Mindfulness
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ORIGINAL PAPER

Relax and Repeat: Disentangling the Roles of Mindfulness and Task Repetition on Duration Perception

Matthew Hopkins[1,2] · Katie Bishop[1] · Mia Ashman[1] · Phil Reed[1] · Irene Reppa[1]

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Abstract

Objectives Mindfulness meditation has been reported to lengthen perceived durations, but it remains unclear whether these effects reflect meditation itself or confounding factors such as task repetition. Brief, app-based mindfulness practices are widely used by novices, yet they may induce states of relaxation rather than genuine mindfulness. The present study investigated whether short meditation sessions produce unique effects on duration judgments, or whether repetition better accounts for observed changes.

Methods In Experiment 1A, 178 adults completed an online visual temporal bisection task before and after a brief 5-min interval which involved either a focused attention meditation ($n = 63$), unfocused attention meditation ($n = 64$), or doing nothing ($n = 50$). Experiment 1B ($n = 60$) was a laboratory replication of Experiment 1A. In Experiment 2 ($n = 64$), the order of sessions was reversed: participants first completed a 5-min meditation and then performed the bisection task twice, allowing direct assessment of repetition effects.

Results In both Experiments 1A and 1B, stimulus durations were overestimated after the interval across all groups, with only small and inconsistent group differences. In Experiment 2, a clear leftward shift in the psychophysical function occurred from the first to the second task session, indicating robust overestimation driven by task repetition.

Conclusions The findings suggest that brief meditation sessions do not uniquely affect time perception in participants with no prior meditation experience. Instead, task repetition emerged as the dominant driver of overestimation, consistent with attention-based models of duration judgments. These results highlight the need to distinguish meditation-specific influences from the more general effects of relaxation and repeated task exposure.

Preregistration This study was not preregistered.

Keywords Focused attention meditation · Unfocused attention meditation · Relaxation · Temporal bisection · Task repetition

Every day, people report feeling pressed for time, despite their free time not decreasing or working hours strongly increasing, and this subjective "time scarcity" is tied to stress, reduced well-being, and impaired cognition (e.g., Robinson, 1999; Szollos, 2009). Mindfulness, broadly defined as intentionally attending to present-moment experience with openness and non-judgment, has been proposed as one avenue for increasing one's sense of available time and alleviating time-related stress (e.g., Kabat-Zinn & Davidson, 2012). By cultivating heightened attention to the "prescient present", mindfulness may not only enhance psychological health but also fundamentally alter how we perceive the passage of time.

Contemporary work on mindfulness shows that focused attention meditation involves having a heightened sense of attention and awareness of the present by focusing on one specific object, e.g., one's breath coming in and out (e.g., Bodhi, 2011; Kabat-Zinn & Davidson, 2012; Prakash et al., 2020). It is known to enhance many aspects of cognition (e.g., Kramer et al., 2013), such as attentional control (e.g., Ahne & Rosselli, 2024; Moore & Malinowski, 2009; Sauer et al., 2012), and working memory capacity (e.g., Bajestani et al., 2024; Jha et al., 2010). Relaxation is generally defined

✉ Irene Reppa
i.reppa@swansea.ac.uk

1 School of Psychology, Swansea University, Swansea, UK

2 Faculty of Health, Education and Society, University of Northampton, Northampton, UK

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as a reduction in physiological arousal following an intervention, such as following a muscle relaxation exercise (e.g., Benson, 1975). Psychologically, relaxation refers to a reduction in mental tension and emotional arousal, such as anxiety or anger. In this definition relaxation is viewed as the decrease in the tendency for emotional arousal.

Mindfulness has been examined as one of the ways to increase the subjective sense of having more time (e.g., Kabat-Zinn & Davidson, 2012). Accurate time perception is implicated in, and associated with, cognitive tasks, such as recall (e.g., D'Argembeau et al., 2012), experience of the prescient present (e.g., Ornstein, 1969), and motor actions (e.g., Wearden, 2016). In one of the first studies to examine the effect of mindfulness on time perception, Kramer et al. (2013) examined the effect of a brief, 10-min meditation on duration of visual stimuli in a temporal bisection task. Meditation-naïve participants were initially presented with a short (0.4 s) and a long standard duration (1.6 s). They subsequently judged whether comparison durations of the same or of intermediate values were more similar to the short or the long standard durations. The temporal bisection task was performed both *before* and *after* the mindfulness exercise or the audio book. The psychophysical function shifted toward the left in the bisection task performed after the meditation exercise compared to that before the meditation exercise, thus lowering the point of subjective equality (bisection point) in a way which is consistent with a lengthening effect of focused attention meditation on duration judgments. The authors attributed their results to the meditation exercises which would have induced heightened attentional control in their participants, causing them to consequently pay more attention to time after than before the meditation exercise.

Yet evidence from later work indicates that the effects of brief mindfulness practice on time perception may be far less robust than initially suggested. Specifically, Droit-Volet et al. (2015) failed to replicate the observation of Kramer et al.'s (2013) of lengthening of durations as a result of a single meditation session in meditation-naïve participants. Instead, they observed a perceived dilation of time occurred for both the meditation and the relaxation groups, only after 20-min of daily meditation or muscle relaxation for 5 weeks in preparation for the study. Although the findings of both studies are consistent with the notion that mindfulness meditation can distort perception of time, causing stimuli to appear longer, such time lengthening effects may only emerge after long-term commitment to the practice as opposed to after a single session.

Crucially, task repetition itself can bias duration judgments, even in the absence of any intervention. Repeating identical pre- and post-treatment timing tasks can lead to duration overestimation, likely due to increased task familiarity or boredom (e.g., Danckert & Allman, 2005; Droit-Volet et al., 2020; Witowska et al., 2020). Individuals who are more prone to boredom tend to overestimate durations to a greater extent (Danckert & Allman, 2005), and boredom experienced during COVID-19 lockdowns was similarly associated with a slowing of perceived time (Droit-Volet et al., 2020).

The aim of the present study was to obtain converging evidence on how different forms of meditation influence duration judgments. We extended previous work in three key ways. First, we included an unfocused attention meditation group to allow us to examine the effects of different meditation exercises on time perception. Second, previous work did not use a neutral baseline, where participants were not involved in any externally guided exercise. To this effect, in Experiment 1 we included a passive control group, where participants were asked to relax and refrain from doing anything for 5 min (see Online Resource 1 for specific instructions). Finally, given that previous studies have compared duration judgments post-meditation to those from a pre-meditation in an identical task, in Experiment 2, we examined the effect of task repetition on duration judgments in addition to meditation practice.

In light of the proliferation of mindfulness apps offering short meditations, the present study focused on the effects of brief, 5-min meditation on the duration judgments of visual stimuli. The temporal bisection task was chosen to study prospective duration perception following a short meditation. Sub-second durations were chosen as those are likely to make the temporal bisection task harder because it makes it harder for participants to count (e.g., Droit-Volet et al., 2015; Kramer et al., 2013). Participants were trained on two anchors: the short anchor was 200 ms, and the long anchor was 800 ms. They were then presented with stimuli at different durations, i.e., 200, 300, 400, 500, 600, 700, & 800 ms and asked whether the comparison intervals were closer to the short anchor, or closer to the long anchor (e.g., Wearden et al., 1999). This procedure allowed us to construct the psychophysical function, which describes how participants judged the durations of stimuli across the full range of intervals.

From this function, we derived two key measures. The first is the Point of Subjective Equality (PSE), which is the duration at which a participant is equally likely to classify a stimulus as "short" or "long". The PSE therefore reflects the subjective midpoint of perceived time, and shifts in the PSE indicate whether durations are perceived as lengthened or shortened. The second measure is the Difference Limen (DL), which reflects timing sensitivity. Specifically, the DL is tied to the concept of the just noticeable difference, which is the smallest change in stimulus duration that can be reliably detected about half the time. A smaller DL indicates greater sensitivity to differences in duration, whereas a larger DL suggests less precise temporal discrimination. Together, the PSE and DL provide complementary indices of how meditation and task repetition influenced both perceived duration and accuracy of timing judgments.

Method

Participants

Experiment 1

Experiment 1A. Participant testing began in April 2022 and was completed by May 2024. All participants provided informed written consent. The target sample size for Experiment 1A was determined a priori using G*Power for the planned paired-samples *t*-tests, which were the primary analyses addressing our hypotheses ($\alpha = 0.05$, 90% power, large effect size, $d = 0.50$; McHugh et al., 2010; Reed, 2019), indicating that 24 participants per group were required. An equivalent analysis for the omnibus ANOVA yielded a similar requirement, confirming the adequacy of this sample size.

A total of 178 university students (135 females, 42 males; 1 other) were recruited. Power analysis indicated that 24 participants per group (72 in total) were required to detect a small to medium effect size. However, because data collection was conducted concurrently by multiple researchers, more participants were tested per condition than originally planned. Participants were between the ages of 18 and 67 ($M = 23.5$; $SD = 8.40$). All were naïve to the purpose of the study. Fifty-five participants were recruited from student peers of two of the authors (KB and MA) through distribution of the experiment link. The remaining 83 participants were recruited from School of Psychology Participant Pool in exchange for participant pool credits. We did not gather information about the amount of prior meditation experience but based on the population we recruited from (i.e., undergraduate students) the majority of our participants were deemed likely to have some familiarity with meditation, but unlikely to have significant meditation experience.

Experiment 1B. Participant testing of started in February 2025 and ended on 17th August 2025. All participants provided informed written consent. The sample size was informed by the power analysis reported in Experiment 1A.

Sixty new participants (42 females and 18 males) who had not taken part in Experiment 1A were recruited via the School of Psychology Participant Pool in exchange for participant pool credits, and from peers of one of the authors (MA). They were between the ages of 18 and 40 ($M = 21.3$; $SD = 4.15$). All were naïve to the purpose of the study. Twenty participants were randomly assigned to the passive control, focused attention, or unfocused attention groups. We did not collect information about prior meditation experience, but we deem the majority of our participants to have some familiarity with meditation, but no significant meditation experience.

Experiment 2

Sixty-four participants, 40 females and 24 males, were recruited from the Prolific website. Thirty-two participants took part in the focused attention group (17 females and 15 males) and 32 participants in the unfocused attention group (23 females, and 9 males). Participants were naïve to the aim of the study and were reimbursed the equivalent of £4.50 for their time. Their age ranged between 18 and 65, with a mean age of 38 ($SD = 11.07$) years. Testing began on the 16th of April 2024 and ended on the 29th of August 2025.

Procedure

Experiment 1

Experiment 1A. The experiment was based on a mixed design with Group (focused attention meditation, unfocused attention meditation, and passive control) as a between-participants variable, and Stimulus Duration (200, 300, 400, 500, 600, 700, & 800 ms) and Session (baseline versus post-manipulation), as within-participant variables. The combination of the two within-participants variables yielded a total of 140 trials per participant, with 10 trials per stimulus duration in each of the two sessions. The dependent variables were the percentage of long responses (responses made to the button associated with long divided by total responses and then multiplied by 100); the point of subjective equality (PSE; where there is equal probability of selecting long or short when a stimulus is presented) and the difference limen (DL; a measure of sensitivity and reflects the amount of change in a stimulus dimension required to produce a noticeable difference in behaviour.

All participants completed the study individually online using the Gorilla experimental platform (gorilla.sc), using their own PCs in their own environment. The use of tablets and phones was disabled as an option in the Gorilla experiment builder software, because we needed participants to respond using a keyboard. Participants were randomly assigned to one of three groups: focused attention meditation ($n = 63$), unfocused attention meditation ($n = 64$), and passive control ($n = 50$). Participants were presented with instructions about the task and then proceeded to the experiment.

In the first phase of the temporal bisection task, each trial during the initial training started with a blank white screen, presented for 1 s, followed by an 86 mm × 54 mm grey oval, presented in the centre of the screen, for either 200 ms or 800 ms – this is known as the *standard stimulus*.

Each standard stimulus was presented 5 times in a random order and then disappeared from the screen. Immediately after each stimulus, the word SHORT (for the 200 ms duration) or LONG (for the 800 ms duration) appeared on the screen for 1 s. Each presentation followed by a 1 s inter-trial interval.

Following the training phase, participants moved to the test phase, where either a square or circle (in red, blue, or green) appeared on the screen for one of the 7 possible durations – 200, 300, 400, 500, 600, 700, and 800 ms. Colour and shape were randomised on every trial independently of duration (in addition to duration order being randomised). There were 10 trials for each condition, yielding 70 trials in total. The task was to indicate whether each comparison interval was closer to the short anchor, or closer to the long anchor. Using a QWERTY keyboard, half of the participants pressed the Z key for "long" and the M key for "short", while the mapping was reversed for the other half of the participants.

Participants were then exposed to either a 5-min focused or unfocused attention meditation or do nothing (passive control) for 5 min. Each meditation group listened to a 5-min audio recording while watching a video of 10 images of nature (e.g., mountains, lakes, valleys, and sunsets), each presented for 30 s and gradually appearing and disappearing from the screen to avoid abrupt changes. In the passive control condition, a timer counting down from 300 s appeared at screen centre, superimposed at the top section of the images. The audio files for the two types of meditation were narrated by a professional instructor of mindfulness meditation, originally created for a study by Hafenbrack et al. (2014). Arch and Craske's (2006) script was modified for use in the focused attention-meditation audio, which used materials from Kabat-Zinn and Davidson (2012).

The instructions for the two meditation groups, provided just prior to the start of the audio appear in Online Resource 1. In the *focused attention* meditation group, participants were instructed to focus their attention on each breath, without trying to control it, but instead experiencing it as it was in that moment with curiosity. Participants were asked to acknowledge and accept any thoughts or feelings without dwelling on them. These instructions were repeated periodically throughout the 5-min session. In the *unfocused attention* meditation group, participants were asked to think about whatever came to mind, and to let their mind wander freely without trying to focus on anything in particular. Those instructions were repeated frequently throughout the 5-min session at the same time intervals used in the focused attention meditation instructions.

Participants in the passive control group were encouraged to relax and refrain from any activities for 5 min (see Online Resource 1). Following the passive control condition, participants were asked to say whether they followed the instructions, how they did so, and if not, what did they do instead. Once 5 min had passed, all participants carried out the same temporal bisection task as before.

Experiment 1B. The design of Exp.1B was identical to Exp.1A.

The procedure of the temporal bisection task was the same as Experiment 1A, with the only difference that the experiment took place in the lab. The experimenter (MA or IR) met the participants and went through the procedure briefly. Participants were asked to put their phones on silent and out of reach, and to put on experimenter-provided headphones to ensure minimisation of distractions for all three groups, and the ability to focus on the audio (for the meditation groups).

Experiment 2

Experiment 2 was a mixed design, with Group (focused attention versus unfocused attention) manipulated between participants, and Session (first versus second) and Stimulus Duration (200, 300, 400, 500, 600, 700, and 800 ms) manipulated within-participants. Participants were randomly assigned to either the focused attention or to the unfocused attention meditation. The dependent measures were percentage of "long" responses, PSE and DL.

The procedure for temporal bisection tasks in Experiment 2 was identical to that in Experiment 1. All participants completed the experiment individually online on a PC (we did not permit the use of tablets or mobile phones). Unlike Experiment 1, participants first followed a 5-min meditation session, followed by the temporal bisection task (first session). After a period of 2 min, they repeated the temporal bisection task (second session), including the re-training with the standard durations.

Measures

Experiment 1

Experiment 1A. The stimuli for the temporal bisection task used in the present study was a grey oval measuring (in millimetres) 86 mm × 54 mm, which was used during training, and a square or circle both appearing in red, blue, or green colours, measuring 85 mm × 85 mm, which was used during the test phase. We used grey ovals as standards and coloured shapes as comparison stimuli to replicate Kramer et al. (2013) as closely as possible and to keep the standards visually distinct from the test items, minimising memory interference between the anchor training and the subsequent decisions.

Experiment 1B. All materials were identical to those of Experiment 1A.

Experiment 2

The materials were the same as in Experiment 1.

Data Analyses

The data analysis procedure followed the same rules for both experiments. The percentage of "long" responses was calculated per participants for each of the 7 stimulus durations. Participants who reported "long" at 200 ms more than 20% of the time and at 800 ms less than 75% of the time were removed from the analysis (e.g., Kramer et al., 2013).

Experiment 1

Experiment 1A. The data cleaning process described above removed 8 participants from the analysis: 2 from the focused attention group, 5 from the unfocused attention group, and 1 from the passive control group. Participants in passive control group reported a variety of activities during the 5-min intervention, including daydreaming, thinking about upcoming tasks, watching the countdown timer, and reflecting on personal matters.

Experiment 1B. The data from 6 participants in the focused attention group, and 5 participants from the unfocused attention group, were removed from the analysis as outliers using the same procedure as outlined in Experiment 1A.

Experiment 2

The data from 3 of the 32 participants in the focused attention group, and 2 of the 32 participants in the unfocused attention group were removed from the dataset due to incomplete data.

Results

Experiment 1

Experiment 1A. Figure 1 shows the group mean percentage times each stimulus duration was classified as "long" after the baseline and post-manipulation conditions: focused attention meditation (top panel); unfocused attention meditation (middle panel); and passive control (bottom panel). For all groups, there was the expected function of greater percentages being classified as "long", as the length of the actual stimulus presented increased.

A 3 (Group: focused attention, unfocused attention, passive control) × 2 (Session: first vs. second) × 7 (Duration: 200, 300, 400, 500, 600, 700, and 800 ms) mixed Analysis of Variance (ANOVA) with Group as the between-participants variable was carried out on the percentage of "long" responses. There was a significant main effect of stimulus Duration, $F(6,1044)=1703.91$, $p<0.001$, $\eta_p{}^2=0.91$, with increasing percentage of "long" responses as stimulus durations increased. There was also a significant main effect of Session, $F(1,174)=36.35$, $p<0.001$, $\eta_p{}^2=0.17$, qualified in a significant Session × Duration interaction, $F(6,1044)=14.39$, $p<0.001$, $\eta_p{}^2=0.08$. Simple main effects analyses showed higher percentage of "long" responses in the second compared to the first session for stimulus durations between 400–600 ms.

There was a significant main effect of Group, $F(2, 174)=4.17$, $p=0.02$, $\eta^2{}_p=0.05$, which was further qualified by a significant Group × Duration interaction, $F(12,1044)=2.11$, $p=0.01$, $\eta^2{}_p=0.02$. Simple main effects analysis showed higher overall percentage 'long' responses for the focused attention compared to the unfocused attention and passive control groups for stimulus durations between 400 and 600 ms. There were no other significant interactions, and importantly no significant interaction between Session and Group, $F(2,174)=0.50$, $p=0.60$.

Next, we present the analysis of each group in separate 2 (Session) × 7 (Duration) ANOVAs. Although these analyses were not necessary given the lack of significant Group × Session interaction, we nonetheless report them here only to facilitate comparison with the study by Kramer et al. (2013), who only reported separate analyses for their control and experimental groups.

Focused attention group analyses. A significant main effect of Session was observed, $F(1,62)=15.97$, $p<0.001$, $\eta^2{}_p=0.20$, indicating a higher percentage of "long" responses in the second session (after the mindfulness audio) of the temporal bisection task relative to the first. A main effect of Duration was also significant, $F(6,372)=806.41$, $p<0.001$, $\eta^2{}_p=0.09$, confirming that the percentage of "long" responses was higher as stimulus durations increased. The Session × Duration interaction was also significant, $F(6,372)=6.93$, $p<0.001$, $\eta^2{}_p=0.10$, suggesting that the percentage of "long" responses varied across durations and this degree of variance was greater in the second session relative to the first. An analysis of the simple main effects revealed there to be a greater percentage of "long" responses for 300 ms, 400 ms and 500 ms in the second session compared to the first ($p=0.02$; $p<0.001$, and $p<0.001$ respectively). There were no significant differences in the percentage of long responses between the first and the second session in the other stimulus durations (all p-values >0.05).

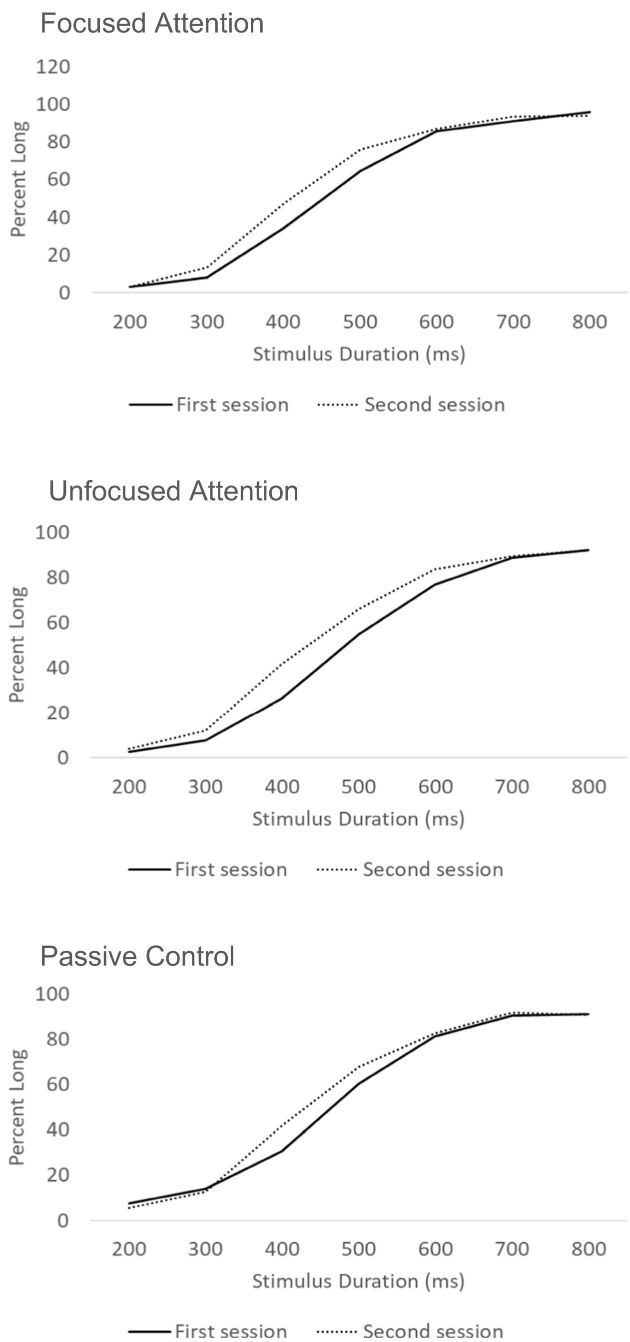

Fig. 1 Percentage of "long" responses at each stimulus duration before (First Session) and after the 5-min treatment (Second Session) for the three groups in Experiment 1A (online testing)

Unfocused attention group analyses. A significant main effect of Session, $F(1,63) = 23.02$, $p < 0.001$, $\eta^2_p = 0.27$, and Duration $F(6,378) = 578.45$, $p < 0.001$, $\eta^2_p = 0.90$, were observed on the percentage of 'long' responses. The Session × Duration interaction was significant, $F(6,378) = 5.18$, $p < 0.001$, $\eta^2_p = 0.08$. Simple main effects analyses showed a significantly greater percentage of "long" responses in the second session relative to the first for the 400 ms ($p < 0.001$), 500 ms ($p < 0.001$), and 600 ms ($p = 0.003$) durations. There were no significant differences in the percentage of long responses between the first and the second session in the other stimulus durations (all p-values > 0.05).

Passive control group analyses. In the passive control group, the main effects of Session, $F(1,49) = 4.86$, $p = 0.03$, $\eta^2_p = 0.09$, and Duration, $F(6,294) = 399.31$, $p < 0.001$, $\eta^2_p = 0.89$, were significant, with higher percentage of "long" responses in the second session (after 5 min of doing nothing), and higher percentage of "long" responses at "long" stimulus durations. The Session × Duration interaction was significant, $F(6,294) = 3.76$, $p < 0.001$, $\eta^2_p = 0.07$. There was a significantly higher percentage of "long" responses in the second session relative to the first session for the 400 ms ($p = 0.01$) and 500 ms ($p = 0.04$) durations. There were no significant differences in the percentage of long responses between the first and the second session in the other stimulus durations (all p -values > 0.05).

PSE and DL analyses. The top panel of Fig. 2 shows the mean change (post-manipulation minus baseline) in the Point of Subjective Equality (PSE) for all three groups. Low PSE values in one condition compared to another suggest a lengthening of perceived time (i.e. an increase in "long" responses), while higher PSE values indicate a shortening of perceived time (i.e. a reduction in "long" responses). PSE decreased for all groups after the post-manipulation, indicating a shift to the left, or greater over-estimation. Visual inspection of these data suggests that increased overestimation (decreased PSE) was most pronounced for the focused and unfocused attention groups, relative to the passive control group.

For the PSE and DL indices, we were primarily interested in whether each group showed a significant change from baseline to post-manipulation, rather than whether groups differed from each other. Accordingly, we ran one-sample t-tests against zero change for each of the groups. Comparisons against zero change using a paired t-test (with Bonferroni correction, $p = 0.05 / 3 = 0.0167$), revealed a large-sized and significant decrease in PSE (increased over-estimation) for the focused attention group, $t(62) = 4.05$, $p < 0.001$, $d = -0.51$, 95% CI[1] [−0.77, −0.25], and for the unfocused attention group, $t(63) = 4.70$, $p < 0.001$, $d = 0.59$, 95% CI [0.32, 0.085]. There was no statistically significant change in overestimation for the passive control group, $t(49) = 1.56$, $p = 0.07$, $d = 0.21$, 95% CI [− 0.01, 0.56].

The bottom panel of Fig. 2 shows the change in variability of temporal judgments, as indexed by the Difference Limen

[1] The Confidence Intervals (CI) reported here and throughout the paper were for the Cohen's d value.

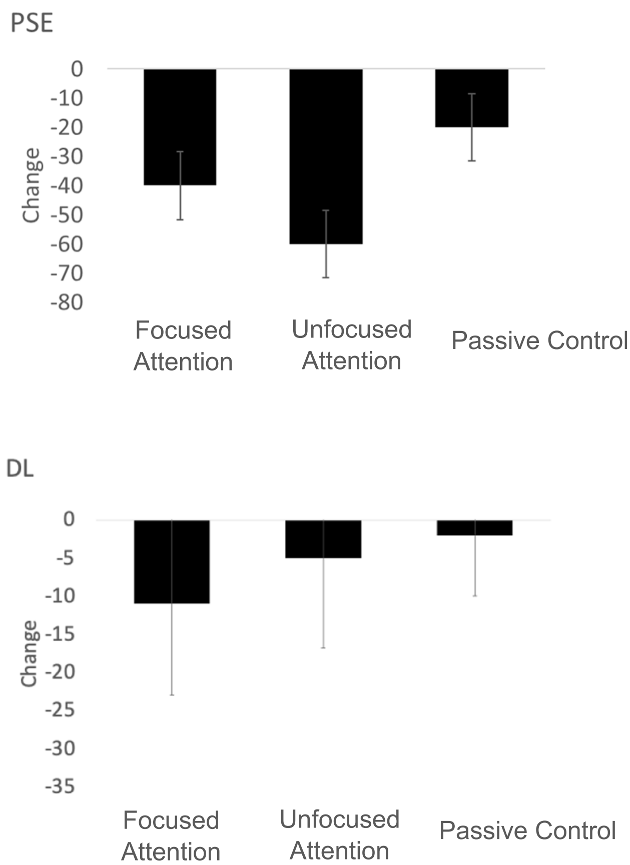

Fig. 2 Changes in the Point of Subjective Equality (PSE) and in the Difference Limen (DL) before and after the 5-min treatment for the three groups in Experiment 1A (online testing). Error bars represent 95% confidence intervals

(DL; exercise minus baseline), for all three groups. The difference limen is an index of time sensitivity, the lower the DL, the steeper the psychophysical function, and the higher the level of time sensitivity. There was no numerical difference in DL scores between the three groups, and when DL scores for each group were compared against a zero-change, using paired-samples *t*-tests, for any group, all *p*s-values > 0.20.

Experiment 1B. The means per condition appear in Fig. 3. A 3 (Group: focused attention, unfocused attention, passive control) × 2 (Session: first vs. second) × 7 (Duration: 200, 300, 400, 500, 600, 700, 800 ms) mixed Analysis of Variance (ANOVA) with Group as the between-participants variable was carried out on the percentage of "long" responses. There was a significant main effect of stimulus Duration, $F(6,324) = 698.73$, $p < 0.001$, $\eta^2_p = 0.93$, with increasing percentage of "long" responses as stimulus durations increased. There was also a significant main effect of Session, $F(1,54) = 68.06$, $p < 0.001$, $\eta^2_p = 0.56$, qualified by a significant Session × Duration interaction, $F(6,324) = 13.78$, $p < 0.001$, $\eta^2_p = 0.20$. Simple main effects analyses showed higher percentage of "long" responses in the second compared to the first session, especially for stimulus durations between 400–600 ms.

Unlike Experiment 1A, in Experiment 1B neither the main effect of Group, $F(2,54) = 1.10$, $p = 0.34$, nor the Group × Duration interaction, $F(12,324) = 0.92$, $p = 0.53$, was significant. There were no other significant interactions, and importantly no significant Session × Group interaction, $F(2,54) = 0.13$, $p = 0.88$.

PSE and DL analyses. As in Experiment 1A, in Experiment 1B the PSE decreased for all groups after the manipulation, indicating greater overestimation – see Fig. 4. Comparisons against zero change using a paired *t*-test (with Bonferroni correction, $p = 0.05 / 3 = 0.0167$), revealed a large-sized and significant decrease in PSE (increased over-estimation) for the focused attention group, t(16) = 3.42, p = 0.003, d = 1.05, 95% CI [−1.37, −0.27], and for the unfocused attention group, $t(18) = 3.38$, $p < 0.001$, $d = -0.77$, 95% CI [−1.28, −0.25]. There was also a significant change in overestimation for the passive control group, $t(19) = 5.09$, p < 0.001, d = −1.14, 95% CI [−1.70,−0.56].

As in Experiment 1A, for Experiment 1B, there was no difference in the DL scores, and when compared against a zero-change, using paired-samples *t*-tests, for any group, all *p* -values > 0.20.

Experiment 2

Figure 5 shows the group mean percentage times each stimulus duration was classified as 'long' in the first and in the second session. A 2 (Group: focused attention, unfocused attention) × 2 (Session: first vs. second) × 7 (Duration: 200, 300, 400, 500, 600, 700 and 800 ms) mixed ANOVA with Group as the between-participants variable was carried out on the percentage of "long" responses. There was a significant main effect of stimulus Duration, $F(6,342) = 378.19$, $p < 0.001$, $\eta^2_p = 0.87$, with increasing percentage of "long" responses as stimulus durations increased. There was also a significant main effect of Session, $F(1,57) = 8.28$, $p = 0.006$, $\eta^2_p = 0.13$, with more "long" responses in the second compared to the first session. The main effect of Group was not significant, $F(1,57) < 1.00$, $p = 0.77$, and there were no other significant interactions.

Despite the lack of a significant main effect and of any interactions involving the factor Group, we present the analyses separately for the two groups for the purpose of comparison with Experiment 1 and previous work (e.g., Kramer et al., 2013).

Focused attention group analyses. A significant main effect of Session was observed, F(1,28) = 10.70, p = 0.003, $\eta^2_p = 0.28$, indicating a higher percentage of "long" responses in the second session (after the mindfulness audio)

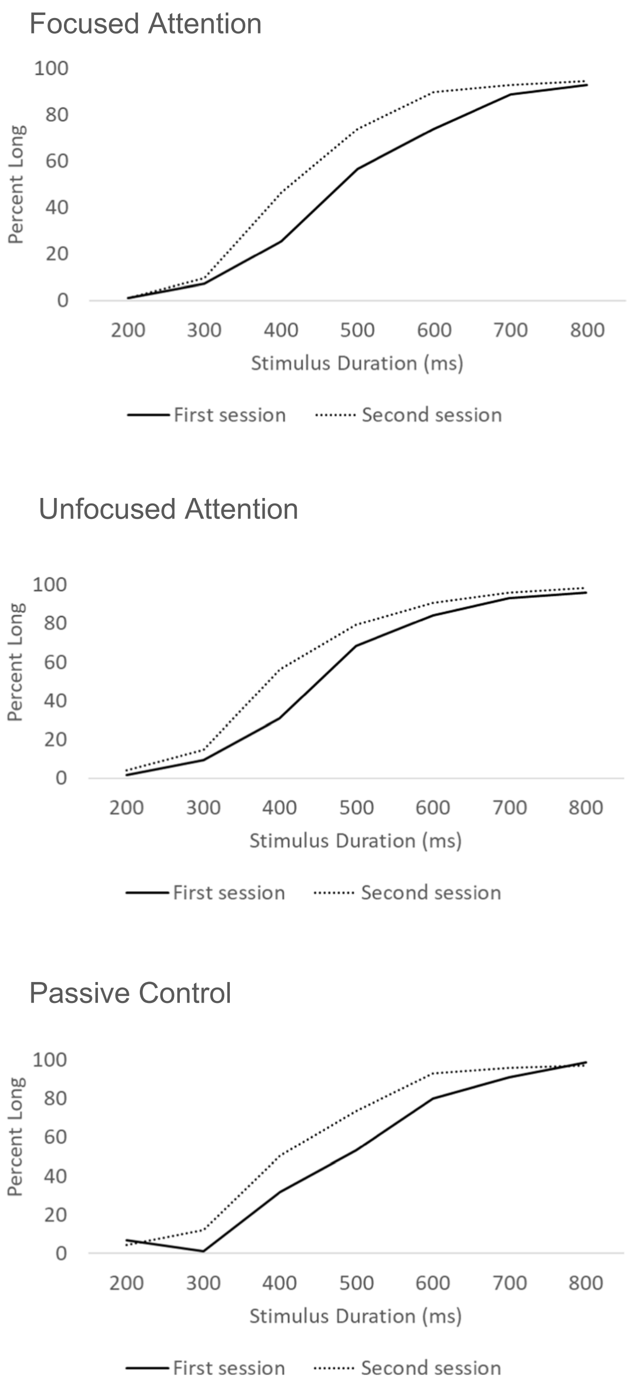

Fig. 3 Percentage of “long” responses at each stimulus duration before (First Session) and after the 5-min treatment (Second Session) for the three participant groups in Experiment 1B (Lab, in-person testing)

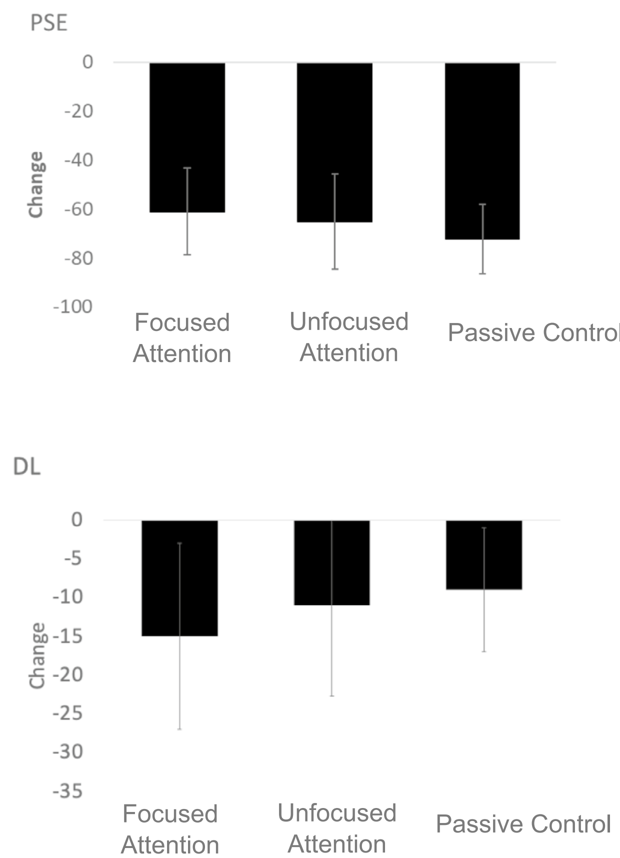

Fig. 4 Changes in the Point of Subjective Equality (PSE) and in the Difference Limen (DL) before and after exercise for the three groups in Experiment 1B (Lab, in-person testing). Error bars represent 95% confidence intervals

of the temporal bisection task relative to the first. A main effect of Duration was also significant, F(6,168) = 178.70, $p < 0.001$, $\eta^2_p = 0.86$, confirming that the percentage of “long” responses was higher as stimulus durations increased. The Session × Duration interaction was not significant, F(6,168) = 1.64, p = 0.14.

Unfocused attention group analyses. There was no significant main effect of Session, F(1,29) = 0.99, p = 0.33, suggesting no difference in the percentage “long” responses between the first and second session. The main effect of Duration however was significant, F(6,174) = 203.29, p < 0.001, η2p = 0.87, confirming that the percentage of “long” responses was higher as stimulus durations increased. The Session × Duration interaction was not significant, F(6,174) = 1.25, p = 0.28, suggesting no difference in duration estimations between the first session (right after the meditation) and the second session (which we use as a baseline).

PSE and DL analyses. The top panel of Fig. 6 shows the mean change (first session minus second session) in PSE for both groups (increased PSE values suggesting a shortening of perceived time). However, comparisons against zero change using paired t-tests (Bonferroni correction, $p = 0.05/2 = 0.02$), revealed small-sized and non-significant changes for both meditation groups, both $t < 1$, and $p > 0.05$. The bottom panel of Fig. 6 shows the change in variability

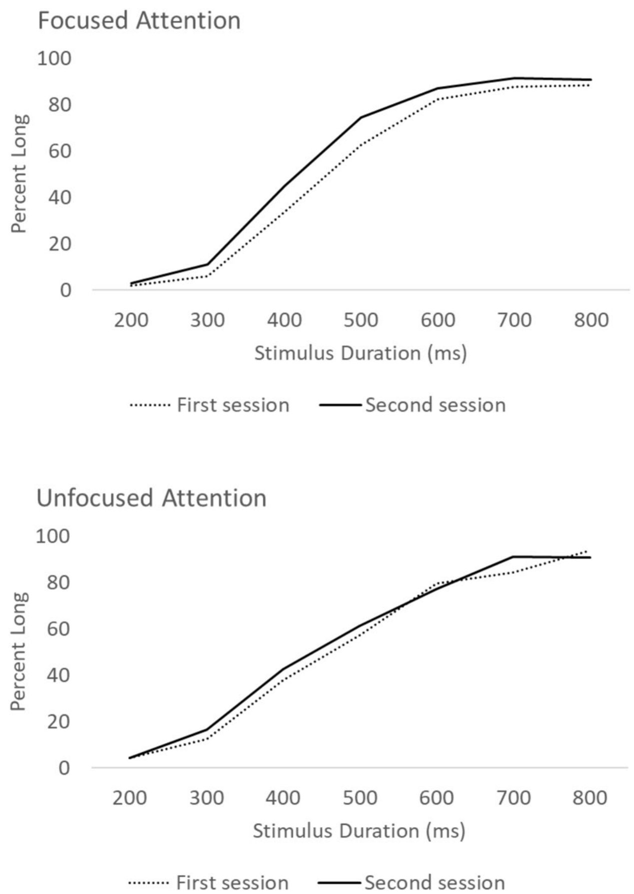

Fig. 5 Percentage of long responses at each stimulus duration, immediately after (First Session) the two meditations, and the second time participants did the temporal bisection task (Second Session) in Experiment 2. Note that unlike Experiments 1A and 1B, in Experiment 2, the First Session happened immediately after the meditation, while the second session happened 2 min after the end of the First Session

of temporal judgments, as indexed by the Difference Limen (first session minus second session) for both groups. There was no difference in these scores, and when compared against a zero-change, using paired-samples t-tests, both $p > 0.10$.

The present results suggest no significant differences between the two meditation tasks. They do, however, show that repeating the task a second time leads to an increase in overestimation of the passage of time. It may be that repetition of the task, by itself, produces a degree of relaxation for the participant (or, at least, reduces levels of stress) Due to increased task familiarity.

To further clarify the relative contributions of meditation and task repetition, we conducted additional comparisons across Experiment 1A and Experiment 2. Figure 7 illustrates these effects separately. For the Focused Meditation groups (Panels A and C) and the Unfocused Meditation groups (Panels B and D), we disentangled the effects of meditation from those of task repetition. The effect of meditation alone is illustrated by comparing performance in the first session of Experiment 1A (baseline) with the first session of Experiment 2 (meditation only). The effect of repetition is illustrated by comparing the second session of Experiment 1A (meditation plus repetition) with the first session of Experiment 2 (meditation only). As can be seen, the effect of task repetition was clearly stronger than that of meditation, indicating that repetition played the dominant role in driving performance improvements.

The findings from Experiment 2 support the interpretation that task repetition plays a stronger role than meditation in driving overestimation of stimulus durations, setting the stage for the broader conclusions and implications we consider in the Discussion.

Discussion

The present study aimed to disentangle the effects of meditation and task repetition on prospective duration judgments. Specifically, we sought to test whether (1) focused and unfocused meditation would lead to overestimation of stimulus durations relative to baseline, reflecting increased attentional control or relaxation, and (2) whether such effects could be distinguished from the influence of performing the temporal bisection task a second time. Based on prior findings that mindfulness can bias temporal perception (Droit-Volet et al., 2015; Kramer et al., 2013), we predicted that both focused and unfocused meditation would increase the proportion of “long” responses, with a potentially stronger effect for focused attention due to its greater demand on attentional control. At the same time, we expected that repetition of the temporal bisection task would itself produce overestimation (e.g., Danckert & Allman, 2005; Witowska et al., 2020), such that any effects of meditation would need to be interpreted against this background. This framework allowed us to evaluate whether short meditation interventions exert unique effects on time perception, or whether observed changes can be more parsimoniously attributed to task repetition.

Across Experiments 1A, 1B, and 2, the most consistent finding was that repeating the temporal bisection task led to an overestimation of durations. Meditation produced similar effects, but these were less reliable, not consistently distinguishable from repetition, and often small in magnitude. Thus, *task repetition* emerged as the dominant influence on time perception in the present data. Although both focused and unfocused meditation appeared to lengthen perceived durations in Experiment 1A, these differences were small, stimulus duration-specific, and did not replicate in Experiment 1B. Moreover, in neither experiment was there a significant Group × Session interaction, indicating that the

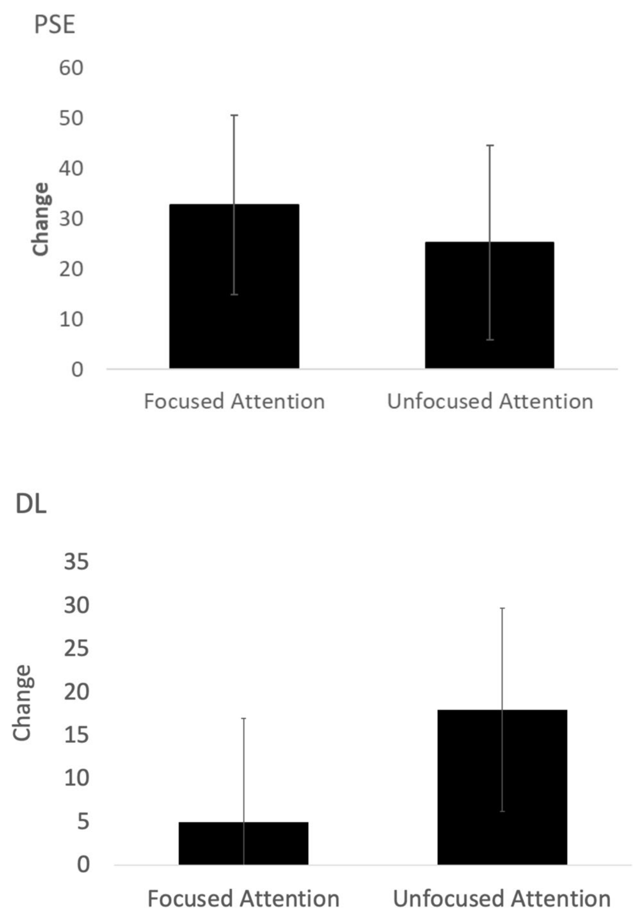

Fig. 6 Changes in the Point of Subjective Equality (PSE) and in the Difference Limen (DL) before and after exercise for the three groups in Experiment 2 (online testing). Error bars represent 95% confidence intervals

pre– and post– meditation changes were similar across all groups. In Experiment 2, the overestimation of durations was clearly tied to repeating the task a second time, regardless of meditation type. Taken together, these findings suggest that the effects previously attributed to meditation may be more parsimoniously explained by the influence of task repetition and increased familiarity with the timing procedure.

At present, it is not possible to draw definitive conclusions about differences between focused and unfocused meditation in meditation-naïve participants. Although the results suggest a possible divergence, no significant main effects or Group interactions emerged. Moreover, while our sample sizes were sufficient to detect medium-to-large effects, they may not have been sufficient to reveal more subtle group differences. Finally, the pattern was not consistent across experiments, further limiting confidence in interpreting group contrasts. For these reasons, any indication of differential effects between the two meditation types should be regarded as preliminary and in need of confirmation in future studies with larger samples and more sensitive designs. Nonetheless, a lack of difference between focused and unfocused meditation has been noticed elsewhere. For example, Arch and Craske (2006) noted that the two activities yielded similar emotional responses for positive and negative images. It is possible that both forms of meditation produce effects for similar, perhaps relaxation related, reasons.

The present results suggest that the most parsimonious explanation across the two experiments is that *task repetition enhances attention to time*, which in turn leads to overestimation of stimulus durations. While both meditation and relaxation are often proposed to influence timing via reduced arousal or increased attentional control, our findings show that similar lengthening effects can occur in the absence of meditation (i.e., following a passive control interval). This points to a mechanism by which repeating the temporal bisection task increases familiarity with the procedure and reduces distraction, thereby allowing participants to attend more directly to the passage of time. In Experiments 1A and 1B, this mechanism was present across all conditions, although slightly stronger after meditation, while in Experiment 2 it was clearly demonstrated by the shift observed when the same task was repeated after meditation. Taken together the present findings suggest that short mindfulness interventions in meditation-naïve participants may not exert a unique effect on duration judgments beyond what can be explained by enhanced attention to time following task repetition. Consistent with this conclusion, the additional comparisons shown in Fig. 7 suggest that performance gains were driven primarily by task repetition rather than by meditation, indicating that repetition was the dominant factor underlying improvement.

Our findings advance the growing consensus that short-term mindfulness interventions do not exert a distinct influence on time perception, but rather produce changes that parallel those associated with general relaxation or increased familiarity. This interpretation is consistent with previous mixed findings in the literature, with some studies reporting meditation-specific effects (e.g., Kramer et al., 2013) and others finding similar outcomes for meditation and relaxation (e.g., Droit-Volet et al., 2015). In Kramer et al. (2013), the proportion of "long" responses was significantly higher following the mindfulness meditation condition compared to their control condition, which was listening to an audiobook extract. However, their sample size was rather small, and both groups showed a similar increase in 'long' responses following the manipulation, with the meditation group larger than the control (audiobook) group. In contrast, Droit-Volet et al. (2015) used two 10-min meditation sessions prior to a temporal bisection task and did not observe a difference between the meditation (body scan) and the relaxation (body muscle relaxation exercises) group. In this latter study, only in the relaxation group was a difference found, and only

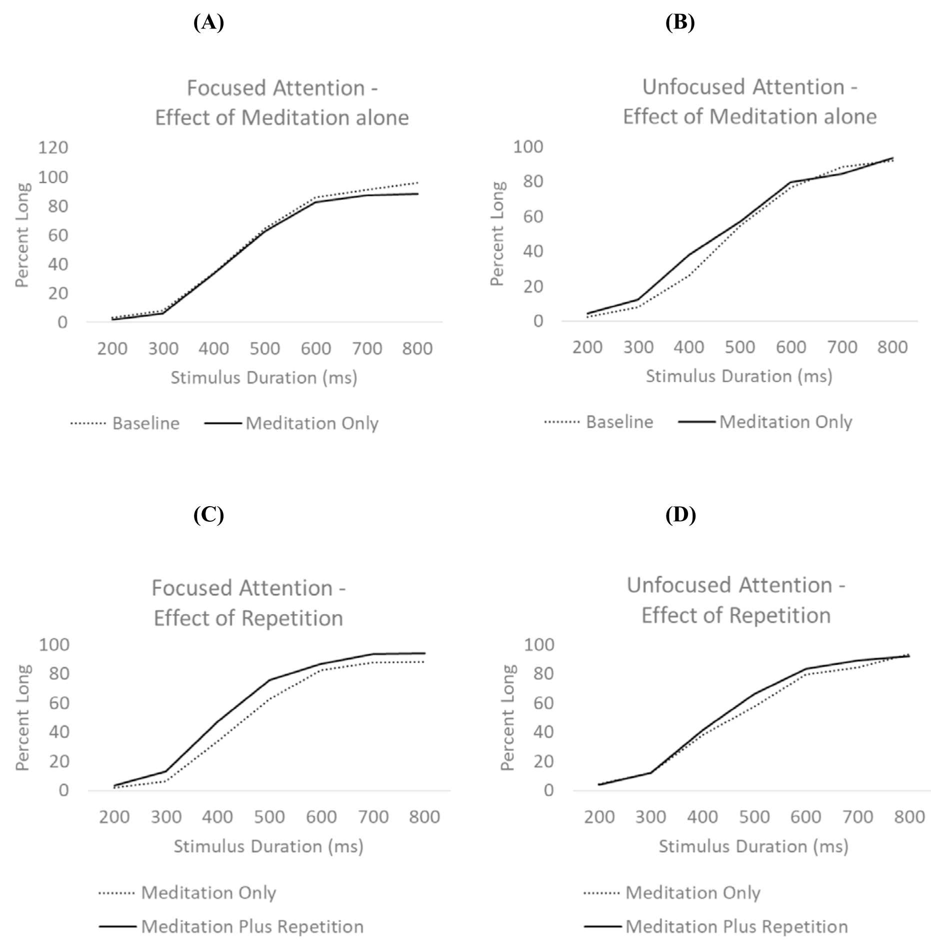

Fig. 7 Graphs illustrating the effects of repetition and the effects of meditation separately. For the Focused Meditation (Panels **A** and **C**) and Unfocused Meditation (Panels **B** and **D**) groups we examined the effect of meditation alone de-couple of the effect of repetition. We examined the effect of **meditation** alone by comparing the first session of Exp.1A (baseline) with the first session of Exp.2 (Meditation only). Then, we examined the effect of **repetition** by comparing the second session of Exp. 1A (Meditation Plus Repetition) with the first session of Exp.2 (Meditation only)

when the task was difficult (i.e. when participants had to decide short or long from durations varying between 4 and 6 s).

It is noteworthy that the Difference Limen (DL), our index of sensitivity to temporal changes, remained stable across all conditions in every experiment. Although the effects were non-significant, these null findings are informative given that our sample sizes and power analyses were adequate to detect effects of medium magnitude. The absence of DL differences indicates that while meditation and/or task repetition may shift subjective duration judgments, likely through greater attentional engagement with time, they do not reliably enhance the perceptual sensitivity required for finer temporal discrimination. This distinction is important: participants may experience the passage of time as elongated, yet their capacity to detect subtle variations in duration remains unchanged.

As highlighted in Morin and Grondin's (2024) review, brief mindfulness practices are unlikely to induce a genuine state of mindfulness comparable to that observed in experienced meditators. Instead, such brief practices more plausibly elicit a general state of relaxation (e.g., Britton et al., 2014), which can reduce anxiety and temporarily enhance attentional capacity. Within this framework, the absence of differences in the proportion of 'long' responses across the two meditation groups and the passive control condition becomes understandable: all conditions appear to have fostered a similarly relaxed mental state, thereby producing comparable effects on temporal judgments.

The present findings pose important challenges for common theoretical accounts of how meditation influences internal timing mechanisms, particularly those centred on pacemaker-based models (e.g., Gibbon, 1977; Treisman, 1963; Wearden, 2016). These accounts typically predict that decreases in arousal associated with relaxation should slow the pacemaker, producing temporal underestimation (e.g., Ong et al., 2012). In contrast, our data consistently showed temporal overestimation following both meditation and passive control conditions, indicating that relaxation alone cannot be accounted for by pacemaker slowing. Instead, the pattern points to effects on a different component of the timing system. Within Scalar Expectancy Theory (SET), the switch component—responsible for gating pacemaker pulses into the accumulator—is thought to be modulated by attentional resources (e.g., Lejeune, 1998; Meck & Benson, 2002). The switch closes in response to a temporally relevant event, allowing pulses to accumulate, and reopens when the event ends, terminating accumulation. Enhanced sustained attention, which can be facilitated by both meditation and relaxation (e.g., Kang et al., 2013; Valentine & Sweet, 1999), may therefore lead to more efficient switch functioning. Increased attentional engagement with temporal information would result in a greater number of pulses being accumulated, producing the observed overestimations of duration (e.g., Wearden, 2016; Wearden et al., 1999). In this sense, participants may simply be attending more closely to time after the intervention or becoming less susceptible to distraction, yielding systematically longer subjective durations.

Limitations and Future Directions

Our conclusions come with certain limitations to note. First, there is a possibility that the meditation manipulations did not work as intended. Some participants may not have engaged in the meditation exercise thus negating any possible effects of meditation and only allowing effects of task repetition to be observed. However, we are reticent to believe this argument can fully account for the present pattern of results, for two reasons: first, we replicated the online pattern of results in our lab replication in Experiment 1B; second, our findings closely resemble previous work in which mindfulness interventions were carried out under laboratory supervision. For instance, Kramer et al. (2013) observed a leftward shift in both the meditation and control groups, and Droit-Volet et al., (2015, Exp. 2) reported overestimation of durations following either relaxation or meditation, with no difference between groups. Similarly, our findings suggest that meditation, relaxation, or even doing nothing can all lead to overestimation of durations.

Another limitation is that we did not assess our participants' prior meditation experience. Although our samples were drawn largely from meditation-naïve populations, some participants may have had varying degrees of familiarity with mindfulness techniques. Without these data, it is not possible to determine whether prior experience moderated the effects of the intervention.

Third, while our sample sizes were determined a priori and doubled in the revised manuscript to strengthen power, they were calibrated to detect medium effects. Smaller, more subtle differences between conditions may therefore have gone undetected. Although effect sizes and confidence intervals provided useful indicators of the magnitude and precision of observed effects, the relatively modest samples – particularly in Experiments 1B and 2 – introduce uncertainty around these estimates.

Finally, our participants were meditation-naïve and exposed only to a brief, 5-min session. For many individuals, such a short period is unlikely to induce a genuine mindfulness state comparable to that of experienced practitioners. It is plausible that participants spent much of this time mind-wandering, intermittently refocusing, or simply relaxing. Thus, our findings are best interpreted as reflecting the kinds of attentional or relaxation states that can be induced by brief, introductory exercises. While this is a limitation, it also carries ecological validity: many popular mindfulness apps and introductory programs are designed around short daily sessions for novices. Future research should investigate longer interventions and samples with established meditation practice to test whether genuine mindfulness states exert effects beyond those attributable to relaxation or task repetition.

Taken together, the present findings indicate that both brief meditation and task repetition bias subjective time perception, but repetition exerts the stronger and more reliable effect. Clinically, the perceived lengthening of durations might help individuals feel less time pressure, potentially reducing stress and facilitating focus in therapeutic contexts. While meditation techniques may not improve the absolute accuracy of time estimation, they may nonetheless offer benefits for wellbeing. Ongoing work in our laboratory is examining whether meditation versus control conditions influence the perception of empty intervals between stimuli, in addition to stimulus durations.

In conclusion, the present study has shown a significant effect of task repetition on duration judgments. That is, when the same task is repeated, participants tend to over-estimate the duration of stimuli. This finding must be considered in light of study limitations, including the relatively brief meditation sessions and the reliance on meditation-naïve participants. Future work should test whether repeated or longer-term meditation training produces additive effects beyond task repetition, and whether such effects extend to temporal sensitivity (DL) as well as duration bias (PSE). Such work will be essential for clarifying the specific contributions of mindfulness training to temporal cognition.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s12671-025-02733-2.

Author Contributions Matthew Hopkins.: Data curation and analysis Writing- Original draft preparation. Katie Bishop: data curation and contributing to the writing of the first draft. Mia Ashman: Data curation, processing and analysis.: Phil Reed: Supervision, data analysis, writing and editing. Irene Reppa: Conceptualization, Design, Data analysis, and Writing & Editing final draft.

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Data Availability The data reported in the current manuscript can be found here.

Declarations

Ethics Approval The study was approved by the Research Ethics Committee of the School of Psychology at Swansea University (Ethics approval number: 22023–8790-7676) and was conducted according to the principles expressed in the 1964 Helsinki declaration and its later amendments.

Informed Consent All participants provided informed written consent.

Use of Artificial Intelligence AI was not used.

Conflict of Interest The authors have no conflict of interest.

References

Ahne, E., & Rosselli, M. (2024). The impact of a single, brief mindfulness intervention on cognitive and emotional reactivity: An EEG study. *Mindfulness, 15*(8), 1940–1957. https://doi.org/10.1007/s12671-024-02406-6

Arch, J. J., & Craske, M. G. (2006). Mechanisms of mindfulness: Emotion regulation following a focused breathing induction. *Behaviour Research and TheraPy, 44*(12), 1849–1858. https://doi.org/10.1016/j.brat.2005.12.007

Bajestani, G. S., Ghanizadeh, A., Makhloughi, F., Hosseinpour Kharrazi, F., Hosseini, A., & Toosi, M. B. (2024). The impact of blended mindfulness intervention (BMI) on university students' sustained attention, working memory, academic achievement, and electroencephalogram (EEG) asymmetry. *Mindfulness, 15*(3), 675–688. https://doi.org/10.1007/s12671-024-02317-6

Benson, H., Greenwood, M. M., & Klemchuk, H. (1975). The relaxation response: psychophysiologic aspects and clinical applications. *The International Journal of Psychiatry in Medicine, 6*(1–2), 87–98.

Bodhi, B. (2011). What does mindfulness really mean? A canonical perspective. *Contemporary Buddhism*, *12*(1), 19–39. https://doi.org/10.1080/14639947.2011.564813

Britton, W. B., Lepp, N. E., Niles, H. F., Rocha, T., Fisher, N. E., & Gold, J. S. (2014). A randomized controlled pilot trial of classroom-based mindfulness meditation compared to an active control condition in sixth-grade children. *Journal of School Psychology, 52*(3), 263–278. https://doi.org/10.1016/j.jsp.2014.03.002

Carroll, C. A., Boggs, J., O'Donnell, B. F., Shekhar, A., & Hetrick, W. P. (2008). Temporal processing dysfunction in schizophrenia. *Brain and Cognition, 67*(2), 150–161. https://doi.org/10.1016/j.bandc.2007.12.005

D'Argembeau, A., Lardi, C., & van der Linden, M. (2012). Self-defining future projections: Exploring the identity function of thinking about the future. *Memory, 20*(2), 110–120. https://doi.org/10.1080/09658211.2011.647697

Danckert, J. A., & Allman, A. A. A. (2005). Time flies when you're having fun: Temporal estimation and the experience of boredom. *Brain and Cognition, 59*(3), 236–245. https://doi.org/10.1016/j.bandc.2005.07.002

Droit-Volet, S., Fanget, M., & Dambrun, M. (2015). Mindfulness meditation and relaxation training increases time sensitivity. *Consciousness and Cognition, 31*, 86–97. https://doi.org/10.1016/j.concog.2014.10.007

Droit-Volet, S., Gil, S., Martinelli, N., Andant, N., Clinchamps, M., Parreira, L., Ruffiac, K, Dambrun, M., Huguet, P., Dubuis, B., Pereira, B., COVISTRESS network, Bouillon, J.B., & Dutheil, F. (2020). Time and Covid-19 stress in the lockdown situation: Time free, «Dying» of boredom and sadness. *PLoS ONE*, *15*(8), e0236465. https://doi.org/10.1371/journal.pone.0236465

Gibbon, J. (1977). Scalar expectancy theory and Weber's law in animal timing. *Psychological Review, 84*(3), 279–325. https://doi.org/10.1037/0033-295X.84.3.279

Grondin, S. (2010). Timing and time perception: A review of recent behavioral and neuroscience findings and theoretical directions. *Attention, Perception, & Psychophysics, 72*(3), 561–582. https://doi.org/10.3758/APP.72.3.561

Hafenbrack, A. C., Kinias, Z., & Barsade, S. G. (2014). Debiasing the mind through meditation: Mindfulness and the sunk-cost bias. *Psychological Science, 25*(2), 369–376. https://doi.org/10.1177/0956797613503853

Hasenkamp, W., Wilson-Mendenhall, C. D., Duncan, E., & Barsalou, L. W. (2012). Mind wandering and attention during focused meditation: A fine-grained temporal analysis of fluctuating cognitive states. *NeuroImage, 59*(1), 750–760. https://doi.org/10.1016/j.neuroimage.2011.07.008

Hu, N., He, S., & Xu, B. (2012). Different efficiencies of attentional orienting in different wandering minds. *Consciousness and Cognition, 21*(1), 139–148. https://doi.org/10.1016/j.concog.2011.12.007

Jha, A. P., Stanley, E. A., Kiyonaga, A., Wong, L., & Gelfand, L. (2010). Examining the protective effects of mindfulness training on working memory capacity and affective experience. *Emotion, 10*(1), 54–64. https://doi.org/10.1037/a0018438

Kabat-Zinn, J., & Davidson, R. (Eds.). (2012). *The mind's own physician: A scientific dialogue with the Dalai Lama on the healing power of meditation*. New Harbinger Publications.

Kang, Y., Gruber, J., & Gray, J. R. (2013). Mindfulness and deautomatization. *Emotion Review, 5*(2), 192–201. https://doi.org/10.1177/1754073912451629

Kramer, R. S., Weger, U. W., & Sharma, D. (2013). The effect of mindfulness meditation on time perception. *Consciousness and Cognition, 22*(3), 846–852. https://doi.org/10.1016/j.concog.2013.05.008

Lejeune, H. (1998). Switching or gating? The attentional challenge in cognitive models of psychological time. *Behavioural Processes, 44*(2), 127–145.

Lomas, T., Ivtzan, I., & Fu, C. H. (2015). A systematic review of the neurophysiology of mindfulness on EEG oscillations. *Neuroscience and Biobehavioral Reviews, 57*, 401–410. https://doi.org/10.1016/j.neubiorev.2015.09.018

Long, E. C., & Christian, M. S. (2015). Mindfulness buffers retaliatory responses to injustice: A regulatory approach. *Journal of Applied Psychology, 100*(5), 1409–1422. https://doi.org/10.1037/apl0000019

McHugh, L., Simpson, A., & Reed, P. (2010). Mindfulness as a potential intervention for stimulus over-selectivity in older adults.

Research in Developmental Disabilities, 31(1), 178–184. https://doi.org/10.1016/j.ridd.2009.08.009

Meck, W. H., & Benson, A. M. (2002). Dissecting the brain's internal clock: How frontal–striatal circuitry keeps time and shifts attention. *Brain and Cognition, 48*(1), 195–211. https://doi.org/10.1006/brcg.2001.1313

Mooneyham, B. W., & Schooler, J. W. (2013). The costs and benefits of mind-wandering: A review. *Canadian Journal of Experimental Psychology = Revue Canadienne De Psychologie Experimentale, 67*(1), 11–18. https://doi.org/10.1037/a0031569

Moore, A., & Malinowski, P. (2009). Meditation, mindfulness and cognitive flexibility. *Consciousness and Cognition, 18*(1), 176–186. https://doi.org/10.1016/j.concog.2008.12.008

Morin, A., & Grondin, S. (2024). Mindfulness and time perception: A systematic integrative review. *Neuroscience and Biobehavioral Reviews*, *162*, 105657. https://doi.org/10.1016/j.neubiorev.2024.105657

Mrazek, M. D., Franklin, M. S., Phillips, D. T., Baird, B., & Schooler, J. W. (2013). Mindfulness training improves working memory capacity and GRE performance while reducing mind wandering. *Psychological Science, 24*(5), 776–781. https://doi.org/10.1177/0956797612459659

Ong, J. C., Ulmer, C. S., & Manber, R. (2012). Improving sleep with mindfulness and acceptance: a metacognitive model of insomnia. *Behaviour research and therapy, 50*(11), 651–660.

Ornstein, R. E. (1969). *On the experience of time*. Penguin.

Ottaviani, C., Shapiro, D., & Couyoumdjian, A. (2013). Flexibility as the key for somatic health: From mind wandering to perseverative cognition. *Biological Psychology, 94*(1), 38–43. https://doi.org/10.1016/j.biopsycho.2013.05.003

Prakash, R. S., Fountain-Zaragoza, S., Kramer, A. F., Samimy, S., & Wegman, J. (2020). Mindfulness and attention: Present state-of-affairs and future considerations. *Journal of Cognitive Enhancement, 4*(3), 340–367. https://doi.org/10.1007/s41465-019-00144-5

Reed, P. (2019). Previous mindfulness experience interacts with brief mindfulness induction when reducing stimulus overselectivity. *Applied Cognitive Psychology, 33*(2), 265–271. https://doi.org/10.1002/acp.3474

Reed, P. (2023). Focused-attention mindfulness increases sensitivity to present schedules of reinforcement. *Journal of Experimental Psychology: Animal Learning and Cognition, 49*(2), 127. https://doi.org/10.1037/xan0000352

Robinson, J. P. (1999). The time-diary method: Structure and uses. In W. E. Pentland, A. S. Harvey, M. P. Lawton, & M. A. McColl (Eds.), *Time use research in the social sciences* (pp. 47–89). https://doi.org/10.1007/978-1-4615-4383-8_3

Sauer, S., Lemke, J., Wittmann, M., Kohls, N., Mochty, U., & Walach, H. (2012). How long is now for mindfulness meditators? *Personality and Individual Differences, 52*(6), 750–754. https://doi.org/10.1016/j.paid.2011.12.026

Seli, P., Risko, E. F., Smilek, D., & Schacter, D. L. (2016). Mind-wandering with and without intention. *Trends in Cognitive Sciences, 20*(8), 605–617. https://doi.org/10.1016/j.tics.2016.05.010

Sommers-Spijkerman, M., Austin, J., Bohlmeijer, E., & Pots, W. (2021). New evidence in the booming field of online mindfulness: an updated meta-analysis of randomized controlled trials. *JMIR Mental Health, 8*(7), e28168. https://doi.org/10.2196/28168

Szollos, A. (2009). Toward a psychology of chronic time pressure: Conceptual and methodological review. *Time & Society, 18*(2–3), 332–350. https://doi.org/10.1177/0961463X09337847

Treisman, M. (1963). Temporal discrimination and the indifference interval: Implications for a model of the 'internal clock.' *Psychological Monographs: General & Applied, 77*(13), 1–31. https://doi.org/10.1037/h0093864

Valentine, E. R., & Sweet, P. L. G. (1999). Meditation and attention: A comparison of the effects of concentrative and mindfulness meditation on sustained attention. *Mental Health, Religion & Culture, 2*(1), 59–70. https://doi.org/10.1080/13674679908406332

Varao-Sousa, T. L., Smilek, D., & Kingstone, A. (2018). In the lab and in the wild: How distraction and mind wandering affect attention and memory. *Cognitive Research: Principles & Implications, 3*(1), 1–9. https://doi.org/10.14288/1.0374210

Wearden, J. (2016). *The psychology of time perception*. Springer.

Wearden, J., Philpott, K., & Win, T. (1999). Speeding up and (...relatively...) slowing down an internal clock in humans. *Behavioural Processes, 46*(1), 63–73. https://doi.org/10.1016/S0376-6357(99)00004-2

Witowska, J., Schmidt, S., & Wittmann, M. (2020). What happens while waiting? How self-regulation affects boredom and subjective time during a real waiting situation. *Acta Psychologica, 205*, 103061. https://doi.org/10.1016/j.actpsy.2020.103061

Zakay, D., & Block, R. A. (1995). An attentional-gate model of prospective time estimation. *Time & the Dynamic Control of Behavior, 5*, 167–178.