gently escorting your attention back to the breath.

Take a deep breath and bring your attention to your feet… becoming aware of whatever sensations are here… bringing a gentle curiosity…noticing sensations of temperature, and pressure… and if you are registering a blank, then simply attend to the experience of no sensations…. Scanning the toes, from the big toes to the little toes…. maybe sensing the gaps between the toes… scanning the bottoms of the feet. Noticing sensations here…. Scanning the feet as a whole.
Shifting your attention to the ankles on the next inbreath… and for a moment, resting your attention here, noting any sensations that may be present… And on the next inhale shifting your attention to the lower leg, including the calf and the shin of the left and right leg … Allowing there to be a gentle curiosity to the sensations that are present here…. Perhaps noticing sensations of pressure as the calf rests on the floor or against the chair…attending to the surface of the skin, bringing awareness to sensations that are here…. sensations of pressure, temperature, tingling.

And on the next inbreath, shifting attention from the lower leg to the left and right knee …. and noting any sensations that are present for you in this moment…. If you notice sensations that are unpleasant, seeing if you can create space for that discomfort… becoming curious about the sensation…. allowing the breath to release any tension… And if ever the sensation becomes too overbearing, knowing that you can then shift your attention back to the breath at the belly, to help anchor you to the present moment once again… and then when you are ready, moving back to the body scan…
And now shifting attention on the next breath from the knee to the upper leg…. The left and right thigh… noticing sensations of contact against the surface of the chair or bed… bringing your attention to the top of the thighs and the sensations that may be present here…. and now on the next inbreath, expanding your attention to include the both legs as a whole… from the top of the thighs all the way down to the toes…. Reminding you that if your mind begins to wander, you may gently guide your focus back to the breath and the sensations in the body, without judgement…

Now see if you can notice your pelvis, directing your breath into this area of the body… Taking a breath here… Inhale… Exhale… Now directing your attention to the abdomen wall as it rises on the inbreath and then deflates back towards the spine on the outbreath…. See if you can soften your stomach, allowing you to breathe more deeply.

Now think of your lower back…. Bringing a gentle curiosity to any sensations that may be present here…… again this is an area of the body that can experience difficult sensations. If this is the case, simply using the breath to ease the discomfort, or choosing, to shift focus to belly breathing for a moment and then when you feel like it, returning to the body scan… bringing an attitude of compassion and acceptance to what is.

And now on the inbreath, moving attention to the middle and upper back…. Noting any sensations that are present here….. moving attention along the spine… Taking a deep inhale, and slowly releasing. Congratulating yourself for making it halfway through this practice…
Now allowing your attention to follow the rib cage to the front of the body….. the expansion and contraction of the rib cage with every inbreath and outbreath…. And then allowing attention to go beyond the rib cage, perhaps noticing sensations of pulsation, heaviness… or nothing at all…. Just bringing a sense of curiosity… A sense of gratitude… Noticing the slight movement of the chest as it rises and falls with every inbreath and outbreath….
moving the focus of attention to the shoulders… shifting focus down to the upper arm… now moving focus of attention down to the lower arm, to the wrists…. Noticing any sensations here…sensations of weight… perhaps pulsation…. Or nothing at all…… and now shifting attention to the hands… sensing the palms of the hands, each finger and thumb… The back of the hands…. Noticing the placement of the hands….. and expanding attention to include the arms as a whole, from fingertips to shoulders…… scanning the entirely of the arms and noting any sensations that are present…. If your mind wanders, gently bring it back to the sensations in the hands…

And now, I invite you to focus your attention on your neck and throat, and feel this part of your body… perhaps when you swallow and when you breathe… just letting it go and shifting your attention to the ears … moving attention to the face…. across the jaw line, the chin, just experiencing them as they are….. the lips, the mouth….bringing attention to the teeth, the gums, the tongue…noticing placement of tongue as we breath….simply experiencing them as they are….

Bringing attention to the cheeks of the face, the nose…. Focusing attention on the nostrils…. Sensing cool air entering the nostrils and warm air leaving the nostrils… attending the ridge of the nose…. The eyes, the eye balls in their eye sockets…. Delicate eye lids…. The brow…… noticing any sensations along the brow…and then moving attention to the forehead and noticing any sensations here…. Breathing in and letting the face dissolve into stillness….. and now bringing attention to the head, scanning the scalp as it meets the forehead and moving back, behind the ears… bringing awareness to any sensations that may be present here. ….
Now, on the next outbreath, expanding your attention to the body as a whole, from the top of the head, all the way down to the toes…. experiencing your entire body breathing…..allowing yourself to feel whole….

Now as this practice comes to an end, I invite you to take three deep breaths… Slowly opening the eyes…congratulating yourself for taking this time for self-care, to bring a little more awareness to sensations of the body, and the mind. remember to be kind to your body as you shift from this practice to the attention task.

Appendix D: Consent Form
Informed Consent Form - URPP

Study Name: The Effects of Relaxation on the Experience of Effort and Cognitive Performance

Researchers: Dr. John Eastwood
Associate Professor
Principal Investigator
118 Behavioural Science Building- BSB
Keele Campus
johneast@yorku.ca

You are being asked to participate in a research study. You must be 16 years of age or older to participate. Please take your time to review this information and ensure you understand what is being asked of you and that you agree to participate before continuing.

Purpose of the Research:
The aim of the present research is to explore how relaxation influences the experience of mental effort and performance on an attention test.

What You Will Be Asked to Do in the Research:
This research study will take place on Zoom with a researcher. You will be required to keep your camera on over the course of the experiment. After reading this consent form, you will be asked to provide basic demographic information (such as age and self-identified gender) that will be used solely to ensure that we have collected a diverse sample of people. You will also complete some questionnaires about your day-to-day mood states and concentration.

You will be asked to complete some practice trials of a sustained attention task. To run the task, you will be asked to click a link which will download a program. After you have completed the study, you will be given instructions on how to remove the program from your computer. In the task, you will be asked to press a key on your keyboard every time you see particular letters presented on your computer screen. You will be asked to respond only to certain letters and to withhold responses for others.

You will be given a ten-minute relaxation exercise presented over your computer speakers or headphones. Then, you will answer some more questions about how you are feeling. Next, you will complete the full sustained attention task you practiced earlier. At different points during the task, you will be asked a few questions about how it felt to do the task and your current mood. After answering those questions, you will return to the task.

Once the task is finished, you'll be asked to complete some questionnaires about your experience. The study will take approximately 1.5 hours to complete. You will be granted 1.5 URPP credits for your participation.

Risks and Discomforts: We do not foresee any discomfort from your participation in the research. It is possible that you may feel upset after reflecting on your feelings; however, this likelihood is no greater than would be expected in everyday life when you think about your feelings. We have deliberately designed the questions to be minimally invasive and only ask about common feelings. You may also feel fatigued when completing the attention test. This is also normal and will be like everyday experiences where you are asked to focus your attention for a period of time. We have attempted to mitigate any risks related to data security

by choosing electronic tools (i.e., Qualtrics, QuestionPro, and Inquisit) that employ state-of-the-art security and confidentiality policies. More details regarding these security and privacy measures and their limits are provided below in the section on confidentiality.

If completing any of the materials has raised difficult personal issues that you find distressing, please consider contacting a mental health professional in your area. If you are in serious emotional distress, then you can call Canada Suicide Prevention Service (1-833-456-4566) or the suicide crisis hotline by dialing 9-8-8. If you are not in serious emotional distress, here are some resources for mental health support:

1. Student Counseling, Health and Well-being. https://students.yorku.ca/counselling
2. Good2Talk. https://good2talk.ca/
3. Government of Canada. https://www.canada.ca/en/public-health/services/mental-health-services/mental-health-get-help.html

Benefits of the Research and Benefits to You:
There will be no direct benefit to you for participating in this study. However, there may be indirect benefits, including (1) an appreciation of the nature of research on human experiences and behaviour; and (2) an opportunity to contribute to scientific research that may have useful practical results. The results from your participation, combined with the results from the other participants, will further our understanding of the effects of emotion regulation on attention, mood and perceived effort.

Voluntary Participation and Withdrawal:
Your participation in the study is completely voluntary, and you may choose to stop participating up until data collection for this study is complete. Your decision not to volunteer, to stop participating, or to refuse to answer particular questions will not influence your grade in your class, status as a participant in the URPP, nor result in a penalty or loss of benefits you would receive otherwise, nor the nature of your relationship with York University either now, or in the future. If you stop participating, you will still be eligible to receive the 1.5 credits for agreeing to be in the project, even if you withdraw without completion of the research. If you stop participating in the study partway through, it will be assumed that you withdrew consent and all associated data collected will be immediately destroyed wherever possible.

Confidentiality:
All information you supply during the research will be held in confidence and unless you specifically indicate your consent, your name will not appear in any report or publication of the research. No identifying information will be collected during this study.

During data collection and analysis, your anonymized data will be safely stored on a secure, password-protected server, and only research team members will have access to this information through their user IDs and passwords.

The data collected in this research project may be used in an anonymous 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 REB. 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.

At the end of the study, anonymized data may be deposited into one or more publicly accessible scientific repositories, such as York University Dataverse, an institutional research data repository, managed by York University Libraries and provided by Scholars Portal on behalf of the Ontario Council of University

Libraries (OCUL), through which researchers from around the world will have access to these data for future research, through a CC standard data sharing license. York University Dataverse does NOT accept content that contains confidential or sensitive information. Dataverse can be used to share de-identified and non-confidential data only. Contributors are required to remove, replace, or redact such information from datasets prior to upload. Scholars Portal makes backup copies of the uploaded data regularly in the event of a server or system malfunction, malicious attack, or other technical issues.

This study will use Qualtrics or QuestionPro and Inquisit to collect data, which are externally hosted cloud-based service. Study questionnaires, and this consent form, are administered using Qualtrics or QuestionPro, which are secure data collection companies that store information in Canada. Qualtrics and QuestionPro involve high-end firewall systems, regular security scans, and encryption for all transmitted data. This study will also use a PHIPA compliant Zoom account for remote testing. When information is transmitted over the internet privacy cannot be guaranteed. There is always a risk your responses may be intercepted by a third party (e.g., government agencies, hackers). Further, while York University researchers will not collect or use IP addresses or other information which could link your participation to your computer or electronic devices without informing you, there is a small risk with any platform such as this of data that is collected on external servers falling outside the control of the research team. *Thus, the confidentiality and privacy of data cannot be guaranteed during web-based transmission.*

Qualtrics' privacy policy can be found here: https://www.qualtrics.com/privacy-statement/

QuestionPro's privacy policy can be found here: https://www.questionpro.com/help/security.html

Inquisit's privacy policy can be found here: https://www.millisecond.com/products/privacystatement/

Zoom's privacy policy can be found here: https://explore.zoom.us/en/privacy/

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 by e-mail (johneast@yorku.ca). 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 Director, Research Ethics in the Office of Research Ethics, Kaneff
Tower, York University (e-mail ore@yorku.ca).

Legal Rights and Signatures:
If you are 16 years of age or older and consent to participate in this study conducted by Dr. John Eastwood, please click the "Yes" button below. Doing so indicates you have understood the nature of this project and wish to participate. Otherwise, please click the "No" button. You are not waiving any of your legal rights by consenting to participate. Your participation in the study is completely voluntary and you may choose to stop participating up until the study is complete and the data has been analyzed.

Appendix E: Deviations from Pre-registered Analysis

Pre-registered Analysis	Analysis Conducted
We we will control for trait mindfulness and experience with meditation, which may influence our dependent variables, by including them as covariates. Any significant between-group differences in demographic outcomes (e.g., age, sex) will also be included as covariates.	We controlled for trait mindfulness, but not experience with meditation.
Analysis 1: A 2 (mindfulness v. audiobook) x 2 (pre-intervention, post-intervention) ANCOVA will be employed to investigate between-group differences in changes in ER (modulate and acceptance) from baseline to post-intervention and five minutes of the CPT.	No deviations.
Analysis 2: A 2 (mindfulness v. audiobook) x 2 (pre-intervention, post-intervention) ANCOVA will be employed to investigate between group differences in changes in negative affect (i.e., distress) following listening to an audiobook (control) or a mindfulness recording (intervention).	No deviations.
Analysis 3: To compare whether the linear slope of negative affect (i.e., distress) over the course of the CPT changes as a function of condition assignment, the slope of the three SDQ measurements throughout the CPT will be calculated. Then, one-sample t-tests for both conditions will be conducted to observe if the slope differs from 0. Lastly, the slopes of both conditions will be compared using a between-subjects t-test.	We conducted a linear growth curve model, which is a more sophisticated version of the proposed analysis and allowed us to control for covariates.
Analysis 4: A serial mediation model will be employed to observe the effect of condition and the mediating effect of emotion regulation (i.e., modulation and nonacceptance subscales) on the path of negative affect (i.e., distress) during the CPT and CPT performance (i.e., omission errors or HRT SD) at blocks two and three of the CPT. This will also allow us to understand how emotion regulation influences distress at each time point during the CPT and how participants' distress mediates their performance on each subsequent CPT block. Two models will be computed, the first with commission errors and the second with HRT SD as the dependent variable. See Image below for mediation model.	We conducted two separate mediation models. The strong auto-regressive effects from including the same measure administered at two time points accounted for a significant portion of the variance. As we were not interested in the stability of our measurements over time, we divided the model into two. Model one included negative affect (after block 2) and CPT performance (at block 3). Model two included negative affect (after block 3) and CPT performance (at block 4).