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Influence of a Brief Online Mindfulness Intervention on Metacognition, Cognition, and Emotional Outcomes Among University Students: A Randomized Longitudinal Trial

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Abstract

Mindfulness-based interventions (MBIs) have been previously linked with improved cognition and reduced stress, anxiety, and depression. Yet, traditional MBIs are lengthy and resource intensive. Brief and online MBIs represent a bridge into more extensive practice—but questions of whether these protocols improve cognition and affect remain. The present experiment used a randomized longitudinal design to assess the effects of a 31-day, 15 min daily mindfulness program compared to a podcast control on a battery of cognitive and self-report measures in a sample of university students. Results indicated that, over the course of the study, the MBI group found their intervention less challenging, more enjoyable, more relaxing, more engaging, and more useful compared to the podcast control group. MBI participants also increased in state and dispositional mindfulness and state metacognition following the intervention relative to the Podcast group. However, both groups scored comparably on all cognitive and affective post-intervention measures, with equivalence testing suggesting that the observed effect sizes in the present study were significantly smaller than in some previously reported effects. Taken together, the results suggest that while brief online MBIs can elicit near transfer to proximal domains (e.g., mindfulness, metacognition), more work is needed to make strong claims that these MBIs elicit far transfer to cognitive and affective domains.

Keywords: mindfulness; metacognition; cognition; affect; transfer

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1. Introduction

Mindfulness-based interventions (MBIs) have become increasingly popular for their potential to enhance cognitive function and emotional well-being—core aims of the broader positive psychology movement. However, traditional MBIs pose practical challenges due to their time, financial, and logistical demands. Brief and scalable alternatives—particularly those delivered online—have recently drawn considerable interest. Yet, despite promising early findings, it remains unclear whether such interventions produce broad psychological benefits or whether their effects are limited to specific, closely related outcomes. In this study, we applied a near- vs. far-transfer framework to evaluate the scope of a standardized 31-day online MBI. Using this framework, we investigated which domains of functioning are most responsive to brief, guided mindfulness training in university students.

1.1. Cognitive and Affective Benefits of Mindfulness

Since its transplantation from ancient traditions to Western contexts, mindfulness has been investigated across myriad empirical studies and linked with numerous benefits. These benefits have been observed in both non-clinical (e.g., Khoury et al., 2015) and clinical (e.g., Goldberg et al., 2018) populations. For example, mindfulness is linked with enhanced cognition, including attention and executive inhibition (e.g., Jha et al., 2007), long-term memory (e.g., Brown et al., 2016), and working memory (e.g., Jha et al., 2010). It has also been associated with improved affective function, including decreased stress (e.g., Creswell & Lindsay, 2014), anxiety, and depression (e.g., Hofmann et al., 2010).

The emotional benefits of mindfulness have also been widely reported. Mindfulness has been associated with improved emotional regulation and greater emotional intelligence (e.g., Miao et al., 2018), with the relationship between mindfulness and subjective well-being ostensibly mediated by emotional regulation (Schutte & Malouff, 2011). Mindfulness can help decrease negative affect and increase positive affect (e.g., Schumer et al., 2018), buffering against stress and thereby enhancing well-being (Creswell & Lindsay, 2014). Johnson et al. (2021) suggest mindfulness may disrupt downward spirals of negative emotions. It may also promote an upward spiral of positive emotions by developing positive emotional resources. Together, these findings position mindfulness as a key practice within both clinical interventions and the positive psychology movement, contributing not only to symptom reduction but to the cultivation of biopsychosocial well-being and human flourishing.

1.2. Near-to-Far Transfer of Mindfulness to Cognition and Affect

The myriad cognitive and affective benefits associated with MBIs can be considered under a near- versus far-transfer theoretical framework (e.g., see Sala et al., 2019). Understanding the extent to which experience in one domain transfers to another domain is a fundamental issue in psychology, with roots that extend back over a century (e.g., the common elements theory of Thorndike & Woodworth, 1901). Based on this perspective, the extent to which one domain yields transfer benefits to a secondary domain depends on the featural overlap (either perceptual or conceptual) between the two. If two domains overlap considerably in features (referred to as "near transfer"), the likelihood of observing transfer between the two domains increases. In contrast, if two domains share relatively few features (referred to as "far transfer"), the likelihood of observing transfer between the two domains decreases. This framework not only makes intuitive sense (e.g., expecting that music training will benefit auditory pitch processing more than verbal reasoning), but it is also supported by extensive work (e.g., see Gobet & Sala, 2022).

In the context of MBIs, conceptualizing the domains that would constitute near versus far transfer depends in part on the specific features of the mindfulness protocol. Nevertheless, given that mindfulness has been considered a fundamentally metacognitive exercise (e.g., Solem et al., 2015), it is reasonable to treat the constructs of both mindfulness and metacognition in a near-transfer framework. In contrast, the actual application of cognitive constructs (e.g., working memory) is not as transparently engaged in the context of most MBIs, and thus, cognitive performance measures could be considered in a near-, medium-, or far-transfer framework, depending on the construct being measured. Similarly, although MBIs might provide individuals with strategies for managing stress, anxiety, and depression, interventions that require individuals to focus attention on one's own breath are not directly aligned with these affective states, and thus these could also be considered in a far-transfer framework. Thus, the present study uses a variety of outcome measures, ranging along a near- to far-transfer continuum, to better assess the benefits of MBIs to cognitive and affective domains.

1.3. Conceptualizing Mindfulness

Generally, mindfulness involves two fundamental aspects: (1) enhanced self-regulated attention and observant awareness of present moment experience, both internal and external (e.g., thoughts, emotions, behaviours and contexts), and (2) open, curious, nonjudgmental and nonreactive acceptance (and release) of those experiences. Mindfulness has also been described as "the awareness that arises by paying attention on purpose, in the present moment, and non-judgmentally" (Kabat-Zinn, 2013, p. xxxv). The mindful individual is "oriented in the present, open to novelty, sensitive to changes in context, and aware of multiple perspectives" (Gallant, 2016, p. 117). They can regulate their emotions through enhanced emotional acceptance, nonjudgment, and nonreactivity. Through mindfulness, individuals tend to mentally decenter from runaway thoughts and emotions and refocus on present awareness. Mindfulness skills are frequently cultivated through regular mindfulness meditation (or other) practice.

Mindfulness represents a multifaceted construct commonly conceptualized in two related ways: (1) as a dispositional (i.e., trait-level) tendency to approach experiences with mindful thinking (e.g., nonjudgmental awareness) and behavioural styles (i.e., dispositional mindfulness) and (2) as a skill that can be learned, practiced, and developed over time (i.e., mindfulness practice). Dispositional mindfulness reflects a "basic human quality" involving a general tendency to attend to and accept present moment experience observantly, nonjudgmentally, and nonreactively (Baer et al., 2006). It thus relates to a certain context-independent style of relating to one's experiences and mental states. State mindfulness, by contrast, refers to moment-to-moment (i.e., state-level) mindfulness during a particular epoch, task, or event (Tanay & Bernstein, 2013). Notably, regular state-level mindfulness practice (e.g., mindfulness meditation) predicts trait-level changes in dispositional mindfulness (Kiken et al., 2015).

Mindfulness and Metacognition

Mindfulness is also associated with several individual difference characteristics including metacognition and Big Five personality factors (e.g., Haliwa et al., 2021). Mindfulness is a fundamentally metacognitive exercise that involves knowledge about thinking (i.e., cognitions about cognitions) and strategies to regulate and control thinking; thus, there is considerable overlap between the two constructs (Solem et al., 2015). Moreover, many mindfulness models explicitly involve or reference metacognition (e.g., Isbel & Summers, 2017). Jankowski and Holas (2014) situate mindfulness and metacognition within the same theoretical space, suggesting that mindfulness reflects a non-conceptual, present-moment awareness that constitutes a form of metacognitive insight. Given this conceptual overlap, metacognition represents a potentially responsive outcome to brief mindfulness training. Indeed, mindfulness training has been linked with enhanced meta-awareness (Baird et al., 2014). Unlike cognitive performance or affective states, metacognitive insight can thus emerge through early shifts in self-observation and introspective awareness, making it an excellent candidate for near-transfer effects following short-term MBIs.

1.4. Theoretical Framework: Monitor and Acceptance Theory

Monitor and Acceptance Theory (MAT) is an influential model of mindfulness that offers a process-based explanation of how mindfulness training leads to psychological outcomes (Lindsay & Creswell, 2017). MAT proposes that mindfulness consists of two interrelated components: monitoring (i.e., sustained attention to present-moment experience) and acceptance (i.e., a nonjudgmental and nonreactive stance/attitude towards those experiences). In this framework, monitoring enhances awareness, while acceptance buffers reactivity and fosters nonjudgment—allowing for the processing of internal (cognitive and

affective) states without becoming entangled in them. Crucially, MAT posits that these components exert different effects: monitoring enhances awareness (and possibly metacognitive insight), while acceptance is essential for improvements in affective well-being (Lindsay et al., 2018a).

Since its proposal in 2017, MAT has undergone increasing empirical scrutiny. A series of dismantling studies by Lindsay et al. (2018a, 2018b) found that while monitoring training alone increased present-moment awareness, only the inclusion of acceptance training led to reductions in stress, loneliness, and increases in positive affect (see also Lindsay et al., 2019)—supporting MAT's claim that the two components exert distinct effects. A synthesis by Lindsay and Creswell (2019) reinforced these distinctions, highlighting growing support for acceptance as a critical emotion regulation pathway. However, recent work (Simione & Saldarini, 2023; Simione et al., 2021) raised concerns about inconsistent findings, problematic designs, and variation in operationalizing core constructs, underscoring the need for more targeted investigation.

More recently, further evidence has emerged in support of MAT. For example, a 2024 trial from the ReSource Project found that monitoring-only training failed to decrease (and in some cases increased) cortisol reactivity, while monitoring combined with acceptance training buffered physiological stress responses; daily positive affect increased and negative affect decreased only in the "monitoring + acceptance" groups (O'Malley et al., 2024). Similarly, Lindsay et al. (2025) found that in the context of brief daily training via a smartphone app, monitoring-only participants experienced improved cognitive control (executive inhibition, sustained attention) but not affect, while monitoring + acceptance led to significant reductions in stress and negative affect. Thus, acceptance consistently emerges as the critical element for far-transfer affective outcomes (stress, emotion), while monitoring seemingly underlies near-to-medium-transfer cognitive and metacognitive change.

1.5. Feasibility, Scalability, and Effectiveness of Brief Online MBIs

Many traditional MBIs involve regular mindfulness practice in the form of mindful meditation (though not always, e.g., dialectical behavioural therapy or acceptance and commitment therapy). For example, mindfulness-based stress reduction and mindfulness-based cognitive therapy both deploy meditative mindfulness practice to reduce stress and improve well-being. The effectiveness of these paradigms has been demonstrated across numerous studies for clinical and healthy populations (e.g., Khoury et al., 2015). However, a key limitation to such MBIs is that they require substantial time and other resource investment on the part of practitioners and administrators of the protocol (e.g., financial cost, travel cost, facilities and administrative costs, etc.). For example, mindfulness-based stress reduction involves eight weeks of intensive daily mindful meditation for approximately one hour, as well as in-person weekly classes and instructions from a qualified instructor. These weekly classes typically last for approximately 2 to 2.5 h—and one week involves a full-day mindfulness retreat; these serve to provide opportunities to deepen mindfulness practice and learn strategies to incorporate mindfulness into daily living (Kabat-Zinn, 2013). These substantial commitments present a significant barrier to entry into mindfulness meditation for would-be practitioners.

Shorter MBIs have been developed to address these limitations and reduce barriers to entry. For example, Zeidan et al. (2010) found that just four 20 min sessions of mindfulness training improved working memory, attention, executive functioning, and visuo-spatial processing, and mood; reduced fatigue and anxiety; and increased mindfulness. Tang et al. (2007) similarly found that five 20 min sessions of mindfulness training led to myriad cognitive, affective, and physiological benefits. These findings thus suggest that

the cognitive and affective benefits associated with dispositional mindfulness might be achievable in relatively brief MBIs.

Online and app-based MBIs have also become increasingly popular. Cavanagh et al. (2013) found that a brief 14-day online MBI was effective in reducing anxiety, depression, and perceived stress and increased dispositional mindfulness. A 2021 meta-analysis by Sommers-Spijkerman and colleagues found significant moderate-sized beneficial effects of online MBIs for depression (Hedge's g = 0.34), stress (g = 0.44), and dispositional mindfulness (g = 0.40) and small effects on anxiety (g = 0.26) and well-being (g = 0.22). Effect sizes were higher for guided relative to unguided online MBIs. However, there was substantial methodological and outcome variability across studies, limiting extrapolation to online MBIs more generally. Notwithstanding, online mindfulness interventions are a prime target for further inquiry, with a view towards the validation of a standardized, effective, brief online MBI that can bridge would-be practitioners into more regular (and lengthier) ongoing mindfulness practice.

Isbel and Summers (2017) offered a standardized MBI designed for use in randomized controlled trials (RCTs) to help resolve questions of methodological inconsistency across MBIs. This MBI removes secondary characteristics found in other interventions that are extraneous to mindfulness per se, thus allowing a more particular interpretation of mindfulness-related cognitive outcomes. While the authors suggest an eight-week structure based on mindfulness-based stress reduction, we believe the standardized instructions and technique in this MBI make it suitable for adaptation to a shorter online intervention. It offers general instructions and phrases amenable to use in a guided online audio intervention (for example), and key instruction phrases that can be used as anchor prompts to guide mindfulness practice. Moreover, this MBI has been demonstrated to beneficially alter mood and cognition, including early visual processing (Isbel et al., 2020). Nonetheless, questions remain on whether such results may generalize to different populations and contexts.

1.6. Brief Online MBIs for University Students

University students represent a prime target demographic for brief online MBIs. Many university campuses offer mindfulness training, mindfulness-oriented counseling or therapy, or general mindfulness learning materials. Considerable research suggests that university students may benefit from online MBIs specifically (e.g., Cavanagh et al., 2013). University students commonly experience stress and burnout, which may be ameliorated via MBIs and increased dispositional mindfulness. An online MBI also seems appropriate given the considerable amount of time university students spend online and the constraints on their time, travel, attention, and financial resources.

1.7. The Present Study

Considering the rising popularity and recognized benefits of mindfulness, this study undertakes a novel approach to assess the effects of a standardized daily online MBI. By focusing on a 31-day regimen, derived from an established and lengthier in-person protocol, we aim to determine if benefits typically associated with this longer MBI can be garnered in a more compressed timeframe, in an online delivery format. Given the constraints and challenges faced by university students, an effective, brief, easily accessible MBI could serve as a critical tool in enhancing cognitive and emotional functioning, laying the foundation for both academic success and holistic well-being.

The present study involved a randomized controlled trial investigating the effects of a standardized daily online MBI that included 15 min per day of audio-guided mindfulness meditation, for a total of 31 days. This adapted MBI was compared to an active control group exposed to a daily 15 min segment from one of four educational podcast episodes discussing

neuroscientific tools for health and well-being that were unrelated to mindfulness. Our sample included undergraduate- and graduate-level university students. We sought to validate the efficacy of our adapted 15-min, 31-day online MBI given the success of its more elaborate 8-week inspiration (Isbel & Summers, 2017). Specifically, we investigated the effects of this adapted, brief online MBI on cognition (long-term memory, working memory, and executive inhibition), affective functioning (perceived stress, anxiety and depression), and individual differences in dispositional mindfulness, state mindfulness, and state and trait metacognition. We sought to clarify the effects of this MBI on metacognition, given the previously reported overlap between dispositional mindfulness and metacognition. Further, we adopt a MAT-theoretic lens to distinguish between near- (e.g., mindfulness, metacognition) and medium- to far-transfer (e.g., cognition, affect) effects related to our adapted MBI.

Our experimental hypotheses were that, relative to the podcast control group, (1) the MBI group would show medium- to far-transfer effects via improvements in cognitive performance (long-term memory, working memory, and executive inhibition) following the intervention; (2) the MBI group would show far-transfer effects via reductions in depression, anxiety, and perceived stress following the intervention; (3) the MBI group would show near-transfer effects via increases in dispositional and state mindfulness following the intervention; and (4) the MBI group would show near-transfer effects via increases in state and trait metacognition following the intervention. These hypotheses are also consistent with MAT's framework, in which monitoring-related skills (emphasized in our training) would be expected to support improvements in awareness-related domains (e.g., mindfulness, metacognition), with more limited far-transfer effects unless acceptance is also emphasized.

2. Methods

2.1. Participants

Participants were recruited from a pool of students at Huron University College. Initial recruitment efforts resulted in 64 individuals; however, the attrition rate was relatively high. Of the 64 recruited individuals, 49 participants completed the pre-intervention measure. Of these 49 participants, 1 participant did not complete any intervention sessions, and an additional 10 participants did not reach the minimum threshold of 12 completed sessions (M = 2.20, SD = 1.40, range of 1 to 5 completed sessions for these 10 participants). All remaining participants completed the post-intervention measure, resulting in an analyzable sample size of 38 (M = 21.60 years old, SD = 6.49 years old, 29 women, 7 men, 2 non-binary). Participants were randomly assigned to either the mindfulness-based intervention experimental group (MBI group) or the podcast active control group (Podcast group). In total, 21 participants were in the MBI group, and 17 participants were in the Podcast group. Of the eleven participants who were removed for not adequately completing the intervention, four were assigned to the MBI group and seven were assigned to the Podcast group, which does not represent a statistically significant difference in attrition based on condition (Binomial Test: p = 0.272). However, in the pre-intervention measure, the 11 participants who did not complete the experiment scored significantly higher in state and trait anxiety, significantly higher in depression, and significantly lower in trait metacognition compared to the 38 participants who completed the experiment (see Supplementary Table S1), suggesting that participant attrition was not entirely random.

Although the present sample size is comparable to previous studies that have found positive effects of MBIs on cognition (e.g., Zeidan et al., 2010), it should be noted that the sample size was only adequately powered (1–β) to detect large effects (Cohen's f = 0.47) based on a sensitivity analysis performed in G*Power version 3.1.9.7 (Faul et al., 2009). As

such, the present study should be considered a preliminary investigation. Both groups were statistically matched on demographic variables, pre-intervention performance on all the administered measures, and the number of completed intervention sessions. Participants received guaranteed compensation for completing the study (CAD 15) and were additionally entered into a prize raffle to earn an additional CAD 50 (see *Overview of Experimental Procedure* for details). The research protocol was approved by the Huron Research Ethics Board and all participants were treated in accordance with the Declaration of Helsinki.

2.2. Materials and Procedure

An overview of the materials and experimental procedure is provided in Figure 1.

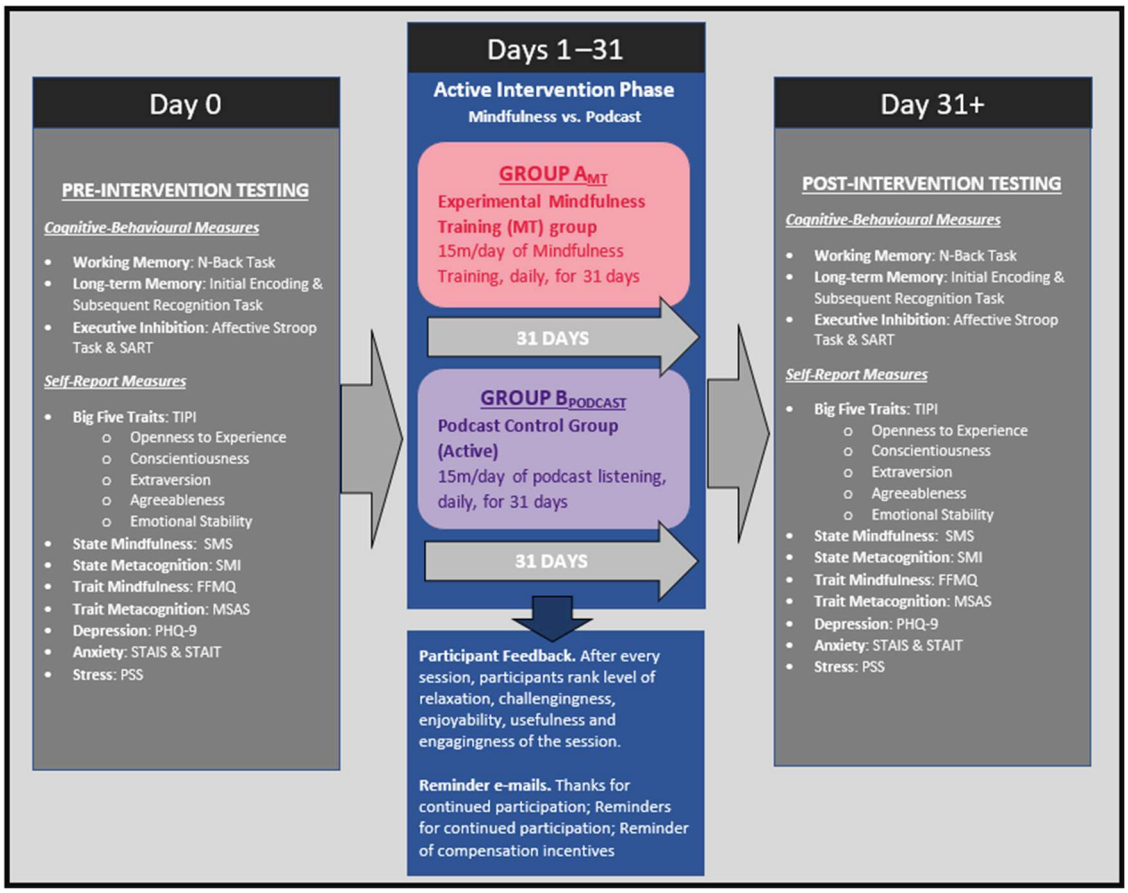

Figure 1. Visualization of the experimental procedure. Note: Prior to beginning their daily online mindfulness-based intervention (MBI) or Podcast control, subjects completed an initial battery of pre-intervention testing (session one), which included cognitive, affective, and individual difference measures. From days 1 to 31, subjects completed their daily online session and post-session feedback. After their final session on day 31, subjects completed the post-intervention testing session (session two), which was identical to session one.

2.2.1. Pre- and Post-Intervention Measures

All pre- and post-intervention testing was conducted online using custom scripts programmed in jsPsych (de Leeuw, 2015). The components of the pre- and post-intervention testing are described in the subsequent subsections.

Cognitive Performance: Working Memory. Working memory was assessed via a visual *n*-back task (e.g., see Owen et al., 2005). The stimuli were letters printed in the center of the computer screen with an inter-stimulus interval of 3000 ms. Each block of the *n*-back consisted of 30 + *n* letters (10 targets, 20 non-targets, presented randomly). Participants were instructed to press a designated key (spacebar) when the current letter matched the

letter previously presented "*n*" positions prior; otherwise, participants were instructed to not press anything. Performance was operationalized in terms of hits (i.e., pressing the spacebar when the current letter matched the letter *n* positions previously) minus false alarms (i.e., pressing the spacebar when the current letter did not match the letter *n* positions previously). All participants completed one block of the 1-back as practice and three blocks of the 2-back as the scored component. Given that the *n*-back is largely conceptualized as a working memory assessment and not a measure of attention per se, we considered *n*-back to represent far transfer in the present context.

Cognitive Performance: Long-Term Memory. Long-term memory was tested using a word recognition paradigm, consisting of an initial encoding phase and a subsequent word recognition phase. "Lure" words, not presented in encoding, were randomly interspersed with studied words in the recognition phase to assess recognition memory. There were four lists of 25 words (A through D), generated specifically for this study, with two matched list pairs (A paired with B; C paired with D). Word lists were paired based on both structural and conceptual similarity of items (e.g., List A contained words such as "apple," "fist," and "lemon," whereas List B contained words such as "apricot," "foot," and "lime"). For example, if participants were presented with List B in encoding, they would be presented with all words from List A and B (in a randomized order) during recognition. The encoding list was counterbalanced across participants. All lists contained nouns that were statistically comparable in terms of concreteness ratings as well as estimated word frequency (Brysbaert & New, 2009). Performance was operationalized in terms of hits minus false alarms. Long-term memory performance was considered to represent far transfer in the present context.

Cognitive Performance: Executive Inhibition. Executive inhibition was tested using two different measures. The first was related to the executive inhibition of emotional stimuli and used the emotional Stroop task (Williams et al., 1996). Participants saw neutral-affect and negative-affect words, selected from a larger standardized word database (Warriner et al., 2013). The selected negative-affect words significantly differed from neutral-affect words in terms of valence, arousal, and dominance (all ps < 0.001); however, negative-affect words were statistically comparable to neutral-affect words in terms of number of syllables, number of letters, and logarithmic word frequency (all ps > 0.204). In the emotional Stroop task, participants were presented with words, printed in one of four possible colors, and were required to press a key corresponding to the printed color of the word (R = red, G = green, B = blue, Y = yellow). Participants first completed a practice block (n = 16 trials, in which the text was a non-word: "XXXXX") to become familiar with the key–color mapping. Following this practice block, participants completed the main assessment, which consisted of 80 total words (40 neutral words and 40 negative words), presented in four blocks of 20 words each. The emotional category was blocked, as blocking (rather than complete randomization) has been shown to increase affect-related interference effects (Ben-Haim et al., 2016). Blocks were interleaved (e.g., neutral, negative, neutral, negative) and counterbalanced across participants. Accuracy and reaction times were recorded, with the relative difference in response time to negative versus neutral words serving as the primary dependent variable.

The second measure of executive inhibition was the Sustained Attention to Response Task (SART; Robertson et al., 1997). The SART consisted of brief (250 ms) visual presentations of numbers (1–9) on the computer screen, with each number being replaced by a fixation cross for 1000 ms, making the inter-trial interval 1250 ms. Participants were instructed to press a designated key (spacebar) when the number was anything other than 3. When the number 3 appeared in the sequence, subjects had to inhibit their primed key-pressing response behaviour. Participants had 1000 ms to respond (i.e., during the number presentation and for the first 750 ms of the fixation cross). If participants responded

correctly, the fixation cross would turn green; otherwise, it would turn red. In the event of a correctly inhibited response, the fixation cross would turn green for the final 250 ms of the trial (i.e., when the window for responding had closed). Participants completed a short practice block (n = 18), followed by a longer main assessment (n = 225). Response times and accuracy were recorded, and participants' commission errors (i.e., pressing the spacebar when the number 3 was presented) were the primary dependent variable. Given that executive inhibition is a critical component of self-regulation, which is a core facet of mindfulness (e.g., Bockmann & Yu, 2023), we considered these tasks to represent medium transfer in the present context.

Self-Report: Personality. Personality factors were measured using the Ten Item Personality Inventory (TIPI; Gosling et al., 2003). The TIPI presented participants with a general prompt ("I see myself as"), followed by ten items, with each item consisting of two adjectives (e.g., "anxious, easily upset"). Each personality dimension (openness, conscientiousness, extraversion, agreeableness, and emotional stability) was measured with two items, with one item being reverse scored. Participants responded on a Likert-style scale ranging from 1 (*Disagree strongly*) to 7 (*Agree strongly*). Mean scores were calculated for each of the five personality factors. Personality measures were not of primary interest to the present research question; however, pre-intervention scores for each of the five personality dimensions were used to assess whether the two participant groups (MBI, Podcast) were statistically matched.

Self-Report: State and Dispositional Mindfulness. State mindfulness was measured using the *State Mindfulness Scale* (SMS; Tanay & Bernstein, 2013). Participants were asked to read 21 statements and indicate how well each statement described their experiences in the study session. The SMS consists of two subscales—a mind subscale (e.g., "I was aware of different emotions that arose in me.") and a body subscale (e.g., "I noticed physical sensations come and go"). Participants responded on a Likert-style scale ranging from 1 (*Not at all*) to 5 (*Very well*). Mean scores for the mind and body subscales were calculated.

Dispositional mindfulness was measured using the *Five Facet Mindfulness Questionnaire—Short Form* (FFMQ-SF; Bohlmeijer et al., 2011). Participants responded to 24 statements regarding mindful tendencies across five dimensions: observing (e.g., "I pay attention to physical experiences, such as the wind in my hair or sun in my face."); describing (e.g., "I'm good at finding words to describe my feelings."); acting with awareness (e.g., "I find it difficult to stay focused on what's happening in the present moment."—reverse scored); non-judging (e.g., "I make judgments about whether my thoughts are good or bad."); and non-reacting (e.g., "I watch my feelings without getting carried away by them."). Participants responded on a Likert-style scale ranging from 1 (*Never or very rarely true*) to 5 (*Very often or always true*). Mean scores for each of the five facets were calculated. Both state and dispositional mindfulness would be considered as near transfer (if not manipulation checks) in the present context.

Self-Report: State and Trait Metacognition. State metacognition was measured using a subset of questions from the *State Metacognitive Inventory* (SMI; O'Neil & Abedi, 1996)—specifically, five questions from the *Awareness* subscale of this inventory, which were most relevant to the present study. Participants responded to statements about their perceptions and experiences during the present testing session (e.g., "I was aware of my ongoing thinking processes."). Participants responded on a Likert-style scale ranging from 1 (*Not at all*) to 4 (*Very much so*). A single mean score was calculated for the five questions.

Trait metacognition was measured using the *Metacognition Self-Assessment Scale* (MSAS; Pedone et al., 2017). Participants responded to statements that quantify various aspects of metacognitive ability, including monitoring (e.g., "I am aware of what are the thoughts or emotions that lead to my actions."); differentiation (e.g., "I am aware that what I think about

myself is an idea and not necessarily true. I realize that my opinions may not be accurate and may change."); integration (e.g., "I can describe the thread that binds my thoughts and my emotions even when they differ from one moment to the next."); decentration (e.g., "I am aware that others may perceive facts and events in a different way from me and interpret them differently."); and mastery (e.g., "I can deal with the problems trying to challenge or enrich my views and my beliefs on problems themselves."). Participants responded on a Likert-style scale ranging from 1 (*Never*) to 5 (*Almost always*). MSAS was analyzed in terms of a single, total score to reduce the number of statistical tests performed. Given the close theoretical link between mindfulness and metacognition, we considered these assessments as near-transfer measures in the present context.

Self-Report: Anxiety. Both state and trait anxiety were assessed using the adapted short-form 5-item versions of the original *State-Trait Anxiety Inventory* (STAI-S5 and STAI-T5; Marteau & Bekker, 1992). The STAI-S5 and STAI-T5 are both answered on a Likert-style scale ranging from 1 (*Not at all*) to 4 (*Very much so*). For the STAI-S5, participants rated how well brief statements (e.g., "I feel upset") described them in the present moment. For the STAI-T5, participants rated how well statements (e.g., "I feel that difficulties are piling up so that I cannot overcome them") described them in general. Mean scores for both the STAI-S5 and STAI-T5 were calculated. Given that anxiety was not specifically referenced in the MBI, these measures were considered to reflect far transfer in the present context.

Self-Report: Depression. Depression was measured using the *Patient Health Questionnaire* (PHQ-9; Kroenke & Spitzer, 2002). Participants were presented with a total of nine statements describing depressive symptoms (e.g., "Little interest or pleasure in doing things") and were asked to rate how much they have been bothered by the listed problems over the last two weeks. Participants responded on a Likert-type scale ranging from 0 (*Not at all*) to 3 (*Nearly every day*). Finally, participants were prompted: "If you checked off any problems, how difficult have these problems made it for you to do your work, take care of things at home, or get along with other people?" Again, a Likert-type scale was used—this time ranging from 0 (*Not difficult at all*) to 3 (*Extremely difficult*). A single mean score from the PHQ was calculated. Given that depression was not specifically referenced in the MBI, this measure was considered to reflect far transfer in the present context.

Self-Report: Stress. Trait-level stress was measured using the *Perceived Stress Scale* (PSS; Cohen et al., 1983). The 10-item measure used a 5-item Likert-style rating from 0 (*Never*) to 4 (*Very often*) to measure trait-level stress (i.e., stress over an extended period of time—in this case, the past month). Subjects were given 10 questions asking about their feelings and thoughts during the last month (e.g., "In the last month, how often have you been upset by something that happened unexpectedly?"; "In the last month, how often have you felt nervous and stressed?"). Subjects indicated how often they felt the way described by each question. Given that stress was not specifically referenced in the MBI, this measure was considered to reflect far transfer in the present context.

Self-Report: Demographics. Participants provided their age (in years) and additionally provided their gender from the following options: (1) Woman, (2) Man, (3) Non-binary, (4) You do not have an option that describes me, and (5) Prefer not to say.

2.2.2. Intervention Measures

There were several elements of the intervention measure that were common across both the MBI and Podcast groups. All participants accessed the intervention website through a URL distributed by the researchers, where they were able to enter their assigned participant identifier to access the relevant materials for their assigned group (MBI or Podcast materials). After each completed intervention session, all participants answered five questions: (1) "Please rank how relaxed you presently feel"; (2) "Rank how challenging you

found the intervention"; (3) "Rank how engaging you found the intervention"; (4) "Rank how useful you found the intervention"; (5) "Please rank how enjoyable you found the intervention". Responses were made on a Likert-type scale ranging between 1 (*Not at all*) and 5 (*Extremely*).

Participants were also presented with two open-ended feedback prompts: (1) "Briefly describe your favourite and least favourite aspects of this session" and (2) "Briefly describe your overall personal subjective experience of this session". For these open prompts, participants were asked to provide a few sentences about their thoughts about and experience of the session they just completed.

A final feedback screen was then presented to participants, which allowed them to submit questions and comments directly to the researchers. Participants were instructed that they would receive a response to any questions or comments within 24 h and that the response would be generalized to all participants in the same intervention to avoid duplication of questions and ensure participants all had equivalent information from the researcher.

Mindfulness-Based Intervention. The MBI group received an adapted version of a standardized mindfulness-based intervention created by Isbel and Summers (2017). Our MBI (see Appendix A) adopted the standardized instructions from the Isbel and Summers (2017) protocol but reduced the daily practice requirements to 15 min. Moreover, the intervention was administered entirely online via a specialized web module specially developed for our purposes. As mentioned in the prior subsection, participant feedback and questions were solicited through the online web module. This method of interaction with participants served to minimally simulate some of the in-person elements originally recommended by Isbel and Summers (2017).

The adapted MBI consisted of a 15 min audio file that contained a reading by the principal researcher of the meditation instructions, with the final four minutes consisting of silence to practice mindfulness techniques outlined in the first 11 min of the file. The audio file presented to MBI participants was the exact same file presented each day. This guided mindfulness meditation served to train participants on the mindfulness practice technique through the repetition of key instructions and offered them silence to briefly practice and consolidate the instructions into memory. Participants were further encouraged (but not required) to practice as often as they wished.

Podcast Intervention. Participants in the Podcast group listened daily to a 15 min segment from one of four educational podcast episodes discussing neuroscientific tools for health and well-being. Four episodes from Dr. Andrew Huberman's publicly available "Huberman Lab" podcast (Episode #95, about learning and speaking languages; Episode #87, about the neuroscience of speech, language and music; Episode #86, about what alcohol does to your brain, body and health; and Episode #85, about exercise, nutrition, and hormones; see https://hubermanlab.com/, accessed on 26 October 2022, for more information) were divided into 15 min segments and presented each day in sequence over the duration of the 31-day intervention period. Thus, in contrast to the MBI group, the Podcast group heard different (but related) audio files each day.

2.2.3. Overview of Experimental Procedure

All components of the study took place online. All participants completed an initial virtual meeting with one of the researchers (JHST). There were two primary purposes of this initial meeting. First, participants were screened to ensure they met eligibility criteria (i.e., that they were meditation-naïve). Second, the study outline was explained, and the importance of study engagement was emphasized to participants. This was to ensure that

participants clearly understood the multifaceted nature of the online study, with the desired outcome of decreasing participant attrition.

Prior to initiating their first daily intervention session (either MBI or Podcast), all participants completed the online pre-intervention testing. Participants were requested to complete the testing session in a quiet area where they could focus on the tasks at hand. All participants began the pre-intervention session by completing the cognitive measures. The ordering of the cognitive tasks was random, apart from the long-term memory task, in which long-term memory encoding was always the first cognitive measure and long-term memory recognition was always the final cognitive measure, to ensure adequate time separating encoding and recognition. The battery of self-report measures (TIPI, SMS, FFMQ-SF, SMI, MSAS, STAI-S5, STAI-T5, PHQ-9, PSS-10, Demographics) followed the cognitive measures, with questionnaire order being completely randomized. Participants received a guaranteed USD 5 payment for completing the pre-intervention measure, regardless of whether they continued with the study.

Once pre-intervention testing was completed, participants could begin their 31-day intervention (either MBI or Podcast depending on the assigned group). Participants were ideally expected to complete one session daily, for a total of 31 completed sessions. Understanding that ideal (full) compliance was not likely, we set the minimum required number of sessions for full participation to 12 sessions, which is equivalent to approximately three sessions per week (and three hours of total training over the 31-day intervention period). Participants were notified of this minimum threshold during their pre-experiment meeting. To incentivize participation in the daily sessions, participants received an entry to a prize raffle (CAD 50 bonus payments, which were randomly awarded to six participants) for each completed session. Thus, participants could earn anywhere between 1 and 31 entries to the prize raffle depending on the number of intervention sessions they completed. Each intervention session began with listening to the 15 min audio file and was followed by the fixed-response and free-response questions described earlier.

At the conclusion of the 31-day intervention period, participants who completed the minimum number of intervention sessions were eligible to complete the post-intervention testing, which was identical to the pre-intervention testing. Participants received a guaranteed payment of CAD 10 for completing the post-intervention measure. The compensation for the post-intervention measure was nominally higher than the pre-intervention measure to encourage participants to complete the entire study. Once all post-intervention test data had been submitted, the bonus raffles were drawn, payments were distributed via electronic transfer, and participants were provided information about study details, protocols and purposes via a Debriefing Letter (Supplementary Material, File S1).

2.3. Data Analysis

The five questions posed immediately following each intervention session were analyzed through linear mixed-effects models using the "lme4" package in R (Bates et al., 2015), given that each participant completed the same set of questions a variable number of times (related to the total number of completed sessions). Separate models were created for each question. Group (MBI, Podcast), session number, and the interaction of group and session number were entered as predictor variables. Each model also included random intercepts for participants.

The pre- and post-intervention measures were analyzed via ANCOVA models with group (MBI, Podcast) as a between-participant factor. Post-intervention scores were used as the dependent variable. Both pre-intervention score and the number of completed intervention sessions were entered as covariates. For the ES Task, we took a difference score of negative versus neutral words to create a single measure per session. In addition to

assessing significant terms from these ANCOVA models, we used the "TOSTER" package in R (Caldwell, 2022; Lakens, 2017) to conduct equivalence testing. Equivalence testing involves specifying the smallest effect size of interest and then testing whether the observed findings are similar enough to this effect size to be considered equivalent. Although there are several possible ways of setting a smallest effect size of interest, in the present experiment, we opted to set the smallest effect size of interest as the mean reported effect sizes from two previous studies examining the effects of MBIs on cognition and affect (Basso et al., 2019; Zeidan et al., 2010), which was determined to be $\eta_p^2 = 0.102$.[1] Finally, for the long-term memory and working memory assessments, performance was assessed against chance using one-sample *t*-tests against a known mean of zero (as this would represent an equal number of hits and false alarms).

3. Results

3.1. Intervention Ratings

In response to the question, "Please rank how relaxed you presently feel", we observed a significant interaction of group and session, B = −0.026, *SE* = 0.009, $p = 0.002$. This interaction was characterized by stable relaxation scores for MBI participants, regardless of session. In contrast, participants in the Podcast group had comparable relaxation scores to the MBI group for the initial intervention sessions, but relaxation subsequently decreased as a function of the session. Neither the main effects of the group nor the session were significant.

In response to the question, "Rank how challenging you found the intervention", we observed significant main effects of both group, B = −0.98, *SE* = 0.25, $p < 0.001$, and session, B = −0.023, *SE* = 0.008, $p = 0.003$, as well as a significant interaction of group and session, B = 0.056, *SE* = 0.011, $p < 0.001$. This interaction was characterized by initially higher challenging scores in the MBI group, which decreased as a function of session, juxtaposed with initially lower challenging scores for the Podcast group, which increased as a function of the session.

In response to the question, "Rank how engaging you found the intervention", we did not observe significant differences as a function of either session ($p = 0.743$) or group ($p = 0.610$). There was, however, a significant interaction between group and session, B = −0.022, *SE* = 0.010, $p = 0.025$, characterized by stable engagement in the MBI group and decreasing engagement in the Podcast group as a function of session.

In response to the question, "Rank how useful you found the intervention", we observed a significant interaction of group and session, B = −0.028, *SE* = 0.010, $p = 0.003$. This interaction is characterized by stable (and nominally increasing) usefulness scores for the MBI group across sessions, in contrast to decreasing usefulness scores as a function of session for the Podcast group. The main effects of group ($p = 0.684$) and session ($p = 0.238$) were not significant.

Finally, in response to the question, "Please rank how enjoyable you found the intervention", we observed a significant interaction of group and session, B = −0.039, *SE* = 0.010, $p < 0.001$. This interaction is characterized by stable (and nominally increasing) enjoyableness scores for the MBI group across sessions, in contrast to decreasing enjoyableness scores as a function of the session for the Podcast group. The main effects of group ($p = 0.670$) and session ($p = 0.085$) were not significant.

In sum, responses to all five questions administered immediately following the intervention showed interactions between the group and the session (Figure 2). As participants became more practiced in their respective interventions, the MBI group found the intervention to be less challenging, more useful, more engaging, and more enjoyable, and experienced greater personal relaxation relative to participants in the Podcast control group.

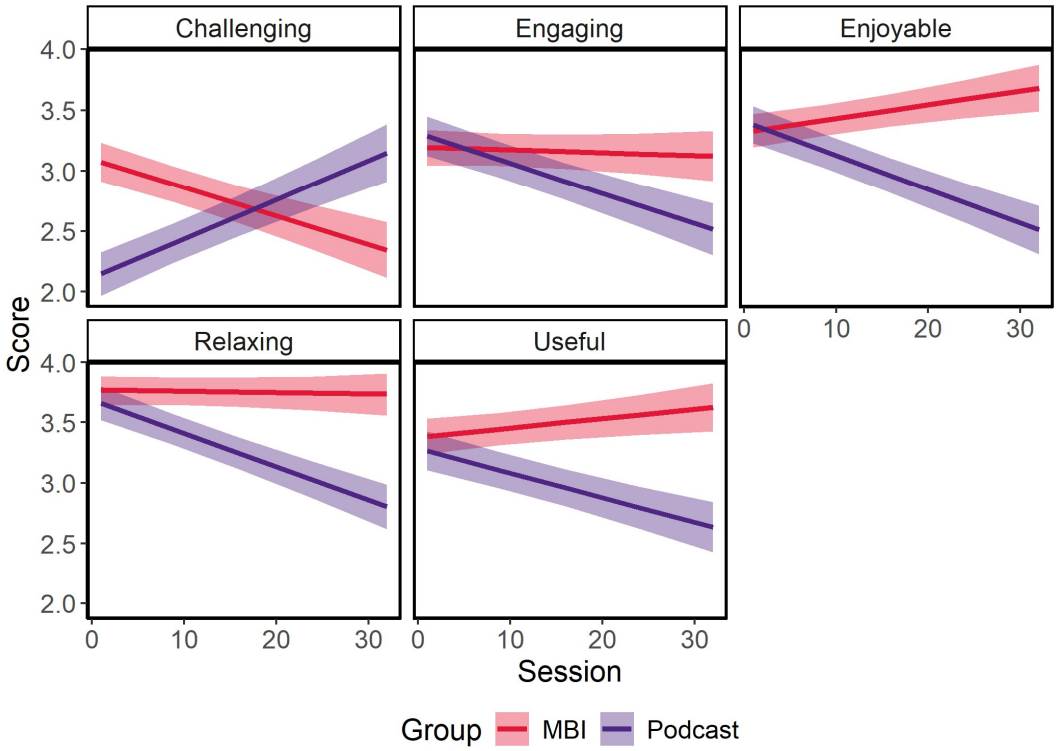

Figure 2. Interaction terms from the mixed-effects models of intervention ratings. Note: All interactions were significant. Error ribbons represent ±1 standard error of the mean.

3.2. Pre-Post Intervention Measures

Table 1 provides descriptive statistics for pre- and post-intervention measures from the testing battery, separated by both group (MBI, Podcast) and session (pre-intervention, post-intervention).

Table 1. Descriptive statistics from pre- and post-intervention testing.

		MBI Group			Podcast Group		
Cognitive Measures		Pre-	Post-	Cohen's *d*	Pre-	Post-	Cohen's *d*
	LTM	11.43 (5.99)	11.52 (7.63)	0.01	12.47 (8.40)	12.82 (8.61)	0.04
	N-Back	16.19 (12.21)	19.10 (11.17)	0.31	21.05 (7.37)	24.00 (5.05)	0.44
	ES	13.82 (49.57)	32.28 (58.32)	0.34	7.49 (50.47)	34.81 (61.08)	0.48
	SART	11.19 (6.70)	9.90 (8.16)	−0.17	9.29 (4.06)	8.53 (5.52)	−0.15
State Measures							
	SMS-B	15.90 (5.93)	20.24 (4.64)	0.80	17.29 (5.13)	16.12 (5.68)	−0.21
	SMS-M	49.29 (11.61)	56.29 (9.76)	0.65	49.94 (13.87)	47.76 (12.05)	−0.17
	SMI	2.01 (0.68)	2.21 (0.45)	0.33	2.00 (0.75)	1.84 (0.72)	−0.22
	PSS	20.19 (6.62)	17.52 (6.83)	−0.40	20.76 (6.28)	18.53 (5.72)	−0.37
	STAI-S5	0.67 (0.60)	0.38 (0.53)	−0.50	0.49 (0.48)	0.55 (0.66)	0.10
	PHQ-9	9.57 (5.53)	8.48 (5.54)	−0.20	10.94 (5.24)	8.29 (4.96)	−0.52

Table 1. *Cont.*

		MBI Group			Podcast Group		
Trait Measures							
	FFMQ-O	14.05 (4.33)	15.48 (3.78)	0.34	13.47 (3.43)	12.59 (3.34)	−0.26
	FFMQ-D	16.57 (3.63)	17.33 (3.76)	0.21	16.82 (4.17)	17.35 (3.35)	0.14
	FFMQ-A	16.24 (5.08)	16.86 (4.97)	0.12	15.12 (4.04)	14.47 (3.81)	−0.16
	FFMQ-NJ	14.05 (3.54)	15.10 (3.87)	0.28	15.59 (4.40)	15.82 (3.80)	0.06
	FFMQ-NR	13.90 (3.13)	15.38 (4.08)	0.39	14.47 (4.05)	14.94 (3.56)	0.12
	MSAS	68.86 (8.55)	72.14 (5.86)	0.42	69.00 (7.39)	70.94 (8.48)	0.24
	STAI-T5	1.62 (0.78)	1.48 (0.73)	−0.19	1.58 (0.78)	1.27 (0.70)	−0.41

Note: Values in parentheses represent standard deviations. LTM = long-term memory; ES = emotional Stroop (negative word minus neutral word response times); SART = sustained attention to response task. Effect sizes represent the change from pretest to posttest for each group.

3.2.1. Cognitive Assessments

Long-term memory performance did not statistically differ as a function of group, $F(1, 34) = 0.10$, $p = 0.749$, $\eta_p^2 = 0.003$, with equivalence testing providing evidence that the observed effect size was significantly different from the smallest effect size of interest ($p = 0.032$). These null results in the long-term memory task could not be explained by overall poor performance, as performance for both groups in both sessions was robustly above chance (all ps < 0.001) with large effect sizes (all Cohen's ds > 1.48), suggesting that participants understood the task and performed it well.

Working memory (n-back) performance did not statistically differ as a function of group, $F(1, 34) = 0.14$, $p = 0.704$, $\eta_p^2 = 0.004$, with equivalence testing suggesting that the observed effect size was significantly different from the smallest effect size of interest ($p = 0.037$). Performance on the n-back was robustly above chance (all ps < 0.001) with large effect sizes (all Cohen's ds > 1.33) for both groups across both sessions, suggesting that participants understood and performed the task well.

In terms of executive inhibition, as measured by the ES task, performance did not statistically differ as a function of group, $F(1, 34) = 0.06$, $p = 0.803$, $\eta_p^2 = 0.002$, with equivalence testing suggesting that the observed effect size was significantly different from the smallest effect size of interest ($p = 0.024$). Finally, commission errors in the SART task did not show a significant main effect of group, $F(1, 34) = 0.06$, $p = 0.800$, $\eta_p^2 = 0.002$, with equivalence testing suggesting that the observed effect size was significantly different from the smallest effect size of interest ($p = 0.025$). Results from the cognitive measures are plotted in Figure 3.

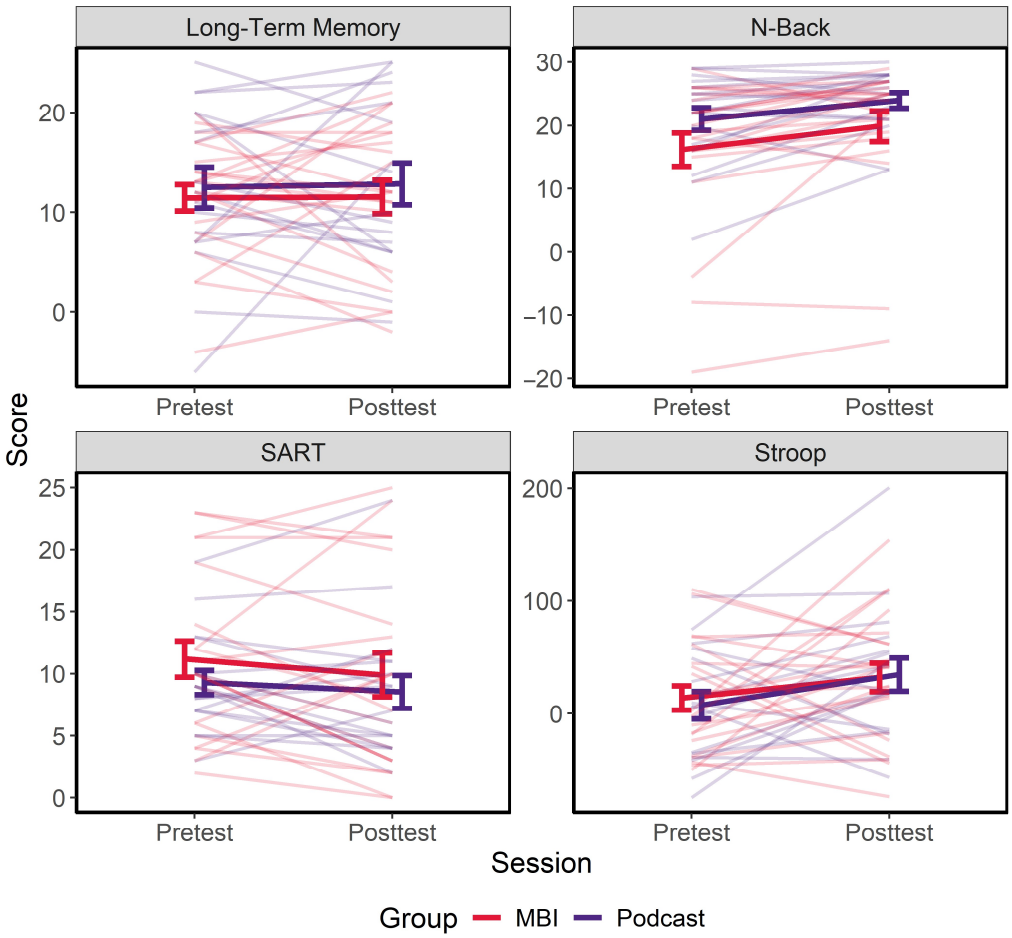

Figure 3. Nonsignificant intervention effects of group on cognitive assessments. Note: Error bars represent ±1 standard error of the mean. Thinner lines represent individual participants.

3.2.2. Self-Report Measures

State Measures. Participants in the MBI group became significantly more mindful of their bodies following the intervention compared to participants in the Podcast group (Figure 4, top left panel), as evidenced by a significant effect of group for the body subscale of the SMS, $F(1, 34) = 7.58$, $p = 0.009$, $\eta_p^2 = 0.182$. Similarly, the mind subscale of the SMS showed a significant effect of group, $F(1, 34) = 6.53$, $p = 0.015$, $\eta_p^2 = 0.161$, with participants in the MBI group scoring higher than participants in the Podcast group (Figure 4, top right panel). Participants in the MBI group also had higher state-level metacognition scores following the intervention compared to participants in the Podcast group, as evidenced by a significant effect of group for the SMI, $F(1, 34) = 5.46$, $p = 0.025$, $\eta_p^2 = 0.138$ (Figure 4, bottom right panel).

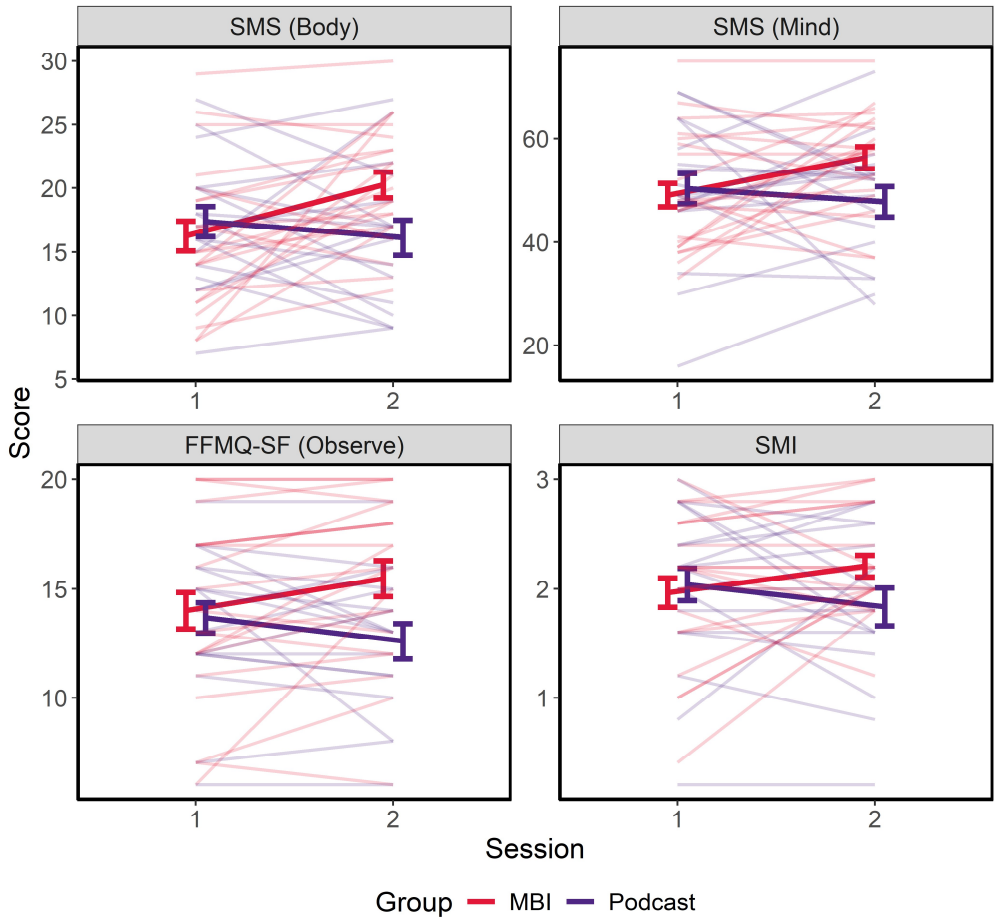

Figure 4. Significant intervention effects of group on mindfulness and metacognition measures. Note: Error bars represent ± 1 standard error of the mean. Thinner lines represent individual participants. SMS = State Mindfulness Scale; FFMQ-SF = Five Facet Mindfulness Questionnaire (Short Form); SMI = State Metacognitive Inventory.

For the affective measures, there was no evidence that the groups differed in stress (PSS), $F(1, 34) = 0.17$, $p = 0.685$, $\eta_p^2 = 0.005$, depression (PHQ-9), $F(1, 33) = 0.59$, $p = 0.446$, $\eta_p^2 = 0.017$, or anxiety (STAI-S5), $F(1, 34) = 2.22$, $p = 0.145$, $\eta_p^2 = 0.061$. However, based on equivalence testing, stress was the only measure that significantly differed from the smallest effect size of interest ($p = 0.042$). These results are plotted in Figure 5.

Trait Measures. Participants in the MBI group showed significantly increased *observing* mindfulness traits following the intervention compared to participants in the Podcast group (Figure 4, bottom left panel), as evidenced by a significant effect of group for the observing subcomponent of the FFMQ-SF score, $F(1, 33) = 12.69$, $p = 0.001$, $\eta_p^2 = 0.272$. Notably, none of the other subcomponents of the FFMQ-SF showed effects of group, with the *describing* and *non-judgmental* subcomponents significantly differing from the smallest effect of interest ($p = 0.017$ and $p = 0.008$, respectively).

In terms of overall trait metacognition, there was no significant effect of condition, $F(1,34) = 0.53$, $p = 0.472$, $\eta_p^2 = 0.015$, and the equivalence test was non-significant. Trait-level anxiety did not show a significant effect of group, and the equivalence test was non-significant.

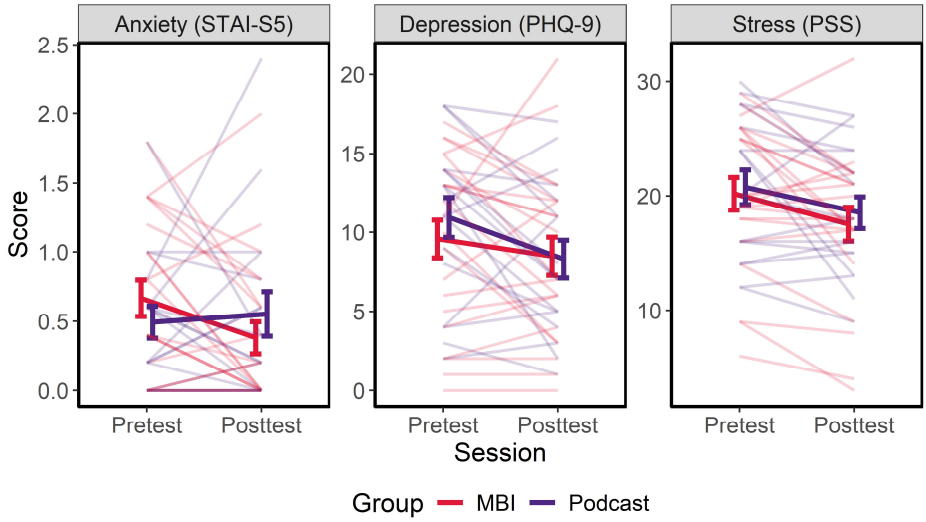

Figure 5. Nonsignificant intervention effects of group on affective assessments. Note: Error bars represent ± 1 standard error of the mean. Thinner lines represent individual participants.

4. Discussion

The present experiment assessed whether a 31-day mindfulness-based intervention (MBI), relative to an active control intervention of listening to podcasts, would result in cognitive and affective benefits that have been reported in previous research (e.g., Basso et al., 2019; Zeidan et al., 2010). Overall, we found no evidence for cognitive or affective improvements following an MBI, with effect sizes small enough to be considered meaningfully different from what has been reported in previous research. In fact, the only post-intervention measures in which the MBI had a significant effect relative to the control group were measures of mindfulness (both state- and trait-level assessments) and a state measure of metacognition. Given that metacognition has been discussed as a highly related construct to mindfulness, the improvements to both mindfulness and metacognition could thus be considered as a near transfer (Solem et al., 2015). These results suggest that mindfulness training can improve mindfulness and closely related constructs, but our findings do not support the notion that brief online MBIs yield medium- to far-transfer effects to cognitive or affective domains.

4.1. Potential Explanations for the Absence of Cognitive Improvements

The lack of MBI-based cognitive improvements contradicts earlier work (e.g., Tang et al., 2007; Zeidan et al., 2010) but conceptually aligns with more recent findings. For example, Baranski (2021) examined the effects of a brief (one session, < 1 h) mindfulness intervention, relative to an active control of drawing, on different executive functions (inhibition, shifting, updating), finding no specific benefits of the mindfulness intervention on any cognitive outcome. Similarly, in a large-scale (n = 585 total) randomized clinical trial among older adults, Lenze et al. (2022) found no evidence that a mindfulness-based stress reduction intervention improved episodic memory or executive function relative to an exercise control group, even after 18 months of performing the intervention. These more recent findings, including the present results, suggest that the far transfer of MBIs to cognitive domains might be limited or absent altogether.

There are several plausible explanations for the null results observed in the cognitive assessments. First, our sample was relatively small and only adequately powered to detect large effect sizes. To address this, we opted to use equivalence testing to compare the present effects to previously reported effects of MBIs (Basso et al., 2019; Zeidan et al., 2010), which suggested that many of our null effects were significantly smaller than the mean

effects reported in previous work. Additionally, our achieved sample size is comparable to the achieved sample size from other influential MBI approaches (n = 49 in Zeidan et al. (2010) and n = 42 in Basso et al. (2019)), which have both been cited extensively (2298 and 374 times, respectively, as of 9 June 2025, as indicated by Google Scholar) and provide support for MBI improvements to cognitive performance. Thus, while the present work cannot be taken to indicate that MBIs have *no* effect on cognition and affect, from the present results, it appears unlikely that MBIs using comparable training approaches would have large effects on these domains. Nevertheless, the present results should be considered preliminary, and future studies with larger sample sizes are needed to help clarify the extent to which online MBIs lead to cognitive or affective improvements (if at all).

Second, it is possible that the cumulative mindfulness practice time in the present experiment was insufficient for more robust changes across our outcome variables. In support of this possibility, Basso et al. (2019) used an eight-week MBI longitudinal design with an interim assessment at the four-week mark and only reported significant group differences after the full eight weeks. Yet, other research in this area has found MBI-based cognitive and affective changes with considerably shorter interventions (e.g., four sessions of approximately 20 min per session in Zeidan et al. (2010), and five sessions of approximately 20 min per session in Tang et al. (2007)), which are both notably shorter than the mean amount of mindfulness training administered in the present study. As such, it is unlikely that the null effects observed in the present study are solely due to issues of insufficient training time, at least based on the benchmarks established by prior research.

Third, it is possible that the cognitive tasks we selected were not optimally aligned with the components of the present MBI. In support of this possibility, Chiesa et al. (2011) note that sustained attention results in MBIs are mixed, with focused-attention meditation altering selective and executive attention, and open-monitoring meditation altering sustained attention. Given that the SART is considered a measure of sustained attention, it is possible our null SART result was related to relatively greater emphasis in the instructions on focused attention (observing) rather than open monitoring meditation (nonjudgment and nonreactivity). However, it should be noted that a recent study (Ford & Nagamatsu, 2024) found significant error reductions in the SART following a focused-attention meditation intervention of a comparable duration as the present study (12 sessions over four weeks), suggesting that more work is needed to clarify how the design of the MBI relates to sustained attention. The emotional Stroop task might also have masked changes to executive inhibition through interference from the additional affective–cognitive load. Future research might benefit from a specific focus on individual cognitive variables that better capture MBI-related changes to attention and cognition through carefully considering the scope of the MBI and how it aligns with the particular constructs being measured by a particular cognitive task.

Although the aforementioned issues (small sample size, training duration, and alignment of cognitive assessments to the administered MBI) should each be given weight in contextualizing the present null results, a fourth possibility for why our MBI did not result in cognitive improvements is that far-transfer effects across domains are rare, if present at all. Indeed, in other domains (e.g., music training, brain training) in which training has been claimed to transfer to untrained domains, recent meta-analytic evidence has suggested that far-transfer effects (e.g., improving executive functions more broadly) are virtually nonexistent (e.g., see Sala & Gobet, 2020, for a discussion of music training and Gobet & Sala, 2022, for a discussion of brain training). Similar challenges to far transfer have been made in the context of sports performance (Fransen, 2024) and bilingualism (Paap, 2022). To follow up on this possibility, future research should consider measuring outcomes

that systematically vary in terms of their overlap with the MBI (i.e., vary along a near- to far-transfer continuum).

4.2. Potential Explanations for the Absence of Affective Improvements

The present experiment did not find evidence that the MBI, relative to the Podcast control group, improved on any affective measure (state or trait anxiety, depression, or stress). Although these findings appear to contradict prior work (e.g., see Hofmann et al., 2010, for a meta-analysis), there are several plausible explanations for these null effects, beyond those already discussed in the previous subsection (i.e., low statistical power, duration of intervention). First, an examination of Table 1 suggests that both interventions were reasonably effective at improving affect. For example, state-level stress was reduced following the MBI with a moderate effect size (Cohen's d = −0.40); however, the Podcast control group also lowered stress to a comparable degree (Cohen's d = −0.37). In this sense, the present findings are conceptually aligned with Zeidan et al. (2010), who found comparable effects on mood resulting from the MBI and the active control group (listening to an audiobook). One notable exception to this pattern was state-level anxiety, which decreased in the MBI group (Cohen's d = −0.50) and nominally increased in the Podcast control group (Cohen's d = 0.10). Although the ANCOVA comparing groups was not statistically significant, these findings suggest that MBIs might be particularly effective at reducing anxiety relative to active control groups.

A second potential explanation for the affective null findings relates to participant attrition. Although attrition is inevitable in any longitudinal study—particularly one that spans 31 days and requires over a dozen sessions, such as the present study, an analysis of the 11 participants who dropped out during the intervention (Supplementary Materials, File S2) showed that they scored significantly higher on depression, state-level stress, and trait-level anxiety compared to the 38 participants who completed the study. There was no statistical bias in the group assignment (MBI, Podcast control) of these 11 participants; however, this baseline difference could suggest that the affective results are relatively conservative. This is because the participants who completed the study (and were therefore included in the analyses), by virtue of scoring lower at baseline on stress, depression, and anxiety, might not have had as much room for improvement as the participants who did not complete the study. These findings emphasize the importance of considering nonrandom attrition in longitudinal studies.

4.3. Positive Effects of the MBI Relative to the Control Group

Despite finding no evidence of far transfer to any cognitive performance or affective measures, the present results suggest that a 31-day MBI can improve both dispositional and state-level mindfulness and state-level (but not trait-level) metacognition. The finding that the present MBI improves dispositional mindfulness aligns with previous work. A meta-analytic review by Sommers-Spijkerman et al. (2021) found that online MBIs have beneficial effects on dispositional mindfulness, in addition to depression, stress, anxiety, and well-being. Effect sizes were greater for guided than unguided meditations, and stress-related effects were moderated by the number of completed sessions (stress decreased more with increasing practice—a trend partially reflected in our own data, as increased session completion was associated with greater reported relaxation over time). Cavanagh et al. (2013) found a significant increase in dispositional mindfulness and decreases in perceived stress, anxiety, and depression for online MBI but not control participants.

Although dispositional mindfulness has also been linked with stress, affect, and psychological health, the changes in mindfulness observed in the present experiment did not appear to translate to these measures. Johnson et al. (2021) suggest that dispositional mind-

fulness may help break negative emotion spirals by encouraging cognitive–experiential decentering (nonjudging) and reducing emotional reactivity to stressors (nonreactivity), thereby broadening and building positive affect-related resources. This framework provides a potential clue into the nonsignificant affective measures in the present experiment, as only the *observing* subcomponent of the FFMQ-SF was improved following the MBI intervention. In contrast, the *nonreactive* and *nonjudging* subcomponents of the FFMQ-SF were not significantly increased following the MBI intervention.

The present findings also support the idea that MBIs can improve some aspects of self-reported metacognitive ability, which aligns with prior theoretical and empirical work. The relationship between mindfulness and metacognition is well characterized by previous research (Solem et al., 2015), and many mindfulness models explicitly involve or reference metacognition (e.g., Jankowski & Holas, 2014). Indeed, Isbel and Summers (2017)'s capacity model explicitly includes metacognition as required to cultivate mindfulness—theoretically differentiating between the cognitive faculty of mindfulness (e.g., sustained attention, nonjudgment) and metacognitive processes that support it. Thus, they theorize its training as part of mindfulness practice (and by extension, as an MBI-related outcome). In that vein, the present experiment contributes to a growing body of research demonstrating that brief MBIs can enhance self-reported state-level metacognition (e.g., Baird et al., 2014). These findings provide another potential path through which MBIs could, in principle, improve cognitive performance, given the strong theoretical associations between metacognition and executive functions (e.g., Roebers, 2017). However, given the fact that only state-level (not trait-level) metacognitive awareness was selectively improved as a function of MBI experience, future work is needed to clarify the relationship between MBIs and improved metacognition.

Beyond specific measures of mindfulness and metacognition, there were several differences in how the MBI group rated their experiences with the intervention compared to the Podcast control group. Specifically, over the course of the 31-day intervention, participants in the MBI group reported their mindfulness sessions as more relaxing, useful, engaging, and enjoyable, as well as less challenging, compared to the participants in the Podcast control group. The finding that participants in the MBI group found their intervention to be more relaxing relative to the control group could be construed as indirect evidence that the MBI reduced stress. Indeed, many MBI subjects reported in their daily post-session subjective experience feedback that they generally felt calmer, more relaxed, and less stressed. However, this needs to be interpreted with caution, as the validated measure of state stress (the PSS) did not show any group effects on perceived stress in the post-intervention session. Similarly, the MBI group results might be cautiously construed as indirect evidence the mindfulness intervention was more personally meaningful—particularly with greater practice over time. This is noteworthy given the close connections between mindfulness, meaning, and well-being—for example, recent meta-analyses show that MBIs increase meaning in life (e.g., Chu & Mak, 2020; Li et al., 2022), which mediates improvements in subjective well-being (e.g., Yuan et al., 2021).

4.4. Situating the Present MBI in Contemporary Mindfulness Theories

Our MBI instructions were focused on continual, attentive noticing (observing) of the breath and its physical sensations and a return to the breath when attention wandered (see Isbel & Summers, 2017). While all aspects of FFMQ mindfulness were incorporated into our instructions, by far the most emphasis was placed on observing—which could explain our increases in observing for MBI subjects but null results for the other facets. Participants may have been biased to focus on developing observing skills, potentially interfering with learning the other facets of mindfulness. Alternatively, observing could be the simplest and

most straightforward facet of mindfulness to learn. It is also possible that cultivating the ability to mindfully observe one's inner and outer experiences might be necessary prior to the successful cultivation of other mindfulness skills. This fits with research suggesting that a particular style or quality of observing is essential to mindfulness and that one's individual style of mindfulness may vary according to meditation experience, affective disposition (positive or negative) and psychopathology.

Baer et al. (2006) found via linear comparisons of FFMQ facets that four of five (all except observing) formed an "overall mindfulness construct"—and that observing was positively correlated with psychological symptoms, thought suppression, dissociation, and absent-mindedness. However, using a person-oriented approach instead focused on patterns or profiles of values across multiple dimensions of dispositional mindfulness, Lilja et al. (2013) noted that observing is indeed an essential dimension of mindfulness, cultivated through meditative practice. Experienced meditators showed higher observing scores (and non-meditators lower scores)—a pattern reflected in our own results.

Importantly, however, observing and nonjudging are not always linked in experienced meditators (Lilja et al., 2013). Thus, the ability to observe and keep a nonjudgmental attitude may not always go together, even among those with higher dispositional mindfulness. This may be especially true for those strongly predisposed to self-judgment.

Johnson et al. (2021) also found that nonreacting and nonjudging (but not other mindfulness facets) indirectly predict perceived stress via negative affect. Baer et al. (2006) note that nonreacting and nonjudging are ways of operationalizing acceptance, as accepting an experience includes refraining from self-criticism (nonjudging) and impulsive reactions (nonreacting). Compared to observing, nonjudging and nonreacting seem to measure more complex mindfulness skills requiring more extensive practice (Lilja et al., 2013). Thus, it is possible that MBI participants only had sufficient time to learn observing in the present study—and that with greater practice time and increased emphasis on nonjudging and nonreacting in the MBI instructions, far-transfer effects may still be achievable.

Applying a Monitor and Acceptance Theory Lens

Our pattern of results (i.e., near-transfer effects of MBI via increased mindfulness and metacognition and null affective results) is consistent with the MAT claim that monitoring without acceptance improves awareness but not affect. As noted, our intervention script was biased toward the observing facet of mindfulness (related to *monitoring* in MAT), though it did incorporate some elements of nonjudgment and nonreactivity (related to *acceptance*). Acceptance plausibly reflects nonjudging and nonreactivity, which involve withholding self-criticism and impulsive responses (Baer et al., 2006). Notably, the word "accept" appears only once in the MBI instructions, and terms like "nonjudgment" and "nonreactivity" do not appear at all. This suggests that acceptance-related attitudes were not explicitly emphasized (while, proportionally, more monitoring skills were).

Through a MAT lens, our combination of monitoring-heavy instruction and lack of acceptance-based instruction would predict no affective far-transfer effects (in line with our results). Framing in terms of near and far transfer adds another layer of explanatory power: awareness-related domains (e.g., mindfulness, metacognition) may be susceptible to early monitoring practice—whereas far-transfer affective (and possibly cognitive) benefits likely depend on the cultivation of nonjudgment, nonreactivity and acceptance (which may require greater practice to master). These results raise the possibility that brief online MBIs emphasizing monitoring/observing should explicitly scaffold acceptance-based instruction to achieve broader affective outcomes. This supports a phased intervention model, in which monitoring is introduced early and acceptance skills are layered in as practitioners develop foundational awareness.

The imbalance between monitoring and acceptance instructions in our MBI reflects the pattern observed in controlled dismantling studies (e.g., Lindsay et al., 2018a, 2018b), in which monitoring-only groups showed increases in awareness but no affective benefits—while groups receiving both monitoring and acceptance training showed reductions in stress and loneliness. More recently, a 2025 RCT by Lindsay, Young and Creswell directly compared these components. They found that monitoring-only training improved cognitive performance (e.g., executive inhibition, sustained attention) but failed to yield improvements in affect. In contrast, monitoring and acceptance training together produced robust reductions in stress and negative affect and concomitant increases in positive affect. These findings and our own reinforce the idea that while monitoring alone may sometimes generate near- and medium-transfer cognitive outcomes, acceptance appears essential for far-transfer affective benefits.

4.5. Limitations

There are several limitations that should be considered in the context of the present study. Beyond the limitations raised previously with respect to interpreting the null results (small sample size, limited duration of training, and alignment of cognitive assessments to the MBI), one important factor to consider was the online administration of the study. Eliminating face-to-face contact (and the social element in general) may have reduced general MBI-related efficacy. Future research might explore social facilitation effects in relation to online versus traditional MBIs and how to integrate social aspects of mindfulness in online delivery. Beyond the social elements of in-person MBIs, the online nature of the present MBI resulted in unaccounted-for variability in the settings where participants completed their intervention sessions. Given the importance of environmental factors (e.g., overall quietness, presence of natural sounds) in facilitating mindfulness meditation (e.g., see Chen & Tang, 2024 for a review), future work assessing online MBIs should either provide stipulations as to where the intervention should be completed or minimally collect this information to try and account for this variance.

Fourth, the present sample was relatively homogeneous. All participants were recruited from a university setting, and as a result, our sample was relatively young (with a mean age of 21.7 years old). Given the literature specifically discussing the efficacy of MBIs on older adults' cognitive abilities (e.g., see Mirabito & Verhaeghen, 2023 for a recent meta-analysis), it is therefore possible that our younger sample was less sensitive to potential intervention-related changes. Relatedly, the participants in the present study were not specifically recruited based on their pre-intervention stress or anxiety. Although both the MBI and Podcast control groups were statistically matched on pre-intervention measures, future work should consider examining how pre-intervention stress and anxiety could serve as a moderating variable in the efficacy of MBIs, as these baseline differences have been recently shown to influence the efficacy of mindfulness interventions (e.g., Wagner et al., 2024) and given the nonrandom attrition in the present study (i.e., individuals higher in stress, anxiety, and depression not finishing the intervention).

5. Conclusions

Relative to participants who listened to a podcast, participants who completed a 31-day MBI experienced significantly greater dispositions towards mindful observing and increased state mindfulness with approximately 4.5 h of cumulative training and practice—confirming near-transfer effects of the MBI on mindfulness. Improvement in state metacognitive awareness additionally suggests a degree of near transfer, given the close connections between mindfulness and metacognition as constructs. The MBI intervention itself became less challenging (suggesting learning of mindfulness skills), and became

increasingly more enjoyable, engaging, useful, and relaxing compared to the Podcast control group.

However, in contrast to previous reports (cf. Zeidan et al., 2010; Cavanagh et al., 2013), we observed no far-transfer effects of MBI training on a battery of cognitive performance assessments, or on measures of depression, stress, or anxiety. Although future research is necessary to further contextualize these null results, it is possible that the close matching of the MBI and Podcast control groups in the present study provided a more conservative assessment of what specifically is trained by MBIs. It is also possible that the online delivery, reduced practice time, or imbalance in emphasis between monitoring and acceptance impacted cognitive and affective outcomes, as predicted by Monitor and Acceptance Theory (Lindsay & Creswell, 2017). Finally, a more extreme possibility is that, similar to recent discussions in other domains (e.g., brain training, music training), far-transfer effects to nontrained domains may be limited or absent altogether (e.g., see Gobet & Sala, 2022; Sala & Gobet, 2020).

We suggest our MBI and similar online MBIs may be used as a bridge to more regular and complex mindfulness practice by facilitating mindful observing (i.e., experiential monitoring ability), thereby laying a foundation to develop complex mindfulness skills like nonreactivity, nonjudgment and acceptance. Doing so would provide a more complete picture as to how (or whether) improvements in mindfulness translate to improvements in cognition and affect, and if so, for whom and in what contexts.

Supplementary Materials: The following supporting information can be downloaded at https://www.mdpi.com/article/10.3390/psycholint7030060/s1: Table S1: Baseline Comparison, File S1: Debriefing Letter, File S2 Debriefing Form. (Baer, 2003; Bremer et al., 2022; Chiesa & Seretti, 2009, 2010, 2011; Chiesa et al., 2011; Isbel & Mahar, 2015; Lomas et al., 2017).

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Appendix A

31-Day, 15-Minute Daily Online Mindfulness-Based Intervention
A Brief Standardized Mindfulness Meditation Training and Practice Protocol
* Instructions Adapted from (Isbel & Summers, 2017)

Appendix A.1. Mindfulness Meditative Practice Module

This adapted mindfulness-based intervention (MBI) involves 31 days of 15 min of daily online mindfulness meditative practice (MMP). The MBI was administered via an online web module (see sample images below). Participants logged in to the website using their assigned credentials and completed each day's MMP module. This web module

served both as the user interface and as a convenient way for researchers to track both compliance and subjective experience and interact with participants to offer guidance. In this way, our web module at least partially simulates the in-person design of the original 8-week MBI (Isbel & Summers, 2017) by providing feedback mechanisms between researcher and participant.

Appendix A.2. Pre-Recorded Guided Meditation—Audio File

Subjects were presented with the same 15 min recorded audio MBI daily, for a total of 31 days. Participants were verbally guided through the instructions listed in Table A1 for their daily sitting meditation. The audio recording contained only a deeper-register male voice (the voice of a principal researcher) annunciating the instructions in a soft, slow-paced, calm—yet strong and alert—manner.

Appendix A.3. Online Participant–Researcher Interactive Feedback

Feedback from participants was solicited after each daily session was completed via the web module. Both fixed-choice and open-feedback responses were sought from participants (see Section 2). Additionally, participants were able to communicate any questions they may have each day about their mindfulness practice to the researcher. This proceeded with a question prompt at the end of each session which reads: *'If you have any questions about the practice or require clarification about anything please ask the researcher here. We will leave you a general response which is displayed to you and all other participants prior to your next session once you log in.'*

Thus, if a participant had any questions after their session or required clarification, they had the opportunity to receive feedback from the researchers—and the researchers' responses were then presented to them in a pop-up-style notification prior to commencement of their next daily session. All researcher responses were aligned with the key instructions in Table A1; researchers tried to stay as closely to the principles in the script and key instructions as possible. All clarifications were efficient and non-elaborative, only providing information that was relevant and aligned with the key instructions of the MBI.

Table A1. Sitting exercise instructions.

Instruction Phase	Key Instruction	Instructions to Participants
Preparation	Assume a comfortable, erect posture	Sit cross-legged on a cushion placed on the floor, or if this is uncomfortable, in a straight-backed chair with your feet placed flat on the floor. Sit in a relaxed, erect posture, with your hands resting either in your lap or resting on your knees. Your eyes can be either closed, or slightly open with the gaze cast slightly down. Adopt a comfortable and alert posture you are capable of maintaining for the duration of the session.
Basic technique	Be attentive to the sensations arising with the breath at the abdomen	Direct your attention to the sensations occurring at the abdomen with each breath. Do not intentionally breathe faster or slower, deeper or shallower, but let the breath remain natural. Observe the sensations of movement or tightness that arise with the rising and falling of the abdomen. As you breathe in, try to notice the beginning, the middle, and the end of the rising movement. As you breathe out, try to notice the beginning, the middle, and the end of the falling movement. Notice these physical sensations without thinking about them in any way

Table A1. *Cont.*

Instruction Phase	Key Instruction	Instructions to Participants
Basic technique	Note the rising and falling with mental labelling	Make a soft mental note of 'rising' while attending to the sensations of the rising abdomen, and 'falling' while attending to the falling sensations. Without thinking about these sensations or the fact that you are attending to them, simply be aware of the sensations of rising and falling as closely as possible while gently noting 'rising, falling.'
	Return again and again to the breath	At the beginning, you will find it difficult to remain attentive to each successive rising and falling movement as it occurs. Remember that this is a learning process, and that the movements of the breath are always present. Simply return your attention with accuracy and clarity to these sensations whenever the mind wanders
Dealing with distraction	Note thoughts as soon as they arise	Mindfulness is not the absence of thought. Distracting thoughts will naturally arise. Simply try to be mindful of thoughts when they arise. When a thought occurs, without getting caught up in or following the thought, simply be aware of the thought. Use the mental label 'thinking' to note it, and return your attention to the sensations of rising and falling.
		Do not follow thoughts, feelings, or emotions when they arise. Do not think about your thoughts. Do not worry if your thoughts are good or bad. Simply note 'thinking' and return to the rising and falling of the abdomen
		You may not be aware for some time that your mind has wandered, but as soon as you become aware of distraction, note 'thinking,' and return to the rising and falling of the abdomen. If you notice many thoughts, this is mindfulness. Being aware of thoughts is mindfulness. Being lost in thoughts is distraction.
	Do not be concerned with other objects	Remain attentive to the rising and falling. Only notice other objects when they draw your attention away from the rising and falling. For example, if a loud sound occurs, be aware of the experience of hearing, without thinking about what caused the sound. Mentally note 'hearing' and once the sound has passed, return to the rising and falling. Do not seek out or be concerned with other objects.
Stay relaxed and balanced	Do not worry about pleasant or unpleasant experiences	Do not be concerned whether your experience is pleasant or unpleasant. You will experience both pleasant and unpleasant sensations while paying attention to your body and mind. Both types of feeling will arise and pass away, so try not to hold onto pleasant feelings or push unpleasant ones away. Simply remain mindful and mentally note everything that occurs
	Stay relaxed	Keep the mental label simple, calm, and natural. While we may experience a bewildering range of thoughts, hopes, concerns, doubts and mental images, simply label them 'thinking' as they arise, and return to the rising and falling movements of the abdomen.

Table A1. *Cont.*

Instruction Phase	Key Instruction	Instructions to Participants
Dealing with difficulties	Direct your attention to discomfort when it arises	After sitting for a while, you may experience persistent feelings of tiredness, discomfort, itching, and pain. At this time, direct your attention to these feelings, maintaining awareness of the sensations by noting 'pain,' 'aching,' or 'itching.' Remain mindful of such sensations without worry or concern. If the sensations fade away, return to the rising and falling. If the sensations continue to increase and you wish to move, change your position mindfully in the following manner
	Move slowly and mindfully	If you intend to scratch an itch on your leg, make a mental note 'intending.' When lifting the hand, note 'lifting.' When moving the hand, note 'moving.' In extending a finger, note 'moving.' When touching the leg, 'touching,' when scratching, 'scratching.' When intending to withdraw one's hand, note 'intending.' When withdrawing the hand back, 'moving,' and in resting the hand in your lap, 'touching.' Do so slowly, directing your attention to the mere sensations that arise with each act. Apply the same mindful attention to other actions, such as adjusting your posture, or swallowing saliva.
Developing proficiency	Continue to note everything that occurs	During the sitting session, simply remain continuously attentive to the sensations of rising and falling as they occur, trying to notice them closer and closer. As thoughts, sounds, feelings, doubts, wishes, and bodily sensations arise, simply note them by applying a soft mental label, and return to the sensations of the rising and falling of the abdomen. If you notice a break between the rising and falling movements, at that time direct your attention to the body as a whole, and be aware of the sitting posture, noting 'rising, falling, sitting,' or 'rising, sitting, falling, sitting.'
	Balance your effort	Practice in a relaxed but alert manner. Avoid becoming tense through excessive striving, or lethargic and dull by relaxing too much. Seek to balance your effort, calmly remaining attentive to the rising and falling movements while noting when your attention wanders or is drawn away
	Relax the use of labelling	Mental labelling helps direct your attention to the sensations you are noting. With practice attention begins to rest evenly upon the rising and falling, so the label can be slowly relaxed. Eventually you may continue without the need for noting.
	Relax in Awareness	After developing proficiency through sustained practice, gradually relax your focus on the sensations accompanying the breath and open your awareness to all of your experience. Gently recognise the knowing quality of awareness. Rest in open awareness free of fixation upon any object or thought.
Ending the session	End your session mindfully	When you wish to end your session, be mindful of this intention, noting 'intending.' Then be mindful of the actions of body and mind as you arise from your sitting posture.

Adapted from Isbel and Summers (2017).

Note

[1] Given that neither paper reported effect sizes for nonsignificant findings, the present determination set the smallest effect size of interest as two-thirds of the mean of the reported effect sizes as a more conservative measure. This approach is conceptually aligned with Lakens (2017), who suggest that one approach for calculating the smallest effect size of interest is to use the smallest effect that would be detectable by an earlier study. Applying this threshold to Basso et al. (2019) yields an effect size of $\eta p2 = 0.105$. However, it should be noted that more conservative approaches have also been proposed. For example, Simonsohn (2015) proposed setting the smallest effect size of interest as the effect size that earlier studies would have 33% statistical power to detect. As such, we acknowledge that the present approach of setting the smallest effect size of interest is relatively liberal and is meant to directly compare to earlier works reporting large effect sizes of MBIs on cognition.

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