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Motivating meta-awareness of mind wandering: A way to catch the mind in flight?

Claire M. Zedelius *, James M. Broadway, Jonathan W. Schooler

Department of Psychological and Brain Sciences, University of California, Santa Barbara, Santa Barbara, CA, USA

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ABSTRACT

Given the negative effects of mind wandering on performance, it may be profitable to be aware of task-unrelated thoughts (TUTs) as they occur. The present study investigated whether motivating people to catch TUTs increases meta-awareness. We offered incentives for increased self-catching during reading. To enhance the veracity of these self-reports, we used a "bogus-pipeline" procedure; we convinced participants that their mental states were being covertly monitored using physiological measures. In reality, mind wandering was assessed covertly by a secondary task ("gibberish detection"), and overtly by experience sampling. The results showed that incentives increased the number of self-catches without increasing overall mind wandering. Moreover, both the bogus pipeline and the opportunity for incentives increased the validity of self-reports, evidenced by significantly increased correlations between self-caught and behaviorally assessed mind wandering. We discuss the relevance of this methodological approach for research on mind wandering and research building on introspective reports more generally.

1. Introduction

As conscious beings, we share one common experience; we often lose track of our thoughts. Rather than focusing on the here and now, we get lost in thoughts that are unrelated to the current context, a phenomenon referred to as mind wandering (Antrobus, Singer, Goldstein, & Fortgang, 1970; Smallwood, McSpadden, & Schooler, 2008; Smallwood & Schooler, 2006). Findings from experience sampling studies suggest that mind wandering pervades almost half of our waking hours (e.g., Killingsworth & Gilbert, 2010; Risko, Anderson, Sarwal, Engelhardt, & Kingstone, 2011). Remarkably, much of this time, the very fact that we are mind wandering escapes our conscious experience. In these instances, mind wandering is said to occur without meta-awareness (e.g., Schooler, 2002).

There are good reasons to want to be meta-aware of one's mind wandering. Mind wandering leads to severe performance deficits on a broad range of tasks, including attention and memory tasks (Carriere, Cheyne, & Smilek, 2008), reading comprehension (Schooler, Reichle, & Halpern, 2004; Smallwood et al., 2008), and error detection (e.g., Schad, Nuthmann, & Engbert, 2012; Zedelius et al., in preparation). In situations in which it is critical to focus one's attention on the here and now, such as when driving a car, mind wandering can even lead to life-threatening accidents (Galera et al., 2012; Stutts, Reinfurt, Staplin, & Rodgman, 2001). Thus, it is not hard to see why it would be desirable to become aware of it when one's mind wanders

* Corresponding author at: Department of Psychological and Brain Sciences, University of California, Santa Barbara, Santa Barbara, CA 93106-9660, USA.
E-mail address: claire.zedelius@psych.ucsb.edu (C.M. Zedelius).

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off-task. The goal of the current study was to test whether increasing people's motivation to become aware of their mind wandering can help increase their meta-awareness of it.

A number of studies have investigated the distinction between mind wandering occurring with and without meta-awareness (e.g., see Schooler, 2002; Schooler et al., 2004, 2011; Smith et al., 2006). These studied have usually employed an experimental paradigm in which participants are asked to monitor their thoughts while performing a task (e.g., reading text) and to press a button whenever they catch themselves mind wandering. In addition to these self-catches, participants are given "thought probes" at random moments cuing them to report whether they were mind wandering in that moment. Whenever a participant responds positively to a thought probe but has failed to self-catch, it is assumed that the person was unaware of their mind wandering prior to being probed. It is typically found that participants are meta-aware of only a small proportion of their mind wandering episodes (e.g., Schooler et al., 2004).

Few studies have tried to discern the processes that lead to meta-awareness. The findings from these studies suggest that contextual factors can affect the likelihood that a person becomes meta-aware of his/her task-unrelated thoughts. For instance, alcohol consumption (Sayette, Reichle, & Schooler, 2009) and cigarette craving (Sayette, Schooler, & Reichle, 2010) both reduce self-caught mind wandering, while simultaneously increasing the frequency of probe-caught mind wandering episodes, indicating reduced meta-awareness of mind wandering. In these studies, the reduction of meta-awareness was attributed to executive failure, due to craving for an addictive substance (alcohol or cigarettes).

Only one study (Baird, Smallwood, Fishman, Mrazek, & Schooler, 2013) can be said to have touched on motivational influences on meta-awareness. In this study, participants attempted to suppress thoughts about a previous romantic relationship. Interestingly, those participants those who had a stronger desire to re-connect with their previous partner, compared to those who had "moved on", were less likely to self-catch spontaneous thoughts about their partner, yet they were more likely to report such thoughts when probed. Thus, the desire to re-connect had a similar effect as alcohol or cigarette craving. Motivation may play a role in this pattern in so far as individuals who have a greater desire to re-connect with their former partner may be motivated to suppress thoughts of their former partner from entering their awareness.

While these previous studies have revealed that contextual factors can lead to a *decrease* in meta-awareness, the present study is the first to test whether it is possible to *increase* meta-awareness of task-unrelated thoughts. Specifically, we tested whether meta-awareness can be increased by offering incentives for frequent self-catching of task-unrelated thoughts. It is well-documented that promising incentives for a task increases motivation and causes people to allocate greater mental resources toward executing the task, leading to better performance (e.g., Bonner & Sprinkle, 2002; Locke, Shaw, Saari, & Lathem, 1981; Ridderinkhof, van den Wildenberg, Segalowitz, & Carter, 2004). Thus, we reasoned that offering incentives for catching task-unrelated thoughts would facilitate keeping the goal of self-catching in mind and increase efforts at monitoring one's thought content and detecting conflict when task-unrelated thoughts arise (see Botvinick, Cohen, & Carter, 2004). As a result, we predicted that incentives tied to self-catching would increase meta-awareness.

Offering incentives for performing a behavior that is assessed only by self-report, such as self-catching task-unrelated thoughts, introduces a special methodological challenge: If the self-reported behavior is increased, this could reflect a genuine increase in meta-awareness, or it could reflect inaccurate or untruthful self-reports. For instance, offering incentives for self-catching could result in participants adopting a more liberal interpretation of what constitutes a task-unrelated thought, leading to more frequent reports of mind wandering. Indeed, recent research has shown that people vary in the confidence they have in their own self-reports of mind wandering (Seli, Jonker, CHeyne, Cortes, & Smilek, 2015), suggesting that there is room for introducing bias. Moreover, given people's eagerness to gain rewards, offering incentives for frequent self-catching may encourage participants to make untruthful reports, again leading to over-reporting of mind wandering. The problem of verifying self-report measures is a problem not only for mind wandering research, but for any research using measures that rely on introspection and metacognitive judgments (see Jack & Roepstorff, 2002; Jack & Shallice, 2001; Marcel, 2003; Overgaard & Sandberg, 2012; Schooler & Schreiber, 2004).

Previous studies have addressed the problem of inaccurate or dishonest self-reports in the context of mind wandering (Seli et al., 2015; Vinski & Watter, 2012). Instead of self-caught mind wandering, these studies focused on participants' self-reports in response to thought probes. Seli et al. (2015) asked participants to report not only whether they were mind wandering or not during a task, but also how confident they were in their self-reports. They found that self-reports made with high confidence showed a stronger relationship with behaviorally assessed mind wandering than low-confidence self-reports. Vinski and Watter (2012) focused on experimentally increasing the likelihood of honest self-reports of mind wandering. They implicitly primed participants with words related to the concept of honesty (compared to neutral words) before asking them to perform a sustained attention task (Robertson, Manly, Andrade, Baddeley, & Yiend, 1997) with thought probes. The authors reasoned that more honest self-reports should be reflected in a stronger correlation between self-reported mind wandering and behavioral indices of mind wandering derived from task performance. And indeed, for participants primed with honesty, compared to those in the control condition, a stronger correlation between probe-caught mind wandering and performance was observed. These results suggest that the validity of self-reports to thought probes can be enhanced by implicitly motivating participants to be honest.

In the present study, a more heavy-handed approach was taken to encourage truthful self-reports. First, we used a so-called "bogus-pipeline" procedure (see Jones & Sigall, 1971), that is, we convinced participants that we could covertly monitor their mind wandering using eye-tracking measures while they read a story for comprehension. Specifically, we told participants that mind wandering could be assessed reliably by measuring pupil dilation and eye movements. Because we only created a facsimile of an eye-tracker for this manipulation, these claims were "bogus" in the present work. However they are in fact supported by existing research, e.g., Foulsham, Farley, & Kingstone, 2013; Franklin, Broadway, Mrazek, Smallwood, & Schooler, 2013; Grandchamp, Braboszcz, & Delorme, 2014; Smallwood et al., 2011; Uzzaman & Hoordens, 2011). Previous research has successfully applied similar bogus pipeline procedures to increase the validity of attitude measures (see Roese & Jamieson, 1993, for a review). In the present study, we combined the bogus pipeline approach with the promise of financial incentives.

To test the effects of the bogus pipeline and the promise of incentives, we compared four *nested conditions*: (1) a control condition, in which we did not use the bogus pipeline and did not offer incentives (henceforth "control" condition), (2) a bogus pipeline condition in which we convinced participants that we were monitoring their mind wandering but did not offer any incentives (henceforth "monitoring" condition), (3) a bogus pipeline condition in which we offered incentives for accurate self-reports (henceforth "accuracy" condition), and (4) a bogus pipeline condition in which we offered incentives for accurate self-reports and for frequent self-catching (henceforth "self-catch" condition). Using this nested design, we aimed to disentangle the effects of motivating participants to self-catch from effects related to the general promise of incentives and the perception of being monitored through eye tracking. After the study, we assessed how strongly participants had been convinced by the bogus pipeline procedure.

To be able to evaluate whether our manipulations affected the validity of the self-catching measure, we included a "covert" behavioral measure of mind wandering. Specifically, participants performed a secondary task, "gibberish detection," requiring them to detect instances of grammatically sound yet meaningless text that appeared at unpredictable moments during the story. Failure to detect gibberish has been shown to be a reliable covert marker of mind wandering that does not rely on overt self-reports (e.g., Zedelius et al., in preparation; see also Schad et al., 2012).

1.1. Hypotheses

The present study tested two hypotheses. The first hypothesis was that meta-awareness of mind wandering can be increased by motivating frequent self-catching. To test this hypothesis, we tested the following predictions. *Prediction 1*: The frequency of self-caught mind wandering episodes is increased in the self-catch condition compared to the monitoring and accuracy conditions and the control condition.

Our second hypothesis was that the bogus pipeline procedure would increase the accuracy of participants' spontaneous self-reports about mind wandering. To examine this question, we tested the following prediction. *Prediction 2*: The correlation between spontaneous self-reported mind wandering and covertly assessed mind wandering (i.e., gibberish detection) would be stronger in the three experimental conditions (all including the bogus pipeline procedure) compared to the control condition. Moreover, we also tested whether the accuracy of participants' spontaneous self-reports could be further enhanced by combining the bogus pipeline procedure with the promise of incentives for accurate self-reports or frequent self-catching.

2. Method

2.1. Participants

136 university students participated in the study. They received a base rate of $10 in exchange for their participation. Participants in the incentive conditions were informed that they could gain an additional bonus of up to $5 dependent on their performance. In the end, all participants received the maximal bonus. Demographic data from 14 participants were lost due to technical error; from demographic data from 122 participants, 76% were women; the average age was 20.64 years, *SD* = 4.56. All participants were native English speakers.

2.2. Design

The design was a one-factorial between-subjects design with four nested conditions (control; monitoring; accuracy; self-catch). Participants were randomly assigned to conditions. The dependent measures were self-caught and probe-caught mind wandering, reading comprehension, and failure to detect gibberish.

2.3. Materials and procedure

2.3.1. Bogus pipeline

Upon entering the experiment, participants in the three experimental conditions (monitoring, accuracy, self-catch) received the same basic bogus pipeline instructions, stating that the study was investigating how much people typically mind-wander during reading by using eye-tracking measures to objectively assess mind wandering. Basic instructions stated that "*eye-tracking is found to be an excellent tool for detecting when people mind-wander. The size of the pupil is a good indicator of whether a person is paying attention or mind wandering*" and that "*Eye-movements reveal subtle scanning patterns that show whether people are indeed reading and processing the words in front of them, or just scanning them 'mindlessly'*". After these basic instructions, participants performed a procedure to "calibrate" the eye-tracking equipment (a simulation of real calibration procedures used with eye-tracking equipment, but presented to participants as if real). Participants were instructed to first look at a central fixation cross and then follow with their gaze stimuli appearing in various locations on the screen. Visual feedback was provided to enhance the credibility of the simulated calibration. (For a depiction of the bogus eye-tracker setup as well as a screenshot of the visual feedback provided in the calibration phase, see Fig. 1.)

Participants in the monitoring condition received no further instructions besides those related to performing the gibberish detection task. Participants in the two incentive conditions (accuracy, self-catch) received further instructions concerning incentives. First, participants in both incentive conditions were told that "*physiological measures are much more accurate indicators of attentional states like mind wandering than verbal reports. In the current study, we want to improve the accuracy of self-reports. To do so, we offer you the opportunity to gain a monetary bonus for accurate reporting*". In the accuracy condition, participants were further told that they would *receive a point for each accurate self-report*, that is, each time they reported having been mind wandering, either when probed or when self-catching, and the eye-tracking measures confirmed that they had indeed been mind wandering. To discourage participants from making false reports in order to gain rewards, they were further told that they would *lose a point for each inaccurate self-report,* which would be determined by the eye-tracking measure. Thus neither under-reporting nor over-reporting of mind wandering should be profitable according to these instructions.

In the self-catch condition, participants got the same instruction as in the accuracy condition, but were further told that a secondary aim of the study was to *increase people's awareness of their own mind wandering*, and that they could therefore gain additional points for *self-catching a greater number of their mind wandering episodes before being probe-caught*. To avoid the possibility that participants would deliberately engage in mind wandering in order to create more opportunities to catch themselves, we stressed that, in calculating their bonus, we would correct for the overall amount of mind wandering. That is, we told participants that, "*in the end, we will factor in the total number of times you were mind wandering. That way, the bonus will not be influenced by how much you mind-wander.*"

Participants were told that at the end of the experiment, the balance of points gained in the task would be calculated and they would receive the corresponding reward value, which could range from $0 to $5.00. Instructions deliberately emphasized communicating to participants that their task was to make accurate self-reports (and self-catch frequently, in the self-catch condition), rather than how their scores would be calculated. After participants had read the instructions, the experimenter verified that instructions were understood correctly.

2.3.2. Gibberish detection task

All participants read a short story written for the second-grade level, presented one word at a time in the center of the screen. Participants advanced the text in a self-paced manner by pressing the space bar. Participants were instructed to read the text for comprehension and, in addition, to detect and report semantic violations (or "gibberish") occasionally appearing in the text by pressing the G-key. Gibberish text passages were created by replacing nouns in one sentence with those from another sentence (e.g., 'The boys needed money to go to the circus' was changed to 'The boys needed box to go to the money). 28 gibberish passages occurred randomly throughout the story. When the text switched to gibberish, it continued as

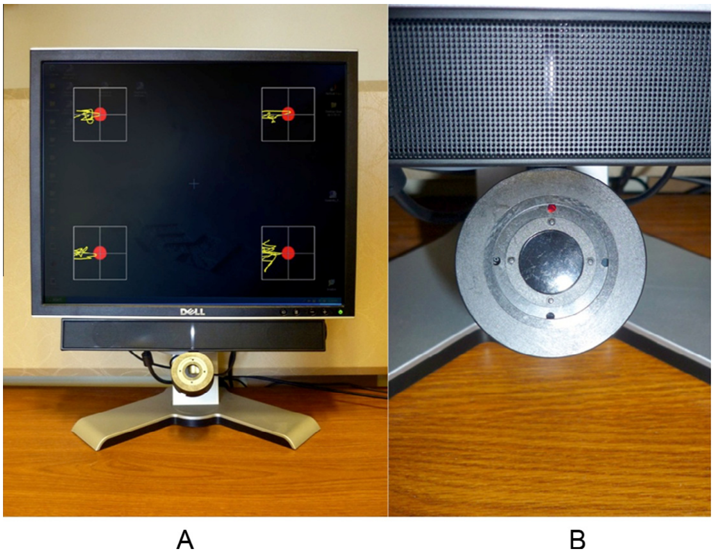

Fig. 1. The bogus pipeline setup. The "camera" of the bogus eye-tracker (constructed from of a part of a record player, a dark, slightly transparent lens, a red LED light, and a cable) is secured underneath the computer monitor, and was adjusted to point toward the eyes of the participant. Panel A shows a display of (bogus) feedback given to participants during the calibration procedure performed at the beginning of the experimental session. Panel B shows a close-up shot of the eye-tracking camera.

gibberish either until detected, or for a maximum of five sentences if undetected. After gibberish detection or the five-sentence maximum, the text returned to the most recent "normal" sentence before gibberish-onset.

During the gibberish detection task, participants were occasionally interrupted by thought-probes asking them to indicate whether or not their attention had been on- or off-task just prior to the probe. 12 thought-probes were administered during the gibberish detection task according to a pseudorandom schedule, with the restriction that successive thought probes were always separated by 200 words or more. Participants were also instructed to report instances when they caught themselves mind wandering by pressing the M-key. After reading the complete story, participants answered 36 questions (each presented with four multiple choice answer options) to test their reading comprehension.

2.3.3. Debriefing questions

At the end of the experiment, participants received a funneled debriefing, in which they were first asked to provide descriptions of what they thought was measured in the study and what they thought were the hypotheses of the study. Except for participants in the control condition, participants were further asked to report: (1) in general, how *accurately* they thought that eye-tracking measures could be used to assess mind wandering, (2) in the present study, how *plausible* it was that eye-tracking measures were used for this purpose, and (3) whether they were *suspicious* about whether eye-tracking measures were recorded at all in the present study. Responses were collected using a 1–4 point Likert scale, with lower numbers indicating lower ratings on the respective dimensions.

3. Results

3.1. Debriefing questions

We first analyzed participants' answers to the debriefing questions to assess how convincing participants found the bogus pipeline procedure. Answers to the debriefing questions did not differ between the three experimental conditions (all Fs < 1.16). Results showed that participants thought that, in general, eye-tracking measures can be used to assess mind wandering fairly *accurately* ($M = 3.00$, $SD = 0.64$), and that they found it *plausible* that our eye-tracking measures in the present study could have been used for this purpose ($M = 3.18$, $SD = 0.75$). However, some participants reported more than a slight degree of *suspicion*s about whether eye-tracking measures were in fact recorded in the present study ($M = 1.97$, $SD = 0.98$). Out of caution, we excluded 30 participants who scored higher than 2 on this question (indicating more than mild suspicion) from further analyses. The following analyses included data from 106 participants (23 in the monitoring condition, 25 in the accuracy incentive condition, 23 in the self-catch incentive condition, and 35 in the control condition).

3.2. Gibberish detection

To quantify gibberish detection performance, we looked at two performance measures; (1) how many gibberish events went completely unnoticed by participants, and (2) for gibberish events that *were* detected, how many sentences it took participants to detect the event. (We deemed the number of sentences a more appropriate level of analysis than the number of words read until gibberish was detected, because it can be crucial to read an entire sentence to judge its correctness.) On average, gibberish was detected after 1.63 sentences ($SD = 0.36$) and relatively few gibberish passages went completely undetected ($M = 1.49$, $SD = 2.57$). Reliability of both gibberish detection measures using Cronbach's alpha was high (0.83 for the number of sentences until detection, and 0.82 for the number of missed gibberish events). A comparison of gibberish detection performance in each condition is presented below. Four participants failed to detect more than a third of the gibberish episodes before the maximum five sentences, and the gibberish detection scores from these participants were additionally determined to be outliers (deviating more than 3 SDs from the mean). Therefore, data from these participants were excluded and data from 102 participants (23 in the monitoring condition, 25 in the accuracy incentive condition, 23 in the self-catch incentive condition, and 31 in the control condition) were included in the following analyses. In this final participants sample, Cronbach's alpha dropped to 0.68 for the number of sentences until detection and 0.67 for the number of missed gibberish events. Text comprehension was relatively high ($M = 0.80$, $SD = 0.10$), indicating that the tasks of gibberish detection and thought-monitoring did not impair performance of the reading task.

3.3. Results relevant to Hypothesis 1

Our first hypothesis was that offering incentives for frequent self-catching of mind wandering would increase the frequency of self-caught mind wandering. To test this first prediction, we performed an ANOVA on the number of self-catches with the between-subjects factor condition (control; monitoring; accuracy; self-catch). Levene's test of Homogeneity of Variances indicated unequal variances among the groups, $F(3, 98) = 5.08$, $p = .003$. We therefore used a Brown & Forsythe-variance weighted ANOVA. As predicted, the results showed that there were indeed differences among the conditions, $F(3, 68.92) = 3.03$, $p = .04$ (see Fig. 2 for the mean frequency of self-caught mind wandering in each condition). Next, a planned contrast analysis was performed to test whether the number of self-caught mind wandering episodes in the self-catch condition was indeed significantly higher than in the other three conditions combined. This prediction was not

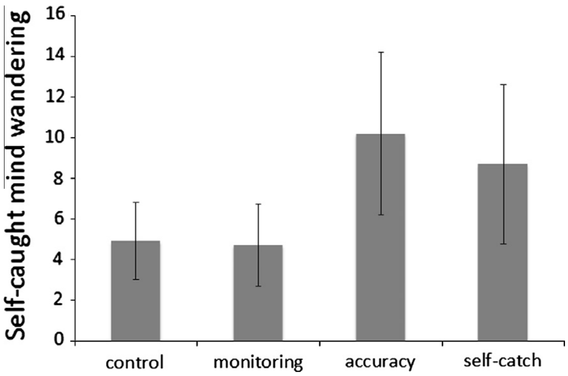

Fig. 2. Number of self-caught mind wandering episodes as a function of condition. Error bars represent 95% confidence intervals.

confirmed ($t(98) = 9.64$, $p = .34$; unequal variances assumed). We next performed more exploratory post hoc follow-up tests in order to characterize the differences among conditions indicated by the ANOVA. Visual inspection (Fig. 2) suggested that number of self-catches was highest in the accuracy condition. Therefore we used Dunnet's *t*-tests (2-sided) to compare the accuracy condition to all other conditions; which corrects for multiple comparisons but is less prone to type II errors than post hoc tests comparing each condition to each other condition. The results showed that the accuracy incentive condition differed significantly from the control condition ($p = .03$, 95% CI −10.28 to −0.31) and the monitoring condition ($p = .04$, 95% CI −10.87 to 0.14), but not from the self-catch incentive condition ($p = .84$, 95% CI −6.87 to 3.86). These results suggest that incentives tied to participants' self-reports of mind wandering led to more frequent self-catching, regardless of whether the incentives were contingent on frequent self-catching or merely on making accurate self-reports.

To rule out that the greater frequencies of self-catches in the accuracy and self-catch conditions, relative to the monitoring and control conditions, were simply due to differences in mind wandering across conditions, we performed additional ANOVAs testing whether participants in the four conditions differed in their number of probe-caught mind wandering episodes or in behaviorally assessed mind wandering, as indicated by their gibberish detection performance. The results of the ANOVA for probe-caught mind wandering revealed no significant differences, but indicated a marginal trend, $F(3, 98) = 2.36$, $p = .08$ (for the frequencies of probe-caught mind wandering per condition, see Fig. 3). Levene's test indicated equal variances among conditions ($F(3, 98) = 2.36$, $p = .50$). After visual inspection of the means, post hoc follow-up tests further investigating this trend indicated that probe-caught mind wandering, which was highest in the control condition, differed significantly from the accuracy incentive condition ($p = .04$, 95% CI −3.54 to −0.09), but not from the monitoring condition ($p = .94$, 95% CI −2.12 to 1.42) or the self-catch condition ($p = .40$, 95% CI −2.66 to 0.76). These results suggest that incentives for accurate self-reports of mind wandering, if anything, led to reduced probe-caught mind wandering.

Gibberish detection performance levels did not confirm this trend. First, there were no differences among conditions in failures to detect gibberish episodes, $F(3, 98) = 1.13$, $p = .34$ (control condition: $M = 0.74$, $SD = 1.37$; monitoring condition: $M = 1.04$, $SD = 1.55$; accuracy incentive condition: $M = 1.20$, $SD = 1.53$; self-catch incentive condition: $M = 1.65$, $SD = 2.69$; Levene's test indicated equal variances among the groups, $F(3, 98) = 2.36$, $p = .10$). Moreover, for gibberish episodes that were detected, there were no differences among conditions in the number of sentences it took participants to detect the gibberish, $F(3, 98) = 1.45$, $p = .22$ (control condition: $M = 1.61$, $SD = 0.29$; monitoring condition: $M = 1.69$, $SD = 0.38$; accuracy incentive condition: $M = 1.51$, $SD = 0.21$; self-catch incentive condition: $M = 1.57$, $SD = 0.30$; Levene's test indicated equal variances

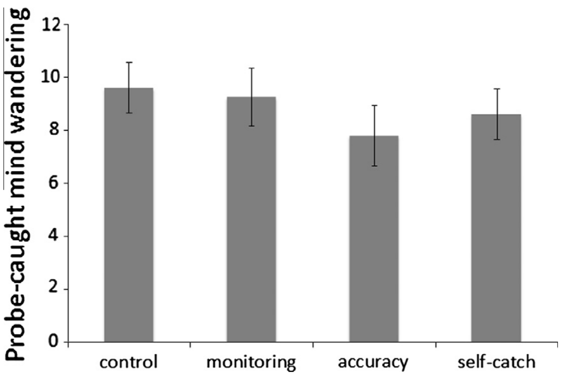

Fig. 3. Number of probe-caught mind wandering episodes as a function of condition. Error bars represent 95% confidence intervals.

among the groups, $F(3, 98) = 2.43$, $p = .07$). Thus, together, these results suggest that the greater frequency of self-caught mind wandering in the incentive conditions was not related to increased overall mind wandering.

3.4. Results relevant to Hypothesis 2

The second aim of the present study was to test the effectiveness of the bogus pipeline procedure at increasing the accuracy of self-reports about mind wandering. Our hypothesis was that self-reported mind wandering should show greater congruency with behaviorally assessed mind wandering in the three conditions using the bogus pipeline procedure compared to the control condition. To test this hypothesis, we first looked at the correlation between self-caught mind wandering and failure at gibberish detection separately for the four conditions (for an overview of the correlations, see Tables 1–4). In the control condition, this correlation was small-to-moderate in size but approached statistical significance, $r = .34$, $p = .06$. The correlation was higher in the monitoring condition, $r = .72$, $p < .001$ and of a similar magnitude in the accuracy condition, $r = .75$, $p < .001$. Relative to the control and other experimental conditions, the correlation in the self-catch condition was intermediate in strength, $r = .53$, $p < .01$. Fisher's z test showed that, compared to the control condition, the correlation between self-caught mind wandering and failure to detect gibberish was marginally stronger in the monitoring

Table 1
Correlations between gibberish detection, self-caught mind wandering, and probe-caught mind wandering in the control condition ($N = 31$).

Measure	Failed gibberish detection	Self-caught mind wandering	Probe-caught mind wandering
Failed gibberish detection			
Self-caught mind wandering	$r = .34$		
Probe-caught mind wandering	$r = -.58^{**}$	$r = -.51^{*}$	
Reading comprehension	$r = -.50^{**}$	$r = -.30$	$r = .42$

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

Table 2
Correlations between gibberish detection, self-caught mind wandering, and probe-caught mind wandering for the monitoring condition ($N = 23$).

Measure	Failed gibberish detection	Self-caught mind wandering	Probe-caught mind wandering
Failed gibberish detection			
Self-caught mind wandering	$r = .72^{**}$		
Probe-caught mind wandering	$r = -.13$	$r = -.05$	
Reading comprehension	$r = -.43^{*}$	$r = -.27$	$r = .12$

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

Table 3
Correlations between gibberish detection, self-caught mind wandering, and probe-caught mind wandering for the accuracy incentive condition ($N = 25$).

Measure	Failed gibberish detection	Self-caught mind wandering	Probe-caught mind wandering
Failed gibberish detection			
Self-caught mind wandering	$r = .75^{**}$		
Probe-caught mind wandering	$r = -.27$	$r = -.52^{*}$	
Reading comprehension	$r = -.14$	$r = -.33$	$r = -.05$

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

Table 4
Correlations between gibberish detection, self-caught mind wandering, and probe-caught mind wandering for the self-catch incentive condition ($N = 23$).

Measure	Failed gibberish detection	Self-caught mind wandering	Probe-caught mind wandering
Failed gibberish detection			
Self-caught mind wandering	$r = .53^{*}$		
Probe-caught mind wandering	$r = -.28$	$r = -.41$	
Reading comprehension	$r = -.03$	$r = -.33$	$r = .35$

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

condition (z = 1.90, p = .06, two-tailed), and significantly stronger in the accuracy condition (z = 2.28, p = .02, two-tailed), relative to that in the control condition. The correlation in the self-catch condition did not differ significantly from the correlation in either of the other experimental conditions or the control condition (z's < .82, two-tailed). Overall these results suggest that the validity of the self-catching self-reports was enhanced by the bogus pipeline and the incentives to be accurate, but was not further enhanced by incentives to self-catch more frequently.[1]

For completeness, we also compared the correlations between probe-caught mind wandering and failed gibberish detection for the four conditions. There was a moderate correlation between failed gibberish detection and probe-caught mind wandering in the control condition ($r = -.58$, p = .001), but not in the other three conditions (monitoring condition: $r = -.13$, p = .56; accuracy condition: $r = -.27$, p = .19; self-catch condition: $r = -.28$, p = .20).[2]

Since the reliability of the correlations depends on the reliability of the individual measures, we also assessed the reliability of probe-caught and self-caught mind wandering. The Cronbach's alpha for probe-caught mind wandering was 0.76, indicating good reliability. The reliability self-caught MW could not be assessed using Cronbach's alpha, since the amount of data points for this measure inherently vary among participants. Therefore, we applied the split-half method to assess the reliability of this measure, dividing the data into a first half (first 50% of self-catches during the task) and a second half (second 50% of self-catches), and computing the correlation between the two halves. We then applied the Spearman–Brown correction to get an estimate of the reliability of the full measure. This method indicated good reliability (r = .75). Nonetheless, given the small number of participants per condition, it is possible that the correlations reported here are inflated, and the correlational results should be interpreted cautiously.

4. Discussion

Inspired by the observation that people are seldom meta-aware of their own mind wandering, the present study explored whether being motivated to monitor and catch oneself when mind wandering can enhance the likelihood of noticing one's spontaneous task-unrelated thoughts. To motivate participants to catch themselves mind wandering, we offered financial incentives for frequently self-catching their task-unrelated thoughts during reading. Doing so, we faced a particular methodological challenge. The self-caught measure is entirely reliant on accurate and truthful self-reports. Therefore, a second aim of the present study was to develop and test a method to increase the validity of self-reports with regard to mind wandering. Specifically, we implemented a bogus pipeline procedure, in which we gave participants the impression that we could covertly monitor their mind wandering using physiological measures over which they had no personal control, and thus could verify the accuracy of their self-reports. Using this deception in combination with covert behavioral assessment of mind wandering, we tested how incentives would impact the likelihood for participants to catch themselves mind wandering, and evaluated the validity of these spontaneous self-reports.

Our first hypothesis was that motivating participants to self-catch their task-unrelated thoughts would lead to more frequent self-catching. Our results confirmed this hypothesis. Participants caught themselves mind wandering more frequently when offered incentives. Interestingly, however, this was true not only when incentives were specifically related to more frequent self-catching. Instead, even offering incentives for merely being *accurate* in one's spontaneous subjective self-reports—a condition that was included to control for the effects of offering incentives more generally—also led to increased self-catching. Making accurate self-reports of one's thought content, even when these reports are externally probed and not spontaneous, requires careful monitoring of one's thought content. Thus, increased active monitoring may have increase meta-awareness in the accuracy condition, even though more frequent self-catching was not the conscious intention of participants in that condition (see Marcel, 2003). Thus, our findings provide novel evidence that meta-awareness can indeed be increased through efforts to monitor and report on one's thoughts.

Our results further showed that the increase in self-catching in the incentive conditions was likely not a result of a greater propensity for mind wandering in general. First, self-reported mind wandering rates showed a trend indicating that, if anything, mind wandering was decreased by the promise of incentives for accurate self-reports. Moreover, behaviorally assessed mind wandering based on gibberish detection indicated no differences among the conditions in mind wandering. These findings are important, as they rule out the possibility that the increase in self-catching results from a simple dual-task trade-off; that is, a shift in priorities in the allocation of attention to the primary task of detecting gibberish in the text and the secondary task of monitoring the content of ones consciousness to detect when one is mind wandering.

The independence of self-caught mind wandering and performance raises an important question about the function of self-catching. It is often suggested that noticing when one is mind wandering may be a crucial first step in regulating one's mind wandering (Schooler et al., 2011). The trend in self-reported mind wandering is in line with this notion. However, our data show no improvements in performance as a result of increased meta-awareness. These results seem to challenge the notion that meta-awareness has a benefit for attentional control.

A potential explanation for these findings is that meta-awareness may lead to immediate and short-lived adjustments of behavior (i.e., bringing attention back to the task after a mind wandering episode is caught), without enabling prospective

[1] No notable differences between conditions were found in the relationship between self-caught mind wandering and reading comprehension, suggesting that gibberish detection is a more sensitive behavioral measure of mind-wandering than reading comprehension.

[2] A similar pattern was found for the relationship between probe-caught mind wandering and reading comprehension, although none of the correlations here reached significance.

control (i.e., preventing future attentional lapses and improving general task performance). In the present study, participants read text one word at a time, and were able to advance only from one word to the next but not backwards in the text. Thus, gibberish episodes embedded in the text could only be detected if full attention was paid to each word as it appeared on the screen or while it was accessible to short term memory. We think it is quite possible that increased self-catching would be associated with increased gibberish detection in an alternative task setup, in which participants have the opportunity to go back and retrospectively detect gibberish episodes that have initially been overlooked due to mind wandering. In many real-life contexts, such as during naturalistic reading, this kind of retrospective control is possible. Thus, while the present data do not demonstrate a behavioral benefit of increased meta-awareness, we think that a benefit may exist under circumstances allowing for corrective behavior.

In addition to our main goal of the present research—to test whether being motivated to catch oneself mind wandering can enhance meta-awareness—we had a secondary aim—to test whether the bogus pipeline procedure would help improve the accuracy of participants' self-reports. If it did, we expected to find an increased correlation between self-reported and behaviorally assessed mind wandering in conditions using the bogus pipeline. With regard to self-caught mind wandering, the results confirmed this hypothesis. The correlations between self-caught mind wandering and failure to detect gibberish in the text were generally higher in the conditions that included the bogus pipeline procedure than in the control condition. This indicates that introducing the bogus pipeline improved the validity, that is, the accuracy and/or the truthfulness of participants' self-reports.

This finding is relevant for research on mind wandering, and particularly for research investigating differences between mind wandering that occurs with and without meta-awareness. Previous studies have repeatedly found that self-caught mind wandering is unrelated to behavioral markers of mind wandering, suggesting that this type of mind wandering may have less of an impact on performance (Smallwood, McSpadden, & Schooler, 2007; Smallwood et al., 2008). These findings were replicated in our control condition, where we found no correlation between self-caught mind wandering and gibberish detection performance. However, our findings from the bogus pipeline conditions shed new light on this issue, suggesting that self-caught mind wandering shows a stronger relationship with performance when participants are highly motivated to actively monitor their thoughts while performing a task and make accurate self-reports.

Interestingly, taking a closer look at the three different conditions that did have the bogus pipeline, we found that the bogus pipeline alone was effective at increasing the validity of self-reports, whereas combining the bogus pipeline procedure with financial incentives did not lead to further increments of validity. When incentives were offered merely for making accurate self-reports, this did not change the magnitude of correlation with covertly assessed mind wandering compared to the bogus pipeline procedure alone. Moreover, providing additional incentives for frequent self-catching even diminished the association between self-caught and covertly assessed mind wandering. Making participants overly eager to frequently catch themselves mind wandering may have led participants to shift their criterion for what was considered a task-unrelated thought, potentially leading to some over-reporting and thus reduced validity of measurement.

4.1. Limitations

While the present research presents a first step at exploring the potential to increase meta-awareness of mind wandering through specific task instructions and incentives, and a first test of a novel procedure to improve the accuracy of self-reports in the domain of mind wandering, this research has important limitations. The sample sizes per condition were small, therefore some analyses were likely under-powered, and the correlational results in particular should be interpreted with caution. Moreover, we were surprised to find that introducing the bogus pipeline (compared to the control condition) did not improve, but rather lead to reduced correlations between probe-caught and behaviorally assessed mind wandering. This suggests that the increased congruency between self-caught and behaviorally assessed mind wandering likely came at the cost of making probe-caught mind wandering a less reliable measure, which presents an important limitation. It is possible that the emphasis that was placed on making accurate *spontaneous* self-reports in this study led to a trade-off, making participants more effective at monitoring and spontaneously catching their task-unrelated thoughts spontaneously, but as a result less good at evaluating the thoughts they had not caught spontaneously. To explore this possibility, it would be insightful to explore the effects of the bogus pipeline under conditions where participants are not required to self-catch. Previous research has shown that people are not perfectly accurate (or honest) even in reporting probe-caught mind wandering, and that differences in such reports are sensitive to motivational factors (Vinski & Watter, 2012). Thus, it is likely that the bogus pipeline procedure could improve probe-caught mind wandering measures in a context where there is no emphasis on self-catching.

4.2. Summary and conclusion

To summarize, the present findings offer interesting opportunities for future research investigating the role of meta-awareness in mind wandering. Because such research necessarily relies largely on subjective reports on internal experiences, any way to verify such reports is of great relevance. The present findings suggest that persuading individuals that the accuracy of their self-reports can be independently verified may enhance genuine meta-awareness of mind wandering by motivating them to more actively monitor their thoughts and self-catch task-unrelated thought as they occur. These findings provide a novel methodological basis for future research investigating the mechanisms that lead to meta-awareness and the role it may play in the regulation of mind wandering.

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