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ORIGINAL ARTICLE

Increasing participant motivation reduces rates of intentional and unintentional mind wandering

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Abstract We explored the possibility that increasing participants' motivation to perform well on a focal task can reduce mind wandering. Participants completed a sustained-attention task either with standard instructions (normal motivation), or with instructions informing them that they could be excused from the experiment early if they achieved a certain level of performance (higher motivation). Throughout the task, we assessed rates of mind wandering (both intentional and unintentional types) via thought probes. Results showed that the motivation manipulation led to significant reductions in both intentional and unintentional mind wandering as well as improvements in task performance. Most critically, we found that our simple motivation manipulation led to a dramatic reduction in probe-caught mind-wandering rates (49%) compared to a control condition (67%), which suggests the utility of motivation-based methods to reduce people's propensity to mind-wander.

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Introduction

Although research has shown that mind wandering can sometimes be beneficial, the vast majority of work on the topic has shown that, in cases wherein people are completing a focal task, this cognitive state is most often associated with negative outcomes (e.g., deficits in learning, accidents and injuries, poor workplace functioning; see Mooneyham & Schooler, 2013, for a review). Given the frequent negative consequences that mind wandering has on concurrent task performance, it is perhaps unsurprising that an emerging area of research has been focused on developing methods to reduce its occurrence in situations in which it has costly consequences. Thus far, however, only a few effective methods have been identified (e.g., Mrazek, Franklin, Phillips, Baird, & Schooler, 2013; Szpunar, Khan, & Schacter, 2013).

To date, the most popular method used to reduce rates of mind wandering has been to train participants to be mindful (Mrazek, Smallwood, & Schooler, 2012b; Mrazek et al., 2013). Although the details of the mindfulness training procedures are not always clearly articulated, mindfulness training in the context of research on mind wandering has often involved instructing participants to focus their attention on some aspect of a sensory experience, such as the act of breathing or one's posture, and to continually refocus attention on the specific aspect of sensory experience whenever the mind wanders (e.g., Mrazek et al., 2012a, b, 2013). The effectiveness of mindfulness training has now been reported in numerous studies (see Brown, 2007, for a review), and scientists and the media alike have enthusiastically reported the beneficial effects of such training procedures. However, some concerns have recently been raised about the effectiveness of mindfulness training, with some researchers arguing that (a) the control

and comparison conditions often used in these studies are potentially problematic, and (b) the purported effect of mindfulness training on mind wandering/cognitive abilities might in fact reflect demand characteristics to perform well on tasks that follow training (Davidson & Kaszniak, 2015; see also Tang, Hölzel, & Posner, 2015). This latter point is particularly noteworthy because it suggests that a more fundamental issue in the context of research aimed at reducing rates of mind wandering might concern whether people are motivated to perform well on laboratory tasks, and whether attempts to increase participant motivation might effectively reduce rates of mind wandering.

The common construal of mind wandering as a cognitive experience that occurs unintentionally and outside of the realm of an individual's control might discourage researchers from examining the role of motivation on mind wandering. Indeed, whereas motivation might reasonably be linked to deliberative processes, mind wandering has often been construed as a spontaneous, uncontrolled process (Seli, Risko, Smilek, & Schacter, 2016, for a review), which would suggest that motivation might have little (if any) influence on rates of mind wandering. Contrary to this hypothesis, however, Unsworth and McMillan (2013) found that participants' levels of motivation to perform well on a reading-comprehension task were negatively associated with their rates of mind wandering during the same task. Relatedly, Mrazek et al., (2012a) found that providing monetary incentives for good performance on a laboratory task led to a reduction in mind wandering (for similar work, see Antrobus, Singer, & Greenberg, 1966). Although assessments of participant motivation were not obtained in this latter study, it is reasonable to assume that the monetary incentives resulted in an increase in participant motivation, which in turn led to the observed decrease in mind wandering. However, to date, this possibility has not been formally tested.

Although the foregoing work provides some initial evidence to suggest that increases in participant motivation might result in decreases in rates of mind wandering, one puzzling question arising from this observation is: How can manipulations of participant motivation affect rates of mind wandering if mind wandering is, as is commonly believed, a spontaneously occurring, unintentional process? Indeed, as noted above, it would seem that such unintentionally occurring thoughts might not be influenced by motivation since such thoughts are, by definition, not under the individual's control.

One way to resolve this apparent conflict is to consider the possibility that not all reported mind wandering is unintentional. Indeed, a growing body of research has shown that, in many cases, a considerable proportion of mind-wandering episodes are engaged with intention (e.g., Giambra, 1995; Grodsky & Giambra, 1990–1991; Seli, Risko, & Smilek, 2016; Seli, Smallwood, Cheyne, & Smilek, 2015c), and that intentional and unintentional types of mind wandering sometimes behave differently in experimental contexts (e.g., Phillips, Mills, D'Mello, & Risko, 2016; Seli et al., 2016). Importantly, these findings suggest the possibility that increasing participant motivation might specifically lead to a reduction in rates of intentional (but not unintentional) mind wandering. In fact, in his early work on the topic, Giambra (1995, p. 2) put forth this very prediction:

> "Voluntary shifts of attention to TUITs [i.e., Task-Unrelated Images and Thoughts, or mind wandering] would seem to involve higher orders of control in information processing or be motivationally determined… However, involuntary shifts of attention from the task at hand to TUITs would seem to involve lower orders of control in information processing and not [be] motivationally determined."

In examining the extant literature on mind wandering, there is at least one study that is consistent with Giambra's prediction. In a correlational study, Seli, Cheyne, Xu, Purdon, and Smilek (2015a) found that, whereas participants' self-reported levels of motivation to perform well on a sustained-attention task were not significantly associated with their propensity to engage in unintentional mind wandering during the task, they were significantly negatively associated with their propensity to engage in intentional mind wandering.

At the same time, however, there are other correlational results that do not so seamlessly fit with Giambra's straightforward prediction. In assessing participant motivation and mind wandering while participants viewed a video-recorded lecture, Seli, Wammes, Risko, and Smilek (2015d) observed a significant negative relation between intentional mind wandering and motivation (as previously reported by Seli et al., 2015a), but in addition, they observed a marginal negative relation between unintentional mind wandering and motivation, suggesting that motivation may in fact have some influence on unintentional mind wandering. Thus, to date, the results of studies examining the relation between motivation and mind wandering have not converged on a firm conclusion.

In the present experiment, we sought to more directly explore the association of mind wandering and motivation by manipulating motivation, measuring motivation (to determine whether our manipulation is effective), and assessing whether our manipulation of motivation will affect rates of mind wandering. It is important to note that prior studies directly assessing the link between mind wandering and motivation have relied on correlational designs, and that, although Mrazek et al. (2012a, b) showed a decrease in mind wandering when providing participants

monetary incentive to perform well on a task, they did not assess levels of participant motivation, and as such, their results do not directly speak to the issue of whether manipulations of motivation, per se, reduce rates of participant mind wandering. More importantly, in addition to directly manipulating and measuring motivation, we sought to determine whether our motivation manipulation would selectively decrease rates of intentional mind wandering, as per Giambra's (1995) prediction. To accomplish this objective, we conducted an experiment in which participants completed a sustained-attention (the Metronome Response Task; MRT; Seli, Cheyne, & Smilek, 2013b), and throughout the task, we assessed rates of intentional and unintentional mind wandering. Critically, whereas half of the participants were subjected to a motivation manipulation that was intended to increase task-based motivation, the other half of participants underwent no such manipulation.

Method

We report how we determined our sample size, all data exclusions (if any), all manipulations, and all measures in the experiment (Simmons, Nelson, & Simonsohn, 2012).

Participants

One-hundred-one undergraduate students participated for partial course credit (mean age was 19.53, with 71 females). It was determined in advance that we would collect data from as many participants as possible before the end of the academic term. Although we typically exclude data from participants who omit responses to at least 10% of the MRT trials (e.g., Seli et al., 2013b; Seli, Jonker, Cheyne, Cortes, & Smilek, 2015b), in the present experiment, we reasoned that our motivation manipulation might lead to a reduction in omission rates, and for this reason, we did not remove any participant data from our subsequent analyses.

The metronome response task (MRT)

The MRT (Seli et al., 2013) is a sustained-attention task that requires participants to monitor a sequence of tones to provide a key-press response in synchrony with the tones. The rationale behind the task is that if an individual experiences mind wandering at any point during task completion, then their estimation of the onset of the tone will be affected, which will in turn result in more variable responding. Consistent with this rationale, numerous studies have reported that self-reported periods of mind wandering during the MRT are associated with significantly greater response variability than are periods of on-task focus (e.g., Seli, Carriere, Thomson, Cheyne, Martens, & Smilek, 2014) and that overall response variability in the MRT is associated with increases in mind wandering (e.g., Seli et al., 2015a).

In the present experiment, each of the MRT trials began with 650 ms of silence followed by the presentation of a tone (lasting 75 ms) and a further 575 ms of silence. Thus, each trial lasted 1300 ms. Participants completed the MRT while wearing Sony MDR-XD200 Stereo Headphones, through which the tones were presented. They were instructed to press the spacebar synchronously with the onset of each tone so that their responses were made at the exact time at which each tone was presented. Participants first completed 18 practice trials to familiarize them with the task. Following the practice trials, they completed 900 experimental trials.

Thought probes

Throughout the MRT, mind wandering was sampled using intermittently presented thought probes. One probe was randomly presented in each block of 50 trials (total of 18 probes). When a probe was presented, the task temporarily stopped and the participant was presented with the following instruction: "Which of the following responses best characterizes your mental state just before this screen appeared?" The possible response options were: (a) on task, (b) intentionally mind wandering (c) unintentionally mind wandering (Seli et al., 2015a; for complete instructions, see the Supplementary Materials). Participants were instructed to respond to the probe screen via key press (1–3), after which the MRT resumed.

Manipulating task-based motivation

To manipulate motivation, we used a between-subjects design wherein we randomly assigned participants to either a motivation condition or a control condition. In both conditions, participants were informed that the experimental session would last approximately 1 h. Unbeknownst to the participants, however, the experimental session only lasted approximately 30 min (i.e., the experiment terminated after about half of the expected time had elapsed, when participants had completed 900 MRT trials). This feature of our experiment was important because it allowed us to manipulate motivation by informing participants in the motivation condition that they could leave the experiment early if, after approximately 30 min (halfway through the MRT), they achieved a certain level of performance on the MRT. In particular, after being provided with instructions pertaining to the MRT and the thought probes (which were identical across both conditions; see Supplementary

Materials), participants in the motivation condition were provided with the following instruction:

> "As you know, this task will take an hour to complete. However, depending on how well you do on the task, you may be able to leave about halfway through the task while still earning full credit. To determine whether you get to leave early, during the task, the computer will monitor your performance on the task. After about 30 min, the task will temporarily stop, and the computer will compute your overall performance on the task up until that point, and then you will be notified if you have achieved a high enough level of performance to be let out of the experiment early while still receiving the full participation credit. If you do not achieve a high enough level of performance on the task, then you will have to complete the task for an additional 30 min, for a total time of roughly 1 h, as stated in the information letter."[1]

On the other hand, participants in the control condition were not provided any instructions pertaining to an early departure from the experiment (they were all informed that the experiment would take roughly 1 h to complete, although these participants were all excused from the experiment after approximately 30 min, or 900 MRT trials).

At this point, it is worth noting one potential concern that we had with our motivation manipulation: Namely, we were concerned that such a manipulation might lead participants to falsely report that they were "on task" in cases where they were in fact mind wandering so that they could feign "good performance" and consequently leave the experiment early. Thus, if we were to find that participants in the motivation condition reported less mind wandering (be it intentional, unintentional, or both) than did participants in the control condition, one obvious concern would be that rates of mind wandering were not in fact different across the conditions, but instead, that participants in the motivation condition were inclined to provide false reports so that they could leave the experiment early. To eliminate this concern, we provided the following additional instruction to participants in the motivation condition to make it clear that their reports of mind wandering were not being considered in the context of their task performance:

> "One thing that is very important to note is that your responses about mind wandering WILL NOT be considered when the computer analyzes your performance on the task, so please be completely honest when reporting whether you were mind wandering (intentionally or unintentionally) or focused on the task. In theory, you could mind-wander 100% of the time but still be let out early if your performance on the task is good enough, i.e., we only care about your performance on the task, and NOT how frequently you report that you are on task or mind wandering.
> So once again, I want to reiterate that your responses about mind wandering WILL NOT be used to determine whether you have achieved a high enough level of performance to leave the experiment early, so please provide accurate responses to the thought-sampling questions!"

With the inclusion of this additional instruction, however, another concern arose: as can be seen above, we instructed participants in the motivation condition to provide "honest" reports to the thought probes. However, as previous research has shown (Vinski & Watter, 2012), priming honesty can lead to decreased reports of mind wandering. Hence, if we were to prime honesty only in the motivation condition (and not in the control condition), we might observe differences in rates of mind wandering, not because rates of mind wandering did in fact differ across conditions, but because participants in the motivation condition provided more honest reports of their mental experiences (and hence, less mind wandering). Thus, to alleviate this final concern, we presented participants in the control condition with a similar instruction to respond honestly to the thought probes:

> "Please be completely honest when reporting whether you were mind wandering (intentionally or unintentionally) or focused on the task. In this study, we are particularly interested in your performance on the task, and not whether you engage in mind wandering, i.e., we only care about your performance on the task, NOT how frequently you report that you are on task or mind wandering.
> So once again, I want to reiterate that we are interested in your performance on the task, and NOT how frequently you report that you are on task or mind wandering, so please provide accurate responses to the thought-sampling questions!"

[1] In the motivation condition, the performance criterion for leaving the experiment early was exceptionally lax (although participants were unaware of this): to meet this criterion, participants merely had to respond (via a spacebar press) to at least one of the 900 MRT tones. As anticipated, all participants met and surpassed this criterion and they were all therefore excused from the experiment after approximately 30 min. On the other hand, all of the participants in the control condition were informed, after approximately 30 min (i.e., after completing 900 MRT trials) that they could leave the experiment early (irrespective of their performance on the MRT; although all of these participants likewise met and surpassed the criterion that we had set for the motivation condition).

Reports of task-based motivation

As in previous work (Seli et al., 2015a; d; Unsworth & McMillan, 2013), we assessed task-based motivation at the end of the MRT.[2] To this end, we presented participants with the following instruction: "We would now like you to complete a single question asking about your motivation level during the task. Please answer this question as HONESTLY and as ACCURATELY as possible. How motivated were you to perform well on the task?" Response options to this question ranged from 1 ("not motivated at all") to 7 ("very motivated").

Measures

Rhythmic-response times (RRTs; Seli et al., 2013) were calculated on each trial as the difference between the onset of each tone and the associated spacebar press. The mean RRT thus indexes the extent to which participants approximate the onset of the tone. Variability in RRTs is, however, the primary measure of interest yielded by the MRT, and we therefore computed an RRT variance score by first categorizing RRTs in 5-trial moving windows over the task duration.[3] As in Seli et al. (2014), to minimize problems of contamination, we excluded from our computations responses from the first five trials of the MRT, as well as the five responses following each thought probes. Within each 5-trial window, we then computed the variances of the observed RRTs, after which we normalized these scores using a natural logarithm transform (Seli et al., 2013b), and then averaged these transformed variance scores for an overall measure of RRT variance (hereafter referred to as "MRT variability"). As noted earlier, we were also interested in examining participants' omission rates during the MRT (i.e., failures to produce a response on a given trial), and as such, we computed each participant's proportion of omissions by dividing the number of omissions by the total number of trials (900).

In addition to MRT performance, we were interested in mind-wandering rates for each of the two types of mind wandering (intentional and unintentional), which were calculated as the proportion of each type of response provided (i.e., the number of reports of each type of mind wandering divided by the total number of thought probes), and in overall rates of mind wandering, which was calculated as the sum of the proportion of intentional and unintentional mind wandering.

Finally, we were interested in determining participants' levels of task-based motivation. To this end, we simply examined participants' responses to the single-item motivation question (Seli et al., 2015a).

Results

We report the descriptive statistics for all primary measures of interest, for both conditions (motivation, control), in Table 1.

First, we conducted a manipulation check to ensure that participants in the motivation condition were in fact more highly motivated to perform well on the MRT than were participants in the control condition. Results of an independent-samples t test indicated that the motivation manipulation was indeed effective: Participants who underwent the motivation manipulation reported significantly higher levels of task-based motivation ($M = 5.38$, $SD = 1.34$; $n = 50$) than did participants in the control condition ($M = 3.71$, $SD = 1.35$; $n = 51$), $t(99) = 6.27$, $SE = 0.27$, $p < .001$, $d = 1.24$.

Having confirmed that our motivation manipulation was successful, we next moved on to examine our primary question of interest: Namely, whether rates of mind

Table 1 Descriptive statistics for all primary measures of interest

	n	M	SD
MRT variance			
Motivation	50	8.1494	0.56282
Control	51	8.4864	0.66525
Omissions			
Motivation	50	0.0105	0.01229
Control	51	0.0331	0.05807
Intentional mind wandering			
Motivation	50	0.1589	0.15184
Control	51	0.2560	0.19407
Unintentional mind wandering			
Motivation	50	0.3344	0.17870
Control	51	0.4161	0.21499
Overall mind wandering			
Motivation	50	0.4933	0.19493
Control	51	0.6721	0.16750
Motivation			
Motivation	50	5.3800	1.33844
Control	51	3.7059	1.34602

[2] In the motivation condition, to avoid possible contamination due to demand characteristics, the responses to the motivation question were obtained after participants learned that they could leave the study early (to maintain consistency across conditions, in the control condition, we also obtained motivation responses after participants learned that they could leave the study early).

[3] For more information surrounding the rationale behind computing the variance measure in this manner, see Seli, Carriere, Levene, & Smilek (2013a).

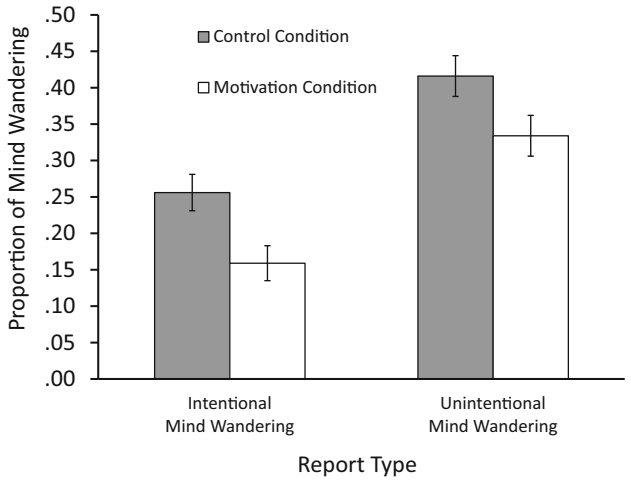

Fig. 1 Proportion of mind wandering as a function of report type (intentional mind wandering, unintentional mind wandering) presented separately for condition (control, motivation). *Error bars* are ±1 SEM

wandering varied as a function of condition (motivation, control), and more specifically, whether the effect of motivation on mind wandering was associated with a decrease in intentional bouts of this experience, as predicted by Giambra (1995). Thus, we conducted a 2 (condition: motivation, control) by 2 (mind-wandering type: intentional, unintentional) mixed analysis of variance with proportion of mind-wandering type as the dependent variable (Fig. 1). Across conditions, there was a significant main effect of mind-wandering type, $F(1, 99) = 26.79$, MSE = 0.05, $p < .001$, $\eta_p^2 = .21$, indicating, as previously reported (e.g., Seli et al., 2015a) that unintentional mind wandering was reported more often than intentional mind wandering (but see Wammes, Seli, Cheyne, Boucher, & Smilek, 2016). Most critically in the context of Giambra's (1995) prediction, we failed to observe a significant condition × mind-wandering type interaction, $F(1, 99) = 0.57$, MSE = 0.05, $p = .812$, $\eta_p^2 = .001$. Importantly, however, we did observe a significant main effect of condition, $F(1, 99) = 24.47$, MSE = 0.02, $p < .001$, $\eta_p^2 = .20$, indicating that participants in the motivation condition reported significantly less mind wandering (collapsing across intentional and unintentional types) than did participants in the control condition. In fact, in examining rates of overall mind wandering (i.e., the sum of the proportion of intentional and unintentional mind wandering) across our two groups, we found that, whereas participants in the control condition reported the experience of mind wandering to 67% of the thought probes, participants in the motivation condition only reported mind wandering to 49% of the probes. Put differently, the motivation manipulation reduced rates of overall mind wandering by 18 percentage points.

Next, we more directly examined the link between task-based motivation and mind wandering by evaluating the possibility that motivation mediated the relation between condition (dummy-coded: control = 0, motivation = 1) and intentional/unintentional mind wandering. Given that (a) intentional and unintentional mind wandering were significantly correlated, and (b) we did not predict this to be a causal relation, rather than house both variables in the same mediation model, separate models were tested for each mind-wandering type. To be conservative in our analyses, when testing for indirect effects of task-based motivation on one type of mind wandering (e.g., intentional), the other type of mind wandering (e.g., unintentional) was included in the model as a covariate.

In our first model, the PROCESS modelling tool (Hayes, 2012) was used to estimate the indirect effect of condition on intentional mind wandering through motivation (with unintentional mind wandering entered as a covariate). PROCESS was set to Model 4, with 1000 bootstrap samples (using the Percentile method; Hayes & Scharkow, 2013), and a 95% confidence level for confidence intervals. The mediation model with unstandardized regression coefficients is depicted in Fig. 2 (top panel). The model is suggestive of partial mediation by task-based motivation: The indirect effect on intentional mind wandering through task-based motivation is statistically significant, −0.0422 (95% CI −0.0940 to −0.0003), but so too is the direct effect of condition on intentional mind wandering when motivation was included in the model, −0.0931 (95% CI −0.1612 to −0.0250).

In our second model, we estimated the indirect effect through motivation on unintentional mind wandering (with intentional mind wandering entered as a covariate). The mediation model with unstandardized regression coefficients is depicted in Fig. 2 (bottom panel). Again, the model is suggestive of partial mediation by task-based motivation: The indirect effect on unintentional mind wandering through task-based motivation is statistically significant, −0.0480 (95% CI −0.0984 to −0.0061), as is the direct effect of condition on intentional mind wandering when motivation was included in the model, −0.0921 (95% CI −0.1700 to −0.0142).

Of secondary interest in the present experiment was an examination of how our motivation manipulation may have impacted task performance. In particular, we wanted to determine whether participants in the motivation condition outperformed participants in the control condition. To this end, we examined MRT performance (MRT variance and omissions) as a function of condition. An independent samples *t* test in which we examined MRT variance as a function of condition revealed that participants who underwent the motivation manipulation had significantly lower variance ($M = 8.15$, SD = 0.56; $n = 50$) than did

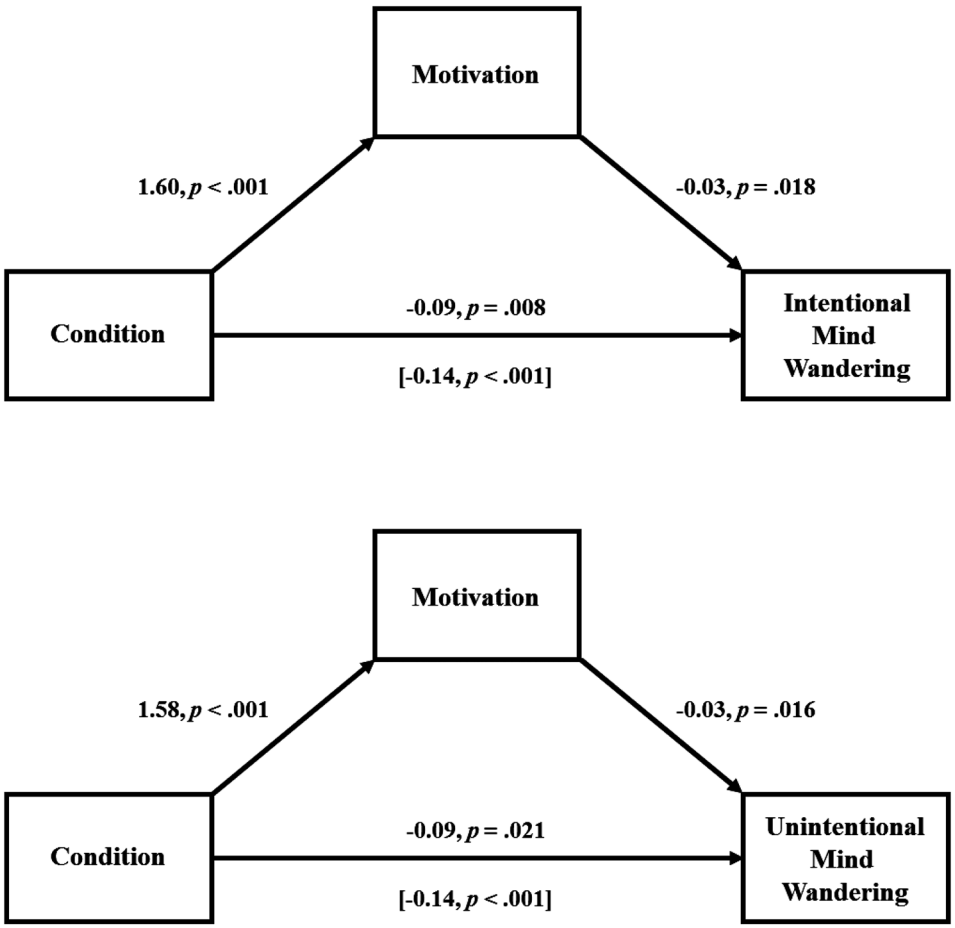

Fig. 2 PROCESS mediation models depicting the relationship between dummy-coded condition (control = 0, motivation = 1) and intentional (*top panel*) and unintentional (*bottom panel*) mind wandering, with task-based motivation as a mediator. In the model in the *top panel*, rates of unintentional mind wandering were entered as a covariate, whereas in the model in the *bottom panel*, rates of intentional mind wandering were entered as a covariate. Direct effects appear *above* the *horizontal lines*, whereas total effects appear (in *square brackets*) *below* the *horizontal lines*

participants in the control condition ($M = 8.49$, SD = 0.67; $n = 51$), $t(99) = 2.75$, SE = 0.12, $p = .007$, $d = 0.55$. Likewise, a parallel analysis with omissions as the dependent measure showed that participants in the motivation condition had significantly lower rates of omissions ($M = 0.01$, SD = 0.01; $n = 50$) than did participants in the control condition ($M = 0.03$, SD = 0.06; $n = 51$), $t(54.554) = 2.710$, SE = 0.01, $p = .009$, $d = 0.53$.[4] Thus, not only did the motivation manipulation result in significantly lower rates of mind wandering, it also led to significant improvements in task performance on the MRT.

Given that participants in the motivation condition reported less mind wandering and showed improved performance compared with the control condition, one question of interest is whether the improvements in performance were driven by decreases in rates of intentional and unintentional mind wandering. To explore this possibility, we first examined the Pearson product–moment correlation coefficients for our performance measures (MRT variance and omissions) and our measures of mind wandering (intentional and unintentional; see Table 2). Contrary to previous reports (e.g., Seli et al., 2015a), here we failed to observe any significant positive relations among MRT variability and intentional and unintentional mind wandering. That said, whereas unintentional mind wandering was not significantly associated with omissions, intentional mind wandering was: Participants who reported more episodes of intentional mind wandering also tended to produce more omissions during the MRT.

Based on the results of the correlation analysis, it appears that the decrease in MRT variance exhibited by participants in the motivation condition was not driven by a decrease in mind wandering (be it intentional or unintentional). Indeed, rates of intentional and unintentional mind

[4] Upon examining the psychometric properties of the primary variables of interest, we found that the distribution of omissions was non-normal (skewness >2, kurtosis >4; Kline, 1998; all other variables had normally distributed data). In an attempt to normalize the omission data, we conducted a log 10 transformation, which was effective (after the transformation, skewness <2, kurtosis <4; Kline, 1998). However, irrespective of whether our succeeding analyses were conducted on the transformed or non-transformed omission data, the same patterns of results emerged. Thus, to retain meaningful mean values for the omission rates, all analyses involving omission data were conducted while using the non-transformed values.

Table 2 Pearson product–moment correlations for measures of MRT performance (MRT variance and omissions) and intentional/unintentional mind wandering ($N = 101$)

	Omissions	Intentional mind wandering	Unintentional mind wandering
MRT variance	0.34**	0.03	0.10
Omissions		0.22*	0.08
Intentional mind wandering			−0.44**

** $p < .01$, * $p < .05$

wandering were not significantly associated with MRT variance, which suggests that mediation via decreased reports of intentional and unintentional mind wandering is unlikely. Nonetheless, to be certain, we formally evaluated the possibility that intentional and/or unintentional mind wandering might mediate the relation between condition (dummy-coded) and MRT variance.

As noted previously, because (a) intentional and unintentional mind wandering were significantly correlated, and (b) we did not predict this to be a causal relation, separate models were tested for each mind-wandering response. In addition, when testing for indirect effects through one type of mind wandering, the other type of mind wandering response was included in the model as a covariate.

We first turned our attention to intentional mind wandering. The PROCESS modelling tool (Hayes, 2012) was used to estimate the indirect effect of condition on MRT variance through intentional mind wandering (controlling for unintentional mind wandering). PROCESS was set to Model 4, with 1000 bootstrap samples (using the Percentile method; Hayes & Scharkow, 2013), and a 95% confidence level for confidence intervals. The mediation model with unstandardized regression coefficients is depicted in Fig. 3 (top panel). As anticipated, the indirect effect through intentional mind wandering was not significant, 0.0105 (95% CI −0.1083 to 0.1077).

The indirect effect through unintentional mind wandering was analyzed in the same manner, with intentional mind wandering included as a covariate. The mediation model with unstandardized regression coefficients is depicted in Fig. 3 (bottom panel). Again, as anticipated, the indirect effect through unintentional mind wandering was not significant, −0.0160 (95% CI −0.1398 to 0.0839).

Next, we conducted parallel mediation analyses, but this time, we examined the possibility that the relation between condition and omissions is mediated by intentional and/or unintentional mind wandering. Given that increases in rates of intentional (but not unintentional) mind wandering were found to be associated with increases in omission rates (see Table 2), we reasoned that if mind wandering does mediate the relation between condition and omissions, then this mediation would likely occur via intentional mind wandering. Consistent with this hypothesis, the indirect effect of condition on omissions through intentional mind-wandering was significant, −0.0079 (95% CI −0.0187 to −0.0011) (see Fig. 4, top panel). At the same time, however, the indirect effect through unintentional mind wandering was not significant, −0.0047 (95% CI −0.0131 to 0.0006) (see Fig. 4, bottom panel).

Discussion

In the present experiment, we explored the possibility that one potentially fruitful way to reduce rates of mind wandering during a sustained-attention task is to increase participant motivation to perform well on the task. Taking a more nuanced perspective, we were also interested in determining whether any motivation-based reductions in mind wandering were associated with decreases in intentional mind wandering, unintentional mind wandering, or both. We found that our motivation manipulation led to similar decreases in rates of intentional and unintentional mind wandering, and that probe-caught reports of overall mind wandering in the motivation condition were 18 percentage points lower than they were in the control condition. Moreover, we found that the relation between condition (control and motivation) and intentional/unintentional mind wandering was partially mediated by participants' reports of task-based motivation. With respect to task performance, we found that increasing participant motivation led to significant improvements, with participants in the motivation condition producing (a) lower response variability and (b) fewer errors of omission than participants in the control condition. Nevertheless, mediation analyses indicated that the reductions in response variability were not attributable to the observed decreases in intentional or unintentional mind wandering in the motivation condition. We did, however, find that the reduction in omission rates was attributable to the lower rates of intentional mind wandering reported in the motivation condition.

Although the reductions in mind wandering observed in the motivation condition were not tied to improved

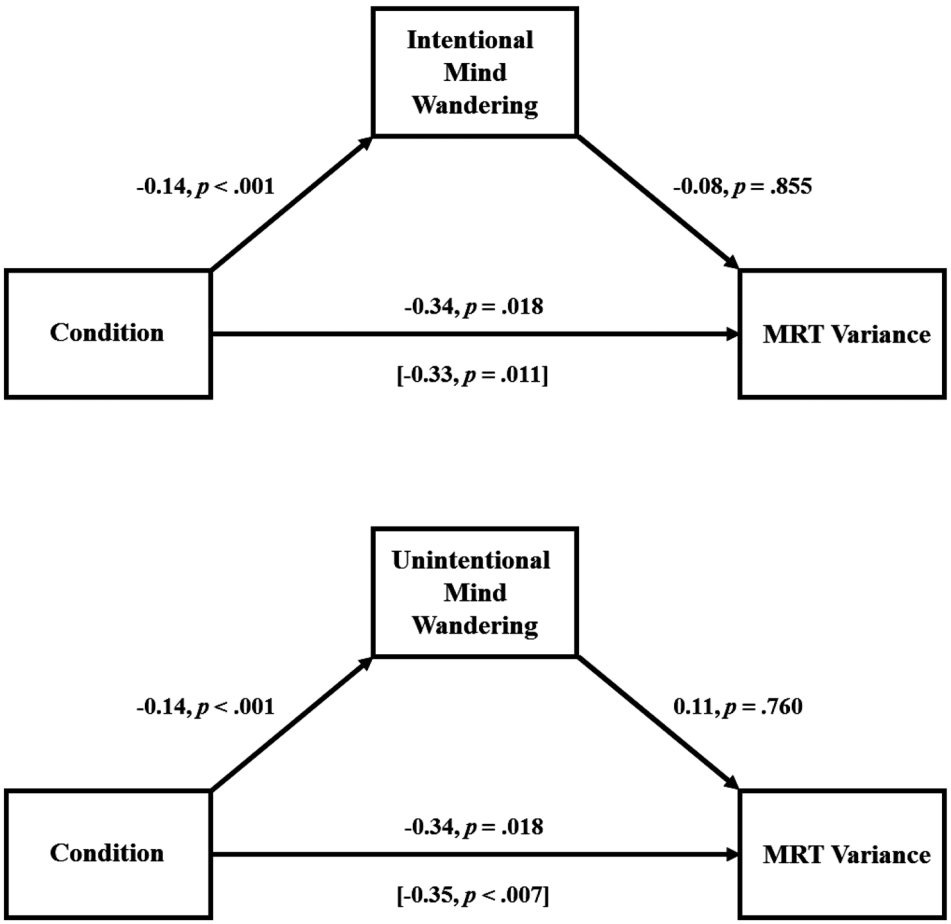

Fig. 3 PROCESS mediation models depicting the relationship between dummy-coded condition (control = 0, motivation = 1) and MRT variance, with intentional (*top panel*) and unintentional (*bottom panel*) mind wandering as a mediator. In the model in the *top panel*, rates of unintentional mind wandering were entered as a covariate, whereas in the model in the *bottom panel*, rates of intentional mind wandering were entered as a covariate. Direct effects appear *above* the *horizontal lines*, whereas total effects appear (in *square brackets*) *below* the *horizontal lines*

performance (with the exception of the link between omission rates and intentional mind wandering), it is worth highlighting the fact that mind wandering has been shown to have negative consequences for performance across various tasks. For example, increased rates of mind wandering have been associated with poorer performance on tasks assessing reading comprehension (e.g., Unsworth & McMillan, 2013), memory (e.g., Smallwood, Baracaia, Lowe, & Obonsawin, 2003), response inhibition (e.g., Smallwood, McSpadden, & Schooler, 2007), and more generally, task-relevant processing (e.g., Barron, Riby, Greer, & Smallwood, 2011; for a review, see Mooneyham & Schooler, 2013). Increased rates of mind wandering have also been associated with poorer performance in academic contexts (e.g., Wammes et al., 2016), daily functioning (e.g., McVay, Kane, & Kwapil, 2009), and while driving (e.g., Yanko & Spalek, 2013). Thus, although rates of mind wandering in the present study were not significantly associated with most of the primary measures yielded by the MRT, the demonstration that rates of mind wandering can be reduced via a motivation manipulation likely has important implications for performance measures in various other contexts. Indeed, in any case where there is a strong link between mind wandering and performance costs, it follows that reducing mind wandering via a motivation manipulation should directly result in improved performance.

Whereas the present work was largely concerned with Giambra's (1995) early theoretical work on mind wandering, another early theory of mind wandering that appears to have some relevance to the present findings is Klinger's current concerns theory (e.g., Klinger, 1971, 1999, 2009). According to this theory, people engage in mind wandering because they have unfulfilled goals ("current concerns") that extend beyond the present moment, and these concerns co-opt their attention. To date, there is an abundance of evidence supporting the contention that people's mind wandering is frequently directed toward their unfulfilled goals or current concerns. For instance, in studies examining mind wandering in daily life, researchers have found that participants rate their episodes of mind wandering as being oriented more toward personal concerns or things they "need to do" than toward worries or daydreams (Kane et al., 2007; McVay et al., 2009). Moreover, research has shown that the current concerns that participants endorse via questionnaires are

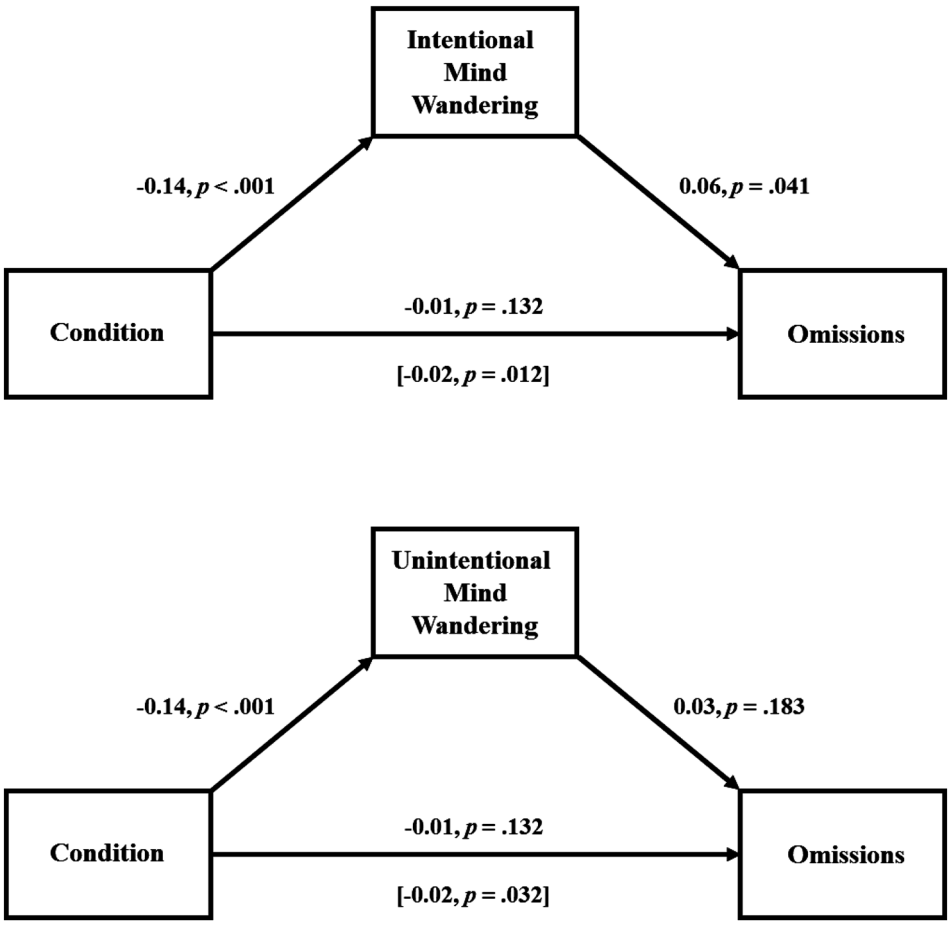

Fig. 4 PROCESS mediation models depicting the relationship between dummy-coded condition (control = 0, motivation = 1) and omissions, with intentional (*top panel*) and unintentional (*bottom panel*) mind wandering as a mediator. In the model in the *top panel*, rates of unintentional mind wandering were entered as a covariate, whereas in the model in the *bottom panel*, rates of intentional mind wandering were entered as a covariate. Direct effects appear *above* the *horizontal lines*, whereas total effects appear (in *square brackets*) *below* the *horizontal lines*

frequently present in their open-ended thought reports over the course of the following 24-h period (Klinger, Barta, & Maxeiner, 1980). In the context of the present study, it is reasonable to assume that our motivation manipulation (a) increased the extent to which participants were concerned with task performance, which (b) led to an increase in task-related thoughts, and (c) led to a reduction in the frequency of other, task-unrelated concerns. Although this is an interesting possibility, given that we did not directly measure current concerns in the present experiment, we cannot confidently speak to this issue, and we therefore recommend that future research investigates the relations among current concerns, motivation manipulations, and rates of mind wandering.

Given that one might intuitively think that motivation is tied to deliberate, but not unintentional processes, one might have expected that our motivation manipulation would have only affected rates of intentional mind wandering. Indeed, this was the rationale behind Giambra's (1995) prediction that rates of intentional—but not unintentional—mind wandering should be "motivationally determined." Although, at face value, this prediction is very reasonable, the present finding of a similar decrease in rates of both intentional and unintentional mind wandering suggests that it is incorrect. At first, the disconfirmation of this prediction might seem paradoxical, as it might be taken to imply that increasing motivation can increase control over unintentional mind wandering; after all, how can unintentional thought be controlled? We suggest that this apparent paradox can be avoided by considering the findings from the vantage point of on-task focus rather than from the vantage point of mind wandering. Specifically, we suggest that, in some cases, increasing motivation has the effect of increasing on-task focus, which in turn increases the 'grip' of attention on task-related information/processes. Furthermore, we propose that this increased 'grip' decreases the likelihood of attention being co-opted (unintentionally) by mind wandering. Of course, such a grip would likewise lead to decreases in wilful mind wandering, which explains why both intentional and unintentional mind wandering are curtailed by increased motivation.

In considering the influence of the motivation manipulation used in the present study, it is worth highlighting the fact that self-reported motivation only partially mediated the relation between condition (control, motivation) and rates of intentional and unintentional mind wandering.

Importantly, what this suggests is the possibility that our motivation instructions may have influenced other dimensions of motivation that were not captured by our motivation scale, and that these factors may have also produced decreases in intentional and unintentional mind wandering. For example, it is possible that our instructions may have influenced aspects of motivation that are relevant to participants' feelings of autonomy (e.g., it could have led them to believe that the structure of their laboratory experience was under their control) and gamification/challenge (e.g., participants may have felt more challenged because the task offered them the potential to earn an early departure). Thus, we recommend that future research assesses these (and perhaps other) potential factors to understand the role that they might play in manipulations of motivation.

One particularly surprising finding yielded by the present experiment was that, although participants in the motivation condition were highly motivated to perform well on the MRT, they nevertheless engaged in a notable amount of intentional mind wandering: They spent more than 15% of their time deliberately thinking about task-unrelated thoughts during the MRT. An obvious interpretation of these findings is that our manipulation of motivation was simply not powerful enough. However, we note that participants in the motivation manipulation reported being quite highly motivated ($M = 5.38$ on a 7-point scale). Given that these participants were quite highly motivated to perform well on the MRT (presumably so that they could be excused early from the experiment), this finding suggests the interesting possibility that people may be unaware of the frequent negative consequences of mind wandering. Indeed, if an individual were highly motivated to perform well on a given task, and if this individual were aware of the negative consequences of mind wandering while completing this task, then it would be most reasonable to refrain from deliberately engaging in mind wandering during the task.[5] There is also the possibility that people do have a general understanding that mind wandering can be deleterious for performance in some cases, but they fail to concern themselves with the negative consequences of mind wandering in the context of the relatively undemanding metronome-response task that they completed. Regardless, if people sometimes underestimate the degree to which mind wandering can negatively impact their performance, it seems that one rather simple method with which researchers might reduce mind wandering is to educate people about its frequent negative outcomes.

The finding that increasing motivation can reduce mind wandering and improve performance raises an interesting question regarding the underlying factors involved in the effects of mindfulness training on mind wandering and performance: Could the beneficial effects of mindfulness training on rates of mind wandering be at least partly mediated by motivational shifts that are induced by the mindfulness training? In the extreme case, if all of the beneficial effects of mindfulness training were due to an increase in motivation, then it would be likely that the effectiveness of the training procedures might not depend on the minute details of the procedures, but instead on the capability of the trainer to boost individuals' motivation to approach tasks in an attentive manner. Indeed, variations in the trainers' abilities to influence motivation in participants might provide a partial explanation for the variation in the reported effectiveness of mindfulness training techniques (Eberth & Sedlmeier, 2012).

Finally, it should be noted that the present results have important implications for the way in which researchers ought to conceptualize mind wandering in future work. In a large portion of the extant literature, it is often assumed that rates of mind wandering can be taken to reflect people's attentional abilities. Indeed, mind wandering has often been discussed in terms of reflecting a "failure of executive control" (e.g., McVay & Kane, 2010) and it has been likened to attentional deficits (e.g., Mowlem et al., 2016). However, in most cases where researchers study mind wandering, the tasks that they administer are rather boring and often involve considerable repetition and little in the way of salient exogenous stimulation (Hancock, 2013). Thus, it seems likely that participants may not be highly motivated to perform well on these sorts of tasks, and as such, they may disengage from the tasks in the service of mind wandering. At the same time, even in tasks that people perform outside of the laboratory (e.g., driving), repeated engagement in the task might lead to reduced motivation to attend to the task because any consequences of inattention are not immediately forthcoming. Importantly, this suggests a motivation-based account of mind wandering, which posits that much of the mind wandering that people engage in might be attributable to low levels of motivation to attend to the task, rather than an attentional deficit.[6] Indeed, in the present experiment, we showed that

[5] This may be particularly true in the present experiment, given that participants were not provided a clear performance criterion, and given that MRT response variability (one of the primary measures of interest) is not likely to be easily monitored by participants. This suggests the possibility that, if participants were to complete a task whose performance measure(s) were more transparent, and one in which they could better monitor their performance, high motivation may lead to greater reductions in intentional mind wandering compared with the reductions observed here (we thank Dr. Michael Kane for suggesting this possibility).

[6] Critically, the motivation-based account and the executive-failures account (McVay & Kane, 2010) are not necessarily mutually exclusive. Indeed, mind wandering could result from a lack of motivation to attend to a focal task, and/or as a result of poor executive control.

motivating participants to perform well on a focal task led to a dramatic reduction in probe-caught mind-wandering rates (49%) compared to a control condition (67%). If, however, mind wandering were strictly reflective of an attentional deficit or a failure of executive control, then it is unclear why a manipulation of motivation would have any effect on rates of mind wandering, which should be impervious to motivational changes. Together with other findings linking mind wandering and motivation (Robison & Unsworth, 2015; Seli et al., 2015a, d; Unsworth & McMillan, 2013), the present findings provide support for a motivation-based account of mind wandering, which we believe has the potential to provide much clarity and insight in future work on the topic, and as such, we encourage researchers to examine the important role of motivation in their studies of mind wandering.

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Compliance with ethical standards

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Conflict of interest Paul Seli declares that he has no conflict of interest. Daniel L. Schacter declares that he has no conflict of interest. Evan F. Risko declares that he has no conflict of interest. Daniel Smilek declares that he has no conflict of interest.

Ethical approval All procedures performed were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

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