

Supplemental Material

for

On the Clock: Evidence for the Rapid and Strategic Modulation of Mind-Wandering

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Preliminary Experiments

In our initial investigation of the possibility that people can modulate their mind wandering on a moment-to-moment basis in anticipation of variations in within-task demands, we conducted two experiments involving a modified version of the Sustained Attention to Response Task (SART; Robertson, Manly, Andrade, Baddeley, & Yiend, 1997). The SART is a popular paradigm for assessing mind wandering, and requires repeated responding (key presses) to a series of randomly presented digits (1-9) and withholding of that response when a rare (NOGO) stimulus appears (e.g., “3”). The critical SART measure is the proportion of NOGO trials on which a participant fails to withhold a response (i.e., NOGO Errors), with more NOGO errors being thought to reflect periods of task inattention/mind wandering (e.g., Christoff, Gordon, Smallwood, Smith, & Schooler, 2009; Seli, Jonker, Cheyne, & Smilek, 2013). Typically, in the SART, NOGO stimuli are pseudo-randomly presented, and hence, it is difficult to predict the precise moment at which they will occur. However, because we were interested in examining the possibility that people can modulate their mind wandering within a task, as the tasks demands wax and wane, we modified the SART to allow participants the opportunity to control their mind wandering in anticipation of upcoming targets by presenting the critical NOGO target every nine trials.

If people can indeed modulate their mind wandering on a moment-to-moment basis, we predicted that the level of mind wandering would initially increase immediately following the NOGO digits because the next critical NOGO digit would not be presented for some time time, which should afford the participants the opportunity to engage in mind wandering without incurring performance costs. Furthermore, we predicted that as the next NOGO digit became more imminent, participants would decrease their level of mind wandering in preparation for this

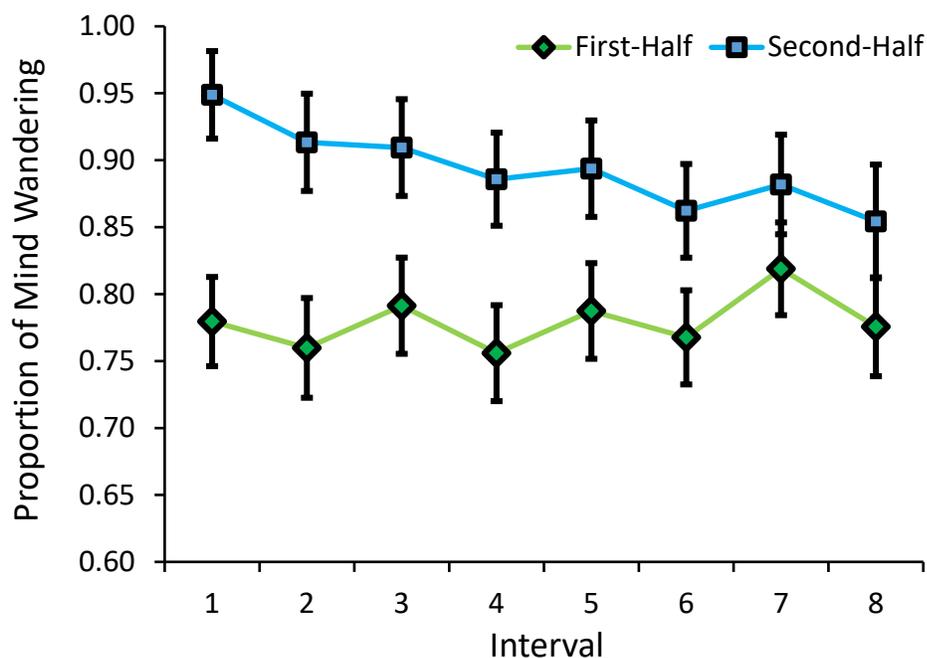
critical event. Importantly, given that the predictable sequence of NOGO trials should take time to learn, we reasoned that the strength of such an effect should increase as the experiment progresses, which we tested by comparing the patterns of mind wandering across the first and second-half of the experiment.

To index rates of mind wandering, we pseudo-randomly presented thought probes throughout the modified SART. In Experiment 1, the probes required participants to report whether they were: (1) completely on task, (2) mostly on task, (3) both on task and thinking about unrelated concerns, (4) mostly thinking about unrelated concerns, or (5) completely thinking about unrelated concerns (Franklin, Smallwood, & Schooler, 2011). Here, we classified all responses except “(1) completely on task” as mind wandering, given that response options 2-5 indicated some degree of mind wandering. Having found evidence for the predicted modulation effect in Experiment 1, we then attempted to replicate this general finding (Experiment 2). In Experiment 2, we made slight modifications to the thought probes by requiring participants to report whether they were (1) on task, or (2) mind wandering, as is more typically done in research on mind wandering. In both experiments, we presented three probes at each of the eight possible temporal positions between NOGO trials. One-hundred thirty undergraduate students participated in Experiment 1, and 48 in Experiment 2.

Results

In Experiment 1, results showed a significant main effect of block, $F(1,126) = 37.03$, $MSE = 0.18$, $p < .001$, $\eta_p^2 = .23$, with more mind wandering during the second relative to the first half of the modified SART. We also observed a significant linear interaction of block and interval, $F(1,126) = 6.02$, $MSE = 0.09$, $p = .016$, $\eta_p^2 = .05$. To follow-up on the interaction, we

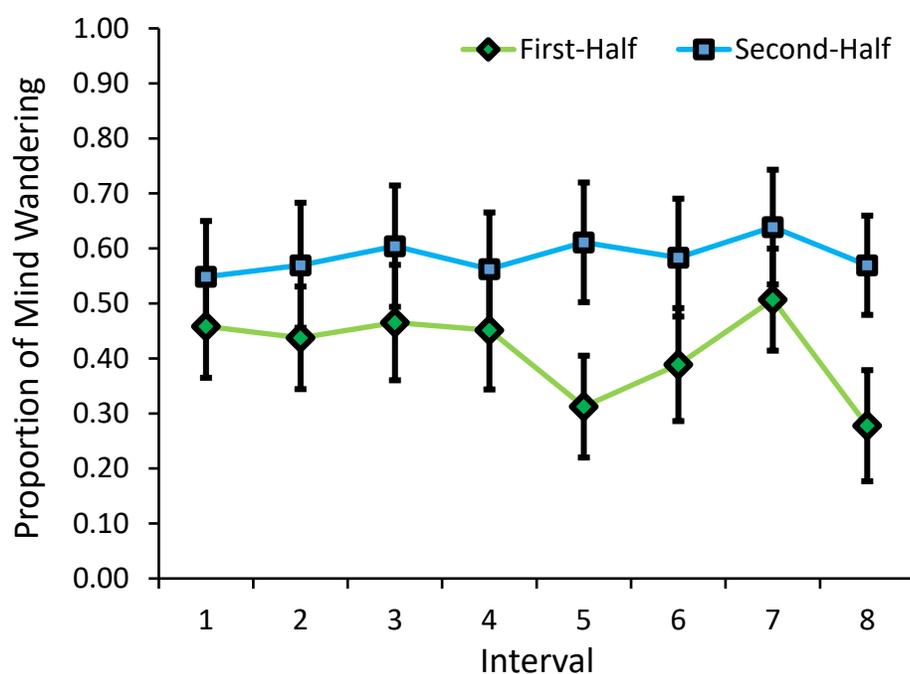
conducted separate analyses on the mind-wandering data from each of the two halves of the experiment. Although there were no significant effects in the first half of the experiment (all p s > 0.25), consistent with our hypothesis, we observed both a significant main effect of interval, $F(1,126) = 2.51$, $MSE = 0.05$, $p = .015$, $\eta_p^2 = .02$, and a significant linear decrease in mind wandering as a function of interval in the second half of the experiment, $F(1,126) = 10.25$, $MSE = 0.07$, $p = .002$, $\eta_p^2 = .08$ (Supplementary Figure 1). This pattern of results was taken as support for our hypothesis that people can and do modulate their mind wandering on a moment-to-moment basis.



Supplementary Figure 1. Mean proportion of mind wandering as a function of interval for first- and second halves in Experiment 1. Bars are 95% confidence intervals computed for within-subjects data.

As noted above, in Experiment 2, we attempted to replicate the modulation effect observed in Experiment 1 (but here we used dichotomous rather than continuous thought

probes). When examining rates of mind wandering, we found a significant main effect of block, $F(1,47) = 43.39$, $MSE = 0.13$, $p < .001$, $\eta_p^2 = .48$, with higher rates of mind wandering during the second half of the task relative to the first half. No other results were significant (all $ps > 0.22$; Supplementary Figure 2). Thus, we failed to replicate the modulation effect observed in Experiment 1.



Supplementary Figure 2. Mean proportion of mind wandering as a function of interval for first- and second halves in Experiment 2. Bars are 95% confidence intervals computed for within-subjects data.

Discussion

In Experiment 1, participants completed a modified version of the SART in which the infrequent, high-demand NOGO targets were presented in a predictable manner (i.e., one NOGO

target was presented every nine trials). Throughout the SART, we intermittently presented continuous thought probes that asked participants to indicate (on a scale of 1-5) the extent to which their minds were wandering just prior to each probe. As reported above, we found that, after some experience with the task (i.e., in the second half of the experiment), participants decreased their levels of mind wandering over trials as they approached the predictable NOGO targets, which was taken as support for the hypothesis that people can and do modulate their mind wandering based on variations in demands within a single task. However, when we attempted to replicate this finding using dichotomous thought probes (Experiment 2), we did not observe the same modulation effect. In considering why this might have been the case, we reasoned that there were three potential problems with our initial design that may have precluded us from observing this effect (see below). In light of these concerns, we then created the Clock Task, which was specifically developed to circumvent these three problems.

Problem 1. Both in Experiments 1 and 2, we did not explicitly tell participants that there was a predictable pattern of SART NOGO targets, but instead left it up to them to recognize this pattern of momentary changes in task demands. This feature of our initial design is particularly important because, if people can in fact strategically modulate their mind wandering based on momentary changes in task demands, then to do so, they must have some understanding of when these changes in task demands will occur (otherwise, a more effective strategy would be to maintain a relatively constant focus of attention across the entire task). Thus, to eliminate this concern, we designed our Clock Task such that the momentary changes in task demands were completely visible (and thus, explicit) and predictable throughout the task. Indeed, for the first 19 seconds of each revolution around the clock's face, participants were told that they would not have to do anything (low demand), whereas during the 20th second, when the clock's hand

pointed at 12 o'clock, they were told to produce a button press (relatively high demand). Thus, the Clock Task allowed us to ensure that participants were explicitly aware of the predictable momentary changes in task demands, which in turn made it possible for them to strategically modulate their mind wandering in accordance with these changes in task demands.

Problem 2. In our original experiments, we did not reward good performance on the SART. The reason this was potentially problematic is that, even if participants were aware of the predictable pattern of changes in task demands, if they were not motivated to perform well on the SART, then it is reasonable to assume that they would not have modulated their mind wandering in accordance with the changes in task demands, but would have instead maintained a relatively constant level of task inattention throughout the SART (i.e., if participants did not care about withholding their response to NOGO targets, then there would be little reason to increase task-based focus just prior to the high-demand NOGO targets). To minimize this concern, in our follow-up experiments we provided bonus money for each correct response on the Clock Task, which should increase participants' motivation to modulate their mind wandering by reengaging their attention just prior to each critical event.

Problem 3. In our original design, even if participants were aware of the predictable pattern of NOGO targets (and even if they were motivated to perform well on the SART), it is reasonable to assume that the presentation of thought probes may have inadvertently disrupted this pattern. If, for example, a participant knew that the critical NOGO target would be presented 6 trials from the current trial, but a thought probe was presented at this point, the participant may have forgotten where in the pattern she was. This would in turn add noise to the mind-wandering reports. Thus, in our new design, to eliminate this concern, when a thought probe was presented, we ensured that the task stimuli (and hence, the predictable pattern) were still visible to

participants, which should reduce noise in reports of mind wandering by allowing participants to continue to modulate their mind wandering based on changes in task demands.

References for Supplemental Material

- Christoff, K., Gordon, A. M., Smallwood, J., Smith, R., & Schooler, J. W. (2009). Experience sampling during fMRI reveals default network and executive system contributions to mind wandering. *Proceedings of the National Academy of Sciences, 106*, 8719-8724.
- Franklin, M. S., Smallwood, J., & Schooler, J. W. (2011). Catching the mind in flight: Using behavioral indices to detect mindless reading in real time. *Psychonomic Bulletin & Review, 18*, 992-997.
- Robertson, I. H., Manly, T., Andrade, J., Baddeley, B. T., & Yiend, J. (1997). "Oops!": Performance correlates of everyday attentional failures in traumatic brain injured and normal subjects. *Neuropsychologia, 35*, 747-758.
- Seli, P., Jonker, T. R., Cheyne, J. A., & Smilek, D. (2013). Enhancing SART validity by statistically controlling speed-accuracy trade-offs. *Frontiers in Psychology*. doi: 10.3389/fpsyg.2013.00265