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Posted Date: August 13th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-10308949/v1

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Additional Declarations:
No competing interests reported.

Figures are available in the Supplementary Files section.

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Abstract

Mindfulness-based interventions (MBIs) and courses have emerged as widely recognized and accessible approaches for promoting mental health, improving cognitive functioning, and fostering overall well-being. This pilot study explored the effects of a 15-session, online, structured mindfulness-based course on sustained attention and well-being, utilizing both objective and subjective measures. The study aimed to determine whether participants' objective sustained attention, assessed via a smooth pursuit eye movement (SPEM) task, improved after completing the online mindfulness-based course. Subjective attention was measured using the Attentional Control Scale (ACS) and a single item from the Adult ADHD Self-Report Scale (ASRS), while subjective well-being was assessed using the Survey on Flourishing (SURF). A randomized controlled design was employed, with participants assigned to either the experimental group (Mindfulness for Humans course) or a control group receiving psychoeducational resources. Results showed no significant improvement in objective sustained attention or self-reported attentional control from pre- to post-intervention between groups. Although the course did not yield significant differences in objective attention measures between groups, both experimental and control groups within themselves demonstrated self-reported improvements in attention over time. Notably, increased course engagement was associated with higher post-intervention well-being scores, highlighting the importance of participant engagement in online MBI's and courses. These findings suggest that while a brief online mindfulness course may offer benefits in well-being and within-participant self-reported attention, maximizing engagement could be critical for enhancing its effectiveness.

Keywords: Online mindfulness course, eye-tracking, well-being, sustained attention, and randomized controlled trial (RCT)

Introduction

Mindfulness is the practice of being consciously aware of one's current experience while maintaining a non-judgmental stance. As described by Jon Kabat-Zinn, founder of Mindfulness-Based Stress Reduction, mindfulness is "...moment-to-moment, non-judgmental awareness, cultivated by paying attention in a specific way, that is, in the present moment, and as non-reactively, as non-judgmentally, and as open heartedly as possible" (Kabat-Zinn, 2015, p. 1). Attention is regarded as a key element within the concept of mindfulness (Prakash et al., 2020). When an individual practices mindfulness, a primary goal is that they deliberately direct and control their attention with purpose (Rice & Liu, 2017). Embedded within the realm of mindfulness attention is a form of attention called sustained attention. Sustained attention, a core component of mindfulness, refers to the ability to remain consistently vigilant over extended periods of time (Posner & Rothbart, 1992). Previous studies have shown evidence that mindfulness practice increases sustained attention (Valentine & Sweet, 1999; MacLean et al., 2010; Verhaeghen, 2021). The current study is aimed to understand whether an empirically based, structured online mindfulness course has the potential to improve participants' sustained attention along with their overall subjective well-being.

In recent years, there has been a growing popularity of online mindfulness-based interventions (MBIs). This has widened the accessibility of mindfulness trainings and resources, offering more opportunities for people to engage with these practices (Taylor et al., 2021). Considering the rapid popularity and expansion of online mindfulness courses and interventions, research has demanded further evaluation and assessment of the effects of such platforms (Cavanagh et al., 2013). Online mindfulness-based courses and MBIs offer numerous advantages, including cost-effectiveness and broader accessibility compared to many in-person alternatives (Karing, 2023). It is possible that mindfulness resources and strategies are more

easily disseminable when delivered through an online format. Further, providing engaging, easily accessible, and affordable treatment that is scalable could be a solution for reaching populations that are under-resourced (Muñoz et al., 2018; Vellakkal & Patel, 2015).

Previous research examining the impact of mindfulness training on sustained attention has produced mixed results. Some studies suggest that mindfulness practice enhances sustained attention, particularly in response to unpredictable stimuli, and indicate that changes in sustained attention are linked to shifts in DMN–DLPFC anticorrelation observed exclusively in mindfulness groups, as well as aid in fostering emotion regulation skills, which influence sustained attention (Valentine & Sweet, 1999; Bauer et al., 2020; Petranker & Eastwood, 2021). However, other studies have found null results (MacCoon et al., 2014). This study aims to contribute to the current literature by examining whether sustained attention can be enhanced through a brief, structured online mindfulness course, according to both objective and subjective measures. Ultimately, we seek to provide clarity on this topic and help bridge the gap between existing findings.

Using objective physiological measures such as a Smooth Pursuit Eye Movement (SPEM) task provides valuable insights into sustained attention. However, self-report questionnaires evaluating subjective perceptions of attention can be a useful complement and comparison to objective methods. Research shows a strong and fundamental link between mindfulness and well-being, which is supported by both correlational studies and intervention research (Nyklíček et al., 2011). Given that enhanced well-being is a core objective of mindfulness practice, it is reasonable to consider investigating it as a secondary outcome in this study.

The current study had multiple objectives. First, it aimed to investigate how an online mindfulness-based course affects objective sustained attention, which was assessed using the

SPEM task. Secondly, we sought to determine whether subjective perceptions of attention, including aspects of sustained attention, were impacted by the same course, as evaluated through the Attentional Control Scale (ACS) and single item on the Adult ADHD Self-Report Scale (ASRS). Lastly, the study aimed to explore changes in subjective well-being resulting from the online mindfulness-based course, measured using the Survey on Flourishing (SURF) questionnaire. Based on previous research that indicates mindfulness practice increases attention and well-being (Kumari et al., 2017; Christie et al., 2017), we hypothesized the following:

Hypothesis 1: A group receiving the 15-session online mindfulness-based curriculum will demonstrate significantly increased self-reported well-being on the SURF questionnaire from pre-to-post-intervention.

Hypothesis 2: A group receiving the 15-session online mindfulness-based curriculum will demonstrate significantly increased self-reported well-being on the SURF questionnaire compared to a control group that receives broad mindfulness psychoeducation.

Hypothesis 3: A group receiving the 15-session online mindfulness-based curriculum will demonstrate significantly increased self-reported attention on the ACS and single question from the ASRS from pre-to-post intervention.

Hypothesis 4: A group receiving the 15-session online mindfulness-based curriculum will demonstrate significantly increased self-reported attention on the ACS and single question from ASRS compared to a control group that receives broad mindfulness psychoeducation.

Hypothesis 5: A group receiving the 15-session online mindfulness-based curriculum will demonstrate significantly increased objective sustained attention, as evidenced by more sustained ocular patterns detected by a SPEM task from pre-to-post intervention.

Hypothesis 6: A group receiving the15-session online mindfulness-based curriculum will demonstrate significantly increased objective sustained attention, as evidenced by more

sustained patterns detected by a SPEM task compared to a control group that receives broad mindfulness psychoeducation.

Materials and Methods

Participants

Participants were recruited through SONA, a software platform designed for university researchers to recruit participants. This platform enables the creation of participant pools, the execution of both laboratory and online studies, and the online distribution of course credit to participants. Participants were selected from a large university located in the southwest. Participants needed to be at least 18 years old, be fluent in English, and currently enrolled in the university as an undergraduate student. Participants who reported any formal diagnosis of attentional disorders were excluded from the study, as this study was not aimed at investigating clinical populations. Since the intervention was online, internet access and an email address to access and be sent the questionnaires and course were also required for participation. For compensation, participants were awarded 1 SONA credits for approximately every 10 minutes spent participating in the study, with a maximum of 12 SONA credits. Participants who completed all study procedures were entered in a raffle for at least a 50% chance to win a $25 Amazon gift card. Participants were also granted a $10 Amazon gift card if they completed all post-study measures (i.e., both the post-study survey and post-SPEM task).

Throughout the fall of 2024, 63 individuals expressed interest in joining the study. Of those who expressed interest, 3 failed to meet inclusion requirements, 7 did not complete the eligibility and consent survey, and 12 were eligible and assigned, but failed to complete one or both of the pre-study measures in the time they were provided (i.e., approximately seven days). The resulting 41 participants participated in either the Mindfulness for Humans (MfH) course,

which served as the intervention group or reviewed unstructured mindfulness psychoeducational skills, for those assigned to the control group.

Of the participants randomly assigned to a group, 53.66% were female, and 46.34% were male. Majority of the sample identified as white (80.49%), with 12.20% identifying as Hispanic, Latino, or of Spanish origin, and 7.32% identifying as mixed ethnicity. Before participating in the study, participants were also asked to indicate their level of familiarity with mindfulness practice. The majority (53.66%) reported being "a little familiar," 31.71% indicated "moderate familiarity," 9.76% reported being "very familiar," and 4.88% indicated they were "not at all familiar."

Procedure

SONA provided researchers with participant email addresses. Once participants were contacted, they were asked to complete an eligibility screening survey, during which they consented to participating in the study. Participants eligible for the study were randomly assigned to either the control group or the experimental group. When assigned, researchers then emailed the participant a link to complete the SURF, ACS questionnaire, and ASRS item and inquired about scheduling a time for completing the SPEM task. Each survey session took approximately 10 minutes to complete. The SPEM task also took roughly 10 minutes to complete. Control group participants were provided with psychoeducational resources from the university's counseling and psychological services website, including handouts on managing anxiety, improving concentration, test anxiety strategies, and heart rate variability regulation, as well as relaxation recordings such as autogenic relaxation, body scans, diaphragmatic breathing, mindfulness meditation, and progressive muscle relaxation. They were instructed to engage with these resources regularly, ideally spending "some time" most days of the week over a period of several weeks engaging in the resources. Once those assigned to the experimental group

completed their pretest measures (ACS, SURF, ASRS and SPEM task), they were sent a link to enroll in the MfH course. In the emails sent to both groups of participants, they were encouraged to complete their assigned activity (i.e., engaging with psychoeducational mindfulness resources or completing the MfH course) within a 30-day timeframe. Participants received weekly reminders to engage with the MfH course or psychoeducational resources. Approximately 30 days later, researchers emailed participants and asked them to complete the ACS, SURF, ASRS and SPEM measures once more. The final surveys included a few additional questions about their experience with the resources and course as well as about their perceived level of improvement with the intervention.

Intervention

The MfH course serves as an introduction to mindfulness practice, focusing on teaching fundamental mindfulness skills through a structured program of 15 sessions, each session approximately 25 minutes long. Sessions include three components: a brief 1–2-minute introduction featuring a reflective quote or poem paired with nature imagery to set the tone, a 5–7-minute instructional video outlining key concepts, and a 15–17-minute guided mindfulness practice. The course offers a total of roughly 2 hours of instructional material and 4 hours of guided practice. The psychoeducational content was developed and informed by comprehensive reviews of mindfulness training literature and Dr. Jared Warren's extensive experience in mindfulness-based interventions spanning over a decade. Participants were not restricted to the number of sessions they could complete in a single day. Participants' progress was tracked using the online course platform (Course Creator 360), where lessons were marked "completed," generating a percentage of course completion recorded as they progressed through the course. Automated and manual text and email reminders were sent to encourage engagement, provide additional support, and suggest revisiting lesson practices. These notifications also facilitated the

detection of irregularities in course completion, such as prematurely marking lessons as completed. The course was accessible to participants for free.

The session modules consist of the following lessons:

1. What is Mindfulness?
2. Why Mindfulness Matters
3. Wherever You Are, Be There
4. Taming the Wild Mind
5. How to Work with Difficult Emotions
6. The Power of Compassion
7. The Gratitude Transformation
8. The Gift of Self-Compassion
9. The Insight of Impermanence
10. Cultivating Curiosity
11. Self-Nurturing: RAIN
12. Mindfulness; Relationships
13. Building Resilience
14. Understanding Interconnectedness
15. Seeing the Joy

Measurement

This study used a randomized, controlled trial to examine the physiological and subjective impact of an online, structured, 15-session mindfulness course. This study utilized a SPEM task to objectively measure sustained attention. Various studies have assessed sustained attentional processes through the use of SPEM (Robinson et al., 1986; Stubbs et al., 2018; Franco et al., 2014). The purpose of the SPEM task is to ensure that the image on the retina stays

focused on the central part of the eye (fovea) while tracking the movement of an object (Kumari et al., 2017). Sustaining accurate SPEM relies on the control of attention (Hutton & Tegally, 2005). Specifically, extended periods of SPEM indicate a purposeful task that requires sustained attention (Barnes, 2008; Korda et al., 2023). SPEM demonstrated high internal consistency, test-retest reliability, and ease of administration; therefore, it has been widely used in research to assess an array of attentional and cognitive functions (Ettinger et al., 2003; Kumari et al., 2017).

There are no known self-report questionnaire measures that solely assess sustained attention; however, the ACS and ASRS are both validated self-report questionnaires that indirectly measure facets of sustained attention. The ACS has shown good reliability for measuring self-reported focus and adequate reliability for attentional shifting (Judah et al., 2014). Additionally, the ASRS has also demonstrated good levels of reliability and validity in various populations, including college samples (Adler et al., 2006; Gray et al., 2014). Participants were asked to complete the ACS (Derryberry & Reed, 2002) and one item from the ASRS (Kessler et al., 2005) during the study to gather subjective data regarding attentional ability. Changes in subjective well-being were examined through the SURF questionnaire.

Smooth Pursuit Eye Movement (SPEM)

SPEM provides an objective measure of sustained attention within this study. By tracking participants' eye movements during a task, we could quantify participants ability to maintain sustained attention over time. In the SPEM task, participants must sustain their attentional engagement to continuously track the target's motion and adjust their eye movements accordingly. Sustained attention during SPEM ensures that participants remain vigilant and responsive to changes in the target's trajectory, minimizing errors and maintaining task performance over time. Internal consistency for the SPEM task ranges from .83 - .88, and the task displays consistent temporal stability over measurements, as evidenced by significant

Pearson and intraclass correlations at higher velocities of target movement (36°/s and 48°/s) (Ettinger et al., 2003).

Eye movements were recorded via an SR Research Eyelink 1000 plus eye tracker (spatial resolution of 0.01°) sampling at 1000 Hz (SR Research, Ontario, Canada). Participants saw stimuli using both eyes, but only the right eye was recorded. A chin-forehead-rest was used to minimize head movements. Participants were seated 60 cm away from a 24" LCD monitor with display resolution set to 1024 x 768 (refresh rate 120 Hz). Head movements were minimized with a chin and head rest. Although viewing was binocular, eye movements were recorded from the right eye. The experiment was controlled with SR Research Experiment Builder software. Participants completed a 9-point calibration procedure at the start and half-way through the experiment. Participants were instructed that they would see a red dot on the screen, and that they should follow it with their eyes. After completing 3 practice trials (1 for each type of movement: horizontal, vertical, or elliptical), the experiment began. Each trial involved the following sequence: the trial began with a stationary red dot. Once the participant was fixated on the dot, the experimenter triggered the trial, and the dot began to move. The three movement types were horizontal (back and forth), vertical (up and down), or elliptical (in a circle). Participants completed 20 trials of each movement type, with trial order randomized for each participant. The entire session lasted approximately 15 minutes.

Attentional Control Scale (ACS)

The ACS provides a quantitative, subjective measure of participants' attentional control abilities. Administering this scale before and after mindfulness interventions can quantify changes in participants' attentional control, providing a clear metric for assessing the self-reported effectiveness of mindfulness practices on attention. The ACS consists of 20 items divided into three correlated sub-factors and is administered on a Likert scale. These sub-factors

gauge an individual's capacity to: “1) focus attention; 2) shift attention between tasks; and 3) flexibly control thought" (Abasi et al., 2017, p. 2). Internal consistency for the ACS is .88, and test-retest reliability ranges from 0.45 to 0.73 (Derryberry & Reed, 2002; Fajkowska & Derryberry, 2010).

Adult ADHD Self-Report Scale (ASRS)

The ASRS is an 18-item self-report survey, administered on a Likert scale and designed to screen for adult symptoms of Attention-Deficit/Hyperactivity Disorder, as defined by DSM-IV criteria (Kessler et al., 2005). The selected ASRS item aligns with the construct of sustained attention, making it an appropriate supplementary item to use when measuring subjective sustained attentional control. In prior validation studies, the ASRS demonstrated strong internal consistency (Cronbach's alpha 0.88–0.89), high total score reliability between scales (ICC = 0.84), strong reliability for symptom subsets (ICC = 0.83), and acceptable agreement on individual items (43%–72%), with all items showing statistically significant kappa values ($p < 0.001$) (Adler et al., 2006).

Survey on Flourishing (SURF)

The SURF is a 20-item self-report survey, administered on a Likert scale and designed to gauge subjective well-being by capturing aspects of emotional, social, and psychological well-being. Given the SURF's comprehensive nature and validated and reliable effectiveness in measuring subjective wellbeing, this makes it a beneficial tool for the current study. The SURF demonstrated internal consistency of .93 - .96 and good convergent and discriminant validity when compared to similar well-being questionnaires (e.g., the PANAS and the SWLS) (Jackman et al., 2025).

Results

Power Analysis

This is a preliminary pilot study that will precede a larger study with an anticipated sample size of 130 participants. Specifically, we used R and Stata to determine that for the future study, we need a sample size of approximately 130 participants to detect a meaningful difference for a *t*-test analysis and 87 participants for a mixed-effects model analysis. However, because this is a pilot for the larger study, we expected the total number of participants in this initial phase to be approximately 40 in total. We used a power analysis and determined the necessary sample size needed to detect an effect size of d = .2 with 80% power. Previous research using SPEM to detect the effects of mindfulness training has found significance using similar effect size and utilized sample size around the same as the current pilot study (Kumari et al., 2017).

Data Analysis Plan

The goal of this study was to determine how participation in the MfH course influenced objective and subjective sustained attention as primary outcomes and self-reported well-being as a secondary outcome. Participants enrolled in the MfH course were tracked based on the percentage of the course and the specific amount completed for each session. This tracking was facilitated by a software program called Course Creator 360, which provided detailed statistics on the completion of participant sessions.

For the SPEM tasks, two dependent variables were analyzed. The first was velocity gain, which is the ratio of the velocity of the eyes and the velocity of the target dot. Perfect pursuit has a velocity gain of 1. The second is root mean square error (RMSE), which is the average distance between the eye fixation position and the target. Perfect pursuit is indicated as having 0 error. Each variable was analyzed using linear mixed effects models (Bates et al., 2015) in R (R Core Team, 2020). *P*-values were obtained using the *lmerTest* package (Kuznetsova et al., 2017; see Luke, 2017 for a justification of this approach). All models contained three fixed effects: Group (Experimental or Control), Session (1 or 2) and Trial Number (a numeric predictor). As the

statistical interactions are of primary theoretical interest in the present study, all possible interactions between these variables were included in every model. All categorical predictor variables were dummy coded, with Contrl and Session 1 as the comparison groups, respectively. Trial Number was centered. All models had random by-participant intercepts and by-participant slopes for Session but not for Trial Number, as this prevented the models from converging. SPEM model outputs are presented in Figures 2 and 3. Figure 2 displays RMSE outcomes, whereas Figure 3 displays velocity gain across sessions for both groups. Prior to data analysis, data from participants who completed only one session were eliminated. Data from practice trials were excluded, as were samples with velocity gain less than 0.5.

To begin data analysis for the pre- and post-surveys, we first cleaned and prepared the data by examining and handling missingness. The dataset was imported from an Excel file, and missing data were assessed systematically. Missing values were identified based on entries coded as "0" or ".". To examine patterns of missingness, a correlation analysis was performed between missingness indicators and other variables. No significant correlations were found, indicating that missing data were likely Missing Completely at Random (MCAR). After cleaning, descriptive statistics were reviewed to confirm the accuracy of the adjustment to the missing data. Outliers were addressed using fencing methods for items analyzed with *t*-tests to ensure that assumptions of normality and homoscedasticity were met. Outliers exceeding ±2.0 IQR were flagged and appropriately adjusted.

Mixed-effects models (MEM) were chosen to examine the SURF and ACS results due to their advantages in handling missing data, unbalanced data, and heterogeneity. MEM also uses least squares estimation as well as maximum likelihood estimation, and this approach is robust in dealing with incomplete data and helps to control for attrition. For example, when appropriate, missing data for participants who did not complete post-test measures was addressed using

maximum likelihood estimation within MEM. Given that participants may vary in how much of the intervention they completed, and the potential for missing data from participants not completing the post-test measures, utilizing MEM during analysis is an appropriate choice. Further, in MEM, the percentage of the intervention course completed can be included as a predictor to assess its impact on outcomes, alongside an interaction with time to explore if changes in outcomes vary by level of completion. This approach allows for modeling the dose-response relationship, making it possible to see if higher engagement in the mindfulness course leads to better outcomes.

For the ASRS analyses, there were several things to consider for analyzing the ASRS single item data using MEM. First, collinearity between time points (i.e., pre- and post-) and ASRS scores may have affected MEM performance. Also, the single-item nature of the ASRS may have limited data variance, making MEM harder to interpret. A paired t-test was chosen to examine pre-to-post- changes within participants because it appeared to be a more straightforward analysis and effective for comparing within-participant changes for those in the intervention. For differences between control and experimental groups, regression was used instead of MEM, as it provides a clearer way to analyze group effects and interactions with single-item data.

Effect sizes for the ACS, SURF, SPEM, and single item ASRS outcomes related to hypotheses 1, 2, 3, and 4 were reported as fixed-effect coefficients (*b*). Hypothesis 3 effect sizes for the ASRS were calculated using Cohen's d based on *t*-test results. Survey analyses were complete in Stata 18 and SPEM analyses in R.

Primary Analyses

First, we calculated descriptive statistics for all variables to examine their distributions and assessed baseline comparability between the intervention and control groups. Independent

sample *t*-tests were conducted to compare demographic characteristics and baseline measures of self-reported attention (ACS and ASRS) and subjective well-being (SURF) between the control and intervention groups. No statistically significant differences were observed in baseline measures across groups, confirming randomization was successful. A total of 16 participants from the experimental group and 18 participants from the control group completed both the pre- and post-study surveys, and their data were included in the analyses.

On average, participants in the intervention group who engaged in the MfH course completed 49.7% of the course. Those in the control group completed a self-reported average of 66.9 minutes per week reviewing the mindfulness resources. Among those who were in the control group, the most frequent resources utilized were: stress management and relaxation techniques. Specifically, breathing exercises and relaxation recordings were among the most mentioned and used resources. Other frequently accessed resources included an insomnia handout, test anxiety worksheet, and time management materials. Additionally, specific mindfulness practices, like body scans and a 3-minute breathing handout, were noted as being used by participants.

Hypothesis 1

Hypothesis 1: A group receiving the 15-session online mindfulness-based curriculum will demonstrate significantly increased self-reported well-being on the SURF questionnaire from pre-to-post- intervention.

A MEM was conducted to examine the impact of a 15-session online mindfulness-based curriculum on participants' self-reported well-being, as measured by the SURF survey, from pre- to post-intervention. Two models were tested: the first examined the within participant SURF scores over time (i.e., from pre- to post-) and the second controlled for the percentage of the course completed by the intervention group.

Results from the first model indicated that the changes of within participant SURF scores from pre- to post-intervention were not statistically significant (b = 0.14, p = 0.766, 95% CI [0.79, 1.07]). Additionally, approximately 38.8% of the total variance in SURF scores was attributable to participant-level variance (ICC = 0.39), meaning that individual differences between participants accounted for nearly 39% of the variation in their SURF scores. This suggests that participants' unique characteristics have a significant influence on their scores, which is salient for understanding how much of the variation is due to factors specific to the individuals themselves, rather than external factors or measurement error. In the second model, which controlled for percentage of the course completed (i.e., percentcomplete), time as a fixed effect in the course remained non-significant (b = -0.19, p = 0.787, 95% CI [-1.56, 1.18]). However, course completion was significantly associated with SURF scores (b = 0.019, p = 0.021, 95% CI [0.003, 0.036]), suggesting that participants who completed a higher percentage of the course reported greater well-being. Additionally, participant-level variance accounted for 37.7% of the total variance in SURF scores (ICC = 0.38).

[Insert Figure 1 here]

Figure 1. Change in Well-Being (SURF Score) Based on Percentage of Course Completed.

Hypothesis 2

Hypothesis 2: A group receiving the 15-session online mindfulness-based curriculum will demonstrate significantly increased self-reported well-being on the SURF questionnaire compared to a control group that receives broad mindfulness psychoeducation.

Compared to the control group that received broad, unstructured mindfulness psychoeducation, a MEM revealed a significant overall increase in SURF scores from pre- to post-intervention across all participants (b = 0.28, p = 0.010, 95% CI [0.07, 0.49]), suggesting that participants reported higher well-being at the end of the study regardless of group

assignment. Further, the interaction between group and time was not significant (b = -0.11, p = 0.600, 95% CI [-0.54, 0.31]), indicating no significant difference in the magnitude of change in SURF scores between the intervention group and the control group. Table 1 displays descriptive statistics for SURF scores at pre- and post- measure for both groups.

Table 1. ***Descriptive Statistics for SURF Scores (Pre- and Post-Measure)***

Group	Pre	Post	Mean Increase
Intervention	4.85 (SD = 1.14)	5.07 (SD = 1.30)	0.22
Control	4.83 (SD = 0.98)	5.16 (SD = 0.86)	0.33

The intraclass correlation coefficient (ICC = 0.83) revealed that 82.5% of the total variance in SURF scores was attributable to individual participant-level differences.

Hypothesis 3

Hypothesis 3: A group receiving the 15-session online mindfulness-based curriculum will demonstrate significantly increased self-reported attention on the ACS and single question from the ASRS from pre-to-post- intervention.

A MEM was conducted to examine the impact of a 15-session online mindfulness-based curriculum on participants' subjective attentional abilities, as measured by the entire ACS survey. For the MEM, two models were tested: the first examined the within participant ACS scores over time (i.e., from pre- to post-) and the second controlled for the percentage of the course completed by the intervention group. A paired t-test was determined to be an adequate analysis to compare within participant differences in the ASRS single item.

Results showed a statistically significant decrease in ACS scores over time (i.e., from pre- to post-) for those in the intervention group (b = -0.25, p = 0.037, 95% CI [-0.49, -0.02]), indicating a slight improvement in participants' self-reported attention control following the

intervention, as decrease in ACS scores indicate heightened attentional ability. The intraclass correlation coefficient (ICC) showed that approximately 7.5% of the variance in ACS scores was attributable to participant-level differences. When controlling for the percentage of the course completed, the time effect (i.e., pre- to post-) became non-significant (b = -0.36, p = 0.062, 95% CI [-0.74, 0.02]), and course completion percentage was not significantly associated with ACS scores (b = -0.002, p = 0.389, 95% CI [-0.006, 0.003]), suggesting that participant engagement did not meaningfully influence subjective attention control outcomes on the ACS.

A paired t-test was performed to assess changes in the single-item ASRS scores from pre- to post-intervention. The mean pre-intervention score was 3.25 (SD = 0.93), and the mean post-intervention score was 3.13 (SD = 1.15), resulting in a mean difference of 0.125 (t(15) = 0.42, p = 0.68, 95% CI [-0.52, 0.77]). This difference was not statistically significant, indicating no meaningful change in ASRS single-item scores from pre- to post-intervention within the intervention group.

Hypothesis 4

Hypothesis 4: A group receiving the 15-session online mindfulness-based curriculum will demonstrate significantly increased self-reported attention on the ACS and single question from ASRS compared to a control group that receives broad mindfulness psychoeducation.

A MEM was conducted to assess the impact of a 15-session online mindfulness-based curriculum on participants' self-reported attentional abilities compared to a control group that participated in unstructured mindfulness psychoeducation, as measured by the full ACS survey. Additionally, a linear regression was used to examine differences in the single item ASRS survey scores between the intervention and control groups from pre- to post- intervention.

Results from the MEM revealed a significant main effect of time (b = -0.16, p = 0.006, 95% CI [-0.28, -0.05]), indicating that ACS scores decreased from pre- to post-measures across

both the intervention and control group. As lower ACS scores indicate better attentional ability, this finding reflects an overall improvement in self-reported attention regardless of group. The intraclass correlation coefficient (ICC) showed that approximately 56.7% of the variance in ACS scores was attributable to participant-level differences. The group and time interaction were not significant (b = -0.20, p = 0.085, 95% CI [-0.42, 0.03]), suggesting that the magnitude of improvement did not differ significant between the intervention and control group. Descriptive statistics revealed that the intervention group's ACS scores decreased from a pre-intervention mean of 2.40 (SD = 0.37) to a post-intervention mean of 2.13 (SD = 0.30), while the control group scores decreased slightly from 2.41 (SD = 0.37) to 2.34 (SD = 0.41). Although these findings indicate a general decline in ACS scores over time for both groups, there were no statistically significant between-group differences.

A linear regression was conducted to examine the effect of group assignment (intervention vs. control) on pre- to post- ASRS scores. The regression model showed that pre-ASRS scores were a significant predictor of post-ASRS scores (b = 0.44, p = 0.047, 95% CI [0.01, 0.87]). This demonstrates that higher pre-ASRS scores were associated with higher post-ASRS scores. However, group assignment (b = −0.18, p = 0.603, 95% CI [−0.87, 0.51]) and the interaction between group and pre-ASRS scores (b = −0.04, p = 0.933, 95% CI [−0.94, 0.86]) were not significant, suggesting that there were no significant differences from pre- and post- on the ASRS between groups. Descriptive statistics showed that the intervention group had a mean pre-ASRS score of 3.25 (SD =0.93) and a mean post-ASRS score of 3.13 (SD = 1.15). The control group had a mean pre-ASRS score of 3.44 (SD = 0.70) and a mean post-ASRS score of 3.39 (SD = 0.92). Overall, the findings suggest no significant differences in ASRS score changes between the control and intervention groups. A summary of the SURF and ACS outcomes for the

within- and between-group analyses is represented in Table 2. Table 3 represents the within- and between-group ASRS outcomes.

Table 2. ***SURF and ACS Outcomes for Within- and Between-Group Subjective Well-Being and Attention Comparisons***

Hypothesis	Outcome	Group Comparison	p-value	Effect size (*b*)	95% CI
1	SURF survey	Within subject (intervention group) pre- to post- subjective well-being	0.766	0.14	-0.79, 1.07
2	SURF Survey	Between subject (intervention vs. control) subjective well-being	0.600	-0.11	-0.54, 0.31
3	ACS	Within subject (intervention group) pre- to post- subjective attention	0.037	-0.25	-0.49, -0.02
4	ACS	Between subject (intervention vs. control) subjective attention	0.085	-0.20	-0.42, 0.03

Table 3. ***ASRS Outcomes for Within- and Between-Group Subjective Attention Comparisons***

Hypothesis	Outcomes	Group Comparison	p-value	Test Statistic	95% CI
3	ASRS	Within subject (intervention group) pre- to post- subjective attention	0.680	t = 0.42	-0.52, 0.77
Hypothesis	**Outcomes**	**Group Comparison**	**p-value**	**Effect Size**	**95% CI**
4	ASRS	Between subject (intervention vs. control) subjective attention	0.933	$b = -0.04$	−0.94, 0.86

Hypothesis 5 and 6

Hypothesis 5: A group receiving the 15-session online mindfulness-based curriculum will demonstrate significantly increased objective sustained attention, as evidenced by more sustained ocular patterns detected by a SPEM task from pre-to-post- intervention. Hypothesis 6: A group receiving the 15-session online mindfulness-based curriculum will demonstrate significantly increased objective sustained attention, as evidenced by more sustained patterns detected by a SPEM task compared to a control group that receives broad mindfulness psychoeducation.

A total of 11 participants from the intervention group and 15 participants from the control group completed both the pre- and post-SPEM measures, and their data were included in the analysis. There was robust evidence that velocity gain decreased for later Trial Numbers (b = 0.00032, se = 0.000071, t = -4.6, $p < .0001$) and that error increased for later Trial Numbers (b = 0.0026, se = 0.00023, t = 11.15, $p < .0001$). There was some evidence of an increase in Velocity Gain from Session 1 to Session 2 (b = 0.017, se = 0.0035, t = 4.67, $p < .0001$). However, Group was not significant in either the analysis of Velocity Gain or RMSE (both ps > .31), and Group did not interact with Session in either analysis (both ps > .62). Thus, these results provide no support for Hypotheses 5 and 6.

[Insert Figure 2 here]

Figure 2. SPEM Error Rates from Pre- to Post- Measure.

[Insert Figure 3 here]

Figure 3. SPEM Velocity Gain from Pre- to Post- Measure.

Discussion

Study Conclusion

This is the first study to our knowledge to examine both the objective and subjective effects of a brief, structured online mindfulness-based course on sustained attention utilizing a

randomized control design. Results revealed that while the mindfulness course did not produce statistically significant overall improvements in objective sustained attention, participant engagement played a salient role in outcomes. Specifically, greater course completion was associated with higher post-intervention well-being scores, emphasizing the importance of active engagement in mindfulness-based interventions. A significant main effect of time on ACS scores indicated that participants, regardless of group assignment, reported improved attentional ability from pre- to post measure. However, the non-significant group and time interaction suggests that the magnitude of improvement did not differ between the intervention and control group. Similarly, the objective measures of sustained attention, assessed through the SPEM eye-tracking task, did not show significant differences between the intervention and control group. This may be due to a potential higher baseline attentional capacity in the undergraduate sample, which could have limited the room for observable improvement. Additionally, it is possible that because both groups received mindfulness-based materials, this may have contributed to within-participant improvements across the entire sample. Lastly, external factors such as participant fatigue or varying levels of motivation during the task could have contributed to variability in SPEM results, further masking potential effects of the intervention.

Taken together, these findings suggest that while the intervention had limited effects on attention, the relationship between participant engagement and outcomes in well-being demonstrates the importance of designing mindfulness interventions that foster consistent and meaningful participation. Future studies are encouraged to explore strategies to increase engagement and examine whether extending the duration of the intervention might yield more substantial effects on both subjective and objective measures of attention and well-being.

Limitations

This study highlights the value of using both objective SPEM and subjective measures such as the SURF, ACS, and a single item on the ASRS to evaluate mindfulness outcomes. This demonstrates a comprehensive approach to assessing intervention effects. The online format of the intervention offers significant advantages, including increased accessibility and scalability, making it particularly beneficial for under-resourced populations (Schueller et al., 2019). However, several limitations must be addressed. First, the small sample size and reliance solely on undergraduate students restricts the generalizability of the findings to broader populations. Second, consistent participant engagement was difficult to ensure, a common challenge in online mindfulness-based interventions (Abeysinghe Mudiyanselage et al., 2024). While course completion rates were tracked, the level of genuine engagement and thoroughness likely varied among participants, introducing uncertainty into the data. Ideally, all participants in the experimental group would fully complete and engage with the course, but the reliance on self-reported engagement data limits the accuracy of this measure. Engagement may be a critical factor for outcomes, as greater course completion was associated with improved post-intervention well-being scores. Finally, an active control group was included in the study, which engaged with unstructured evidence-based mindfulness resources comparable to those provided in the structured course. Despite this distinction between the structure, it is reasonable to expect that both the structured course and the unstructured mindfulness resources would yield beneficial effects for participants in both groups, a trend that was modestly observed in the findings. Future research should investigate factors influencing participant engagement and incorporate additional measures to better capture intervention efficacy. Lastly, the pre-post design of this study limits the ability to evaluate long-term effects, emphasizing the need for future studies to adopt longitudinal approaches to better assess sustained effects.

Future Direction

This study provides a preliminary exploration of the effects of a structured, online mindfulness-based curriculum on attentional ability and well-being, highlighting the potential of such interventions to enhance accessibility to evidence-based mindfulness resources. However, the small sample size and homogenous population sampled (i.e., composed primarily of undergraduate students), limits the generalizability of these findings to broader populations. It is difficult to determine whether the observed results would hold true in more diverse or larger samples. Future research must address these limitations by recruiting participants from varied demographics and increasing the sample size to ensure statistical power and broader applicability of the results. Despite these constraints, the intervention shows promise as a scalable, cost-effective means to deliver evidence-based mindfulness resources to individuals who might otherwise lack access. By refining the engagement strategies of online evidence-based programs, future studies can better evaluate their efficacy and expand their reach to under-resourced populations, ultimately contributing to the growing field of accessible mental health interventions.

Statements and Declarations

Clinical trial number: not applicable.

Funding: This study was funded with internal funds provided by the College of Family Home and Social Science and Department of Psychology at Brigham Young University.

Competing interests and conflicts of interest: The authors have no competing interests or conflicts of interest to declare that are relevant to the content of this article.

Ethics approval and consent to participate: All study activities were approved by Brigham Young Universities' institutional review board (IRB2024-175). All participants provided informed consent.

Consent for publication: Not applicable.

Availability of data and materials: All data and materials will be made available upon request.

Authors' Contributions: *Eve Barton: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Resources, Data Curation, Writing - Original Draft, Writing - Review & Editing, Visualization, Supervision, Project administration, Funding acquisition

Steven G. Luke: Conceptualization, Methodology, Software, Validation, Formal analysis, Resources, Data Curation, Writing - Original Draft, Writing - Review & Editing, Visualization, Supervision, Project administration

Ruth A. Jack: Conceptualization, Investigation, Resources, Writing - Review & Editing, Project administration

Jared S. Warren: Conceptualization, Methodology, Writing - Original Draft, Writing - Review & Editing, Supervision

Acknowledgements: Our study team would like to acknowledge the undergraduate research assistant Coral Van Noy for her contributions to the study design and data collection.

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