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The Awakening of the Attention: Evidence for a Link between the Monitoring of Mind Wandering and Prospective Goals

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Abstract

Across two independent samples, we examined the relation between individual differences in rates of self-caught mind wandering and individual differences in temporal monitoring of an unrelated response goal. Rates of self-caught mind wandering were assessed during a commonly used sustained-attention task, and temporal goal monitoring was indexed during a well-established prospective-memory task. The results from both samples showed a positive relation between rates of self-caught mind wandering during the sustained-attention task and rates of checking a clock to monitor the amount of time remaining before a response was required in the prospective-memory task. This relation held even when controlling for overall propensity to mind-wander (indexed by intermittent thought probes) and levels of motivation (indexed by subjective reports). These results suggest the possibility that there is a common monitoring system that monitors the contents of consciousness and the progress of ongoing goals and tasks.

Keywords

Mind wandering; Prospective Memory; Attention Monitoring; Meta-Awareness; Self-Caught

> "Most people probably fall several times a day into a fit of something like this: The eyes are fixed on vacancy, the sounds of the world melt into confused unity, the attention is dispersed so that the whole body is felt, as it were, at once, and the foreground of consciousness is filled, if by anything, by a sort of solemn sense of surrender to the empty passing of time. In the dim background of our mind we know meanwhile what we ought to be doing: getting up, dressing ourselves, answering the person who has spoken to us, trying to make the next step in our reasoning… Every moment we expect the spell to break, for we know no reason why it should continue. But it does continue, pulse after pulse, and we float with it, until also without reason that we can discover an energy is given, something we know not what enables us to gather ourselves together, we wink our eyes, we shake our heads, the background-ideas become effective, and the wheels of life go round again … The abolition of this condition is what we call the awakening of the attention"

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(James, 1913).

In one of his many insightful observations of mental processes, William James (1913) captured some key features of mind wandering[1], which we now know is a pervasive mental state (e.g., Killingsworth & Gilbert, 2010; McVay, Kane, & Kwapil, 2009) that is associated with performance decrements across a host of different tasks. For instance, mind wandering has been implicated as a source of error in driving-related contexts (e.g., Yanko & Spalek, 2013a, 2013b) and in tasks assessing reading comprehension (e.g., Schooler, Reichle, & Halpern, 2005; Unsworth & McMillan, 2013), sustained attention (Christoff, Gordon, Smallwood, Smith, & Schooler, 2009; Seli, 2016), and working memory (Mrazek, Franklin, Phillips, Baird, & Schooler, 2012; Rummel & Boywitt, 2014) (for a review see Mooneyham & Schooler, 2013). Mind wandering has also been associated with poor performance in academic settings (Seli, Wammes, Risko, & Smilek, 2016; Smallwood, Fishman, & Schooler, 2007; Wammes, Seli, Cheyne, Boucher, & Smilek, 2016), at the workplace (Knowles & Tay, 2002) and more generally, in everyday life (McVay et al., 2009). In these and other related situations in which mind wandering can have serious negative consequences, one way that people can reduce their propensity to mind-wander is to first become aware of the fact that they are mind wandering, and to then terminate the process. In the extant literature, this ability to notice one's mind in flight has been referred to as "self-catching" mind wandering (Smallwood & Schooler, 2006). Although self-catching appears to provide a relatively straightforward and effective way to terminate mind wandering, with a few exceptions (e.g., see Schooler et al., 2011, for a review), little research has investigated this process, and as such, little is known about the mechanism(s) underlying people's ability to self-catch their mind wandering. Here, we sought to elucidate the processes involved in this beneficial cognitive activity by exploring the possibility that people's propensity to self-catch their mind wandering is related to their more general propensity to transiently disengage from focal tasks in the service of considering other, task-relevant goals.

Although it often seems that we are aware of the contents of our conscious experiences, evidence suggests that we frequently have conscious experiences in the absence of explicit awareness of the things to which we are attending (e.g., Reichle, Reineberg, & Schooler, 2010; Schooler, 2002; Schooler et al., 2011; Zedelius, Broadway, & Schooler, 2015). For instance, consider the scenario in which an individual is reading, and her attention wanders away from the text. Although this individual is conscious, she nevertheless continues to mindlessly scan the page without processing the text. In consideration of this, and other related scenarios in which people fail to take explicit note of the contents of their consciousness, Schooler (2002) developed a theoretical account of the mind in which he proposed a distinction between "basic-consciousness" and "meta-consciousness" (also referred to as "meta-awareness"; e.g., Schooler et al., 2011; Smallwood, McSpadden, & Schooler, 2007). On the one hand, basic consciousness, which Schooler defined as cognitive processing that includes "perceptions, feelings, and non-reflective cognitions" (Schooler, 2002; p. 341), is a process that persists throughout our waking lives. On the other hand, meta-consciousness is said to involve "an explicit re-representation of consciousness in which one interprets, describes, or otherwise characterizes the state of one's mind" (p. 340).

[1]Conceptualized and operationalized here as task-unrelated thought.

In addition to the distinction between basic- and meta-consciousness, Schooler's theoretical account includes a monitoring system, which intermittently "checks" consciousness, thereby allowing people to consider the relation of the current contents of their consciousness and their goals. Critically, according to Schooler (2002), it is the monitoring system that allows people to (a) gain awareness (or "meta-awareness") of, (b) self-catch, and (c) terminate a bout of mind wandering.[2]

To empirically demonstrate that people do in fact sometimes mind-wander in the absence of explicit awareness of their mind wandering, Schooler, Reichle, and Halpern (2004) conducted a study wherein participants read passages of text, and in addition to reading, they were instructed to monitor their mental states so they could "self-catch" and report any mind wandering they experienced. Throughout the reading task, participants were also periodically presented thought probes asking them to report whether they were "on task" or "mind wandering" just prior to the presentation of each probe. Schooler et al. found that, although participants often self-caught their mind wandering while reading, in some cases, their episodes of mind wandering were caught by the probes. According to Schooler et al., if participants were always aware of their mind-wandering episodes, they would have self-caught these episodes, reported them, and subsequently refocused their attention on the reading task. One important corollary of this argument, then, is that if participants were always aware of their mind wandering, they should never have reported "mind wandering" when presented with a thought probe. However, given that participants' episodes of mind wandering were sometimes caught by the probes, Schooler et al. concluded that, in some cases, people mind-wander in the absence of explicit awareness of the fact that they are doing so.[3]

According to Schooler's (2002) theoretical account, the purpose of the proposed monitoring system is to allow people to take stock of the contents of basic consciousness so they can evaluate whether their thoughts are aligned with their latent goals; and, as noted above, in the context of research on mind wandering, it has been theorized that this monitoring plays an essential role in prompting people to realize that their minds have wandered away from a given task, which in turn allows them to terminate this process (Schooler, 2002). Critically, however, monitoring one's conscious state/self-catching one's mind wandering is but one of many latent goals that people might maintain in daily life. Another latent goal, for instance, is remembering to disengage one's attention from a television show so that one can remove food from the oven at the appropriate time. In line with Schooler's account, it would appear that the successful attainment of these goals – both of which rely on prospective memory (PM; e.g., Einstein & McDaniel, 1990; Park, Hertzog, Kidder, Morrell, & Mayhorn, 1997) – would require the engagement of the monitoring system. Indeed, in both scenarios, the

[2]It should be noted, however, that recent work has demonstrated that people do not always self-catch and terminate their mind wandering in cases where they are aware of its occurrence (Seli, Ralph, et al., 2017). Importantly, then, this finding indicates that meta-awareness may be a necessary, but not a sufficient condition for self-catching/terminating mind wandering.

[3]As noted above, however, recent research (Seli, Ralph, et al., 2017) has indicated that there are cases in which people are meta-aware of their mind-wandering episodes but do not self-catch/terminate these episodes. At first blush, this finding might be taken to suggest that Schooler et al.'s conclusion that people sometimes mind-wander in the absence of explicit awareness was potentially unfounded. Nevertheless, research has since corroborated Schooler et al.'s claim by demonstrating that, when presented with thought probes assessing the level of meta-awareness of mind wandering, people report a considerable number of instances of probe-caught mind wandering occurring without meta-awareness (e.g., Seli, Cheyne, & Smilek, 2013; Smallwood, Beach, Schooler, & Handy, 2008; see Schooler et al., 2011 for a review).

people would have to intermittently “check in” if they are to complete their latent goal (in the former case, keeping mind wandering at bay, and in the latter case, remembering to take food out of the oven). Although this view is consistent with Schooler’s theoretical account of mind wandering, to date, it is unclear whether his proposed monitoring system is involved not only in self-catching of mind wandering, but also in the completion of more generic PM tasks.

The Present Study

Here, we examined the possibility that people’s propensity to monitor and check in on their mind wandering is positively associated with their more general tendency to disengage from a focal task in the service of considering another latent task/goal. To do this, we assessed rates of self-caught mind wandering and time-based PM[4] across two separate tasks. Specifically, participants’ rates of self-caught mind wandering were assessed during the Sustained Attention to Response Task (SART; Robertson, Manly, Andrade, Baddeley, & Yiend, 1997), which has been commonly used in laboratory assessments mind wandering (e.g., Mrazek, Smallwood, & Schooler, 2013; Seli, Risko, & Smilek, 2016; Smallwood, Fitzgerald, Miles, & Phillips, 2009). In addition to having participants self-catch their mind wandering, following previous studies, we also included intermittent thought probes, which allowed us to more fully index overall mind-wandering tendencies (e.g., Zedelius et a., 2015).

In a separate task assessing time-based PM, we measured the frequency at which these same participants “checked in” on their latent, prospective goal. For this task, which was comprised of two component tasks, participants were instructed to provide ongoing “manmade” or “natural” judgments to a series of single words (e.g., CAR, ORANGE; e.g., Maillet & Rajah, 2016). In addition, they were instructed to press the “+” key every time one minute had passed (the latter component being the “prospective” task, and the former component being the “ongoing task”; Vanneste, Baudouin, Bouazzaoui, & Taconnat, 2016). To help participants perform this prospective task, they were informed that they could press the “T” button at any point during the task, which would temporarily display of a digital clock (in the top corner of the screen) showing how much time had passed since the beginning of the task (Vanneste et al., 2016).

Critically, because (a) instances during which people self-catch their mind wandering in the sustained-attention task provide a measure of their monitoring of their mind wandering (Schooler, 2002), and (b) instances during which people press the “T” button provide a measure of their monitoring of the PM task, we expected that the rate at which people press “T” and the rate at which they self-catch their mind wandering in a separate task should be

[4]It is worth noting that PM tasks have typically been divided into two types: *time-based* and *event-based*. Whereas time-based PM tasks require people to perform some action after a prespecified amount of time has passed (e.g., remembering to attend a meeting 10 minutes from now), event-based PM tasks require people to maintain an intention to perform some action upon presentation of a cue (e.g., remembering to wash the dishes when you arrive at home). Although there are important differences between these two types of PM (e.g., Jager & Kliegel, 2008), in the case of self-catching mind wandering, it appears that this activity can be both time- and event-based. For instance, at the beginning of a lecture, a student may make a mental note to check in on the contents of her consciousness every few minutes to ensure that she maintains focus on the lecture. At the same time, however, the occurrence of a bout of mind wandering appears to comprise an “event” that could prompt one to remember to terminate the mind-wandering episode.

positively associated. Such a finding would provide evidence to suggest that people's inclination to catch their mind wandering and their ability to remember to perform a task in the future (their time-based PM ability) are both associated with the same general attentional monitoring system.

Method

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

Participants

We collected data from two independent samples to allow for replication. After completing data collection for Sample 1, we preregistered our hypotheses, primary analyses, and sample size for Sample 2 (https://aspredicted.org/ef8mf.pdf). Each of the two samples consisted of 105 participants (Sample 1: 55 females, mean age = 23.40; Sample 2: 61 females, mean age = 21.79)[5] who were recruited from Harvard University and Boston University. All participants indicated that they had normal or corrected-to-normal vision, no history of medical or psychological impairment, and were native English speakers from birth or before the age of 6. All participants provided informed consent, were treated in accordance with guidelines approved by the ethics committee at Harvard University, and received pay ($10) or course credit for completing the study. It was determined in advance that, for our first sample, we would collect data from as many participants as possible before the end of the term. Following the completion of data collection for Sample 1, it was determined in advance that, for Sample 2, we would collect data from 105 participants (i.e., the same number of participants as in Sample 1) [6]. As a result of a computer error, data were unavailable for one participant in Sample 2, and as such, the final sample size for Sample 2 was 104.

Materials

Time-Based Prospective Memory Task—On each trial, a single common word (e.g., "CAR") was presented for 2 seconds in the center of the computer monitor, followed by a 1-second fixation cross (total trial duration = 3 seconds). Participants were instructed to make key presses ("M" or "N") to indicate whether each of the words represented a "manmade" or "natural" object, respectively. In addition to making these judgments, participants were given a time-based PM task that required them to press the "+" key every time one minute had passed (Vanneste et al., 2016). To help them perform this task, they were told that they could press "T" at any point during the task, which would in turn display a clock in the top-left corner of the screen, for 3 seconds, that showed how much time had passed since the beginning of the task. After 14 practice trials, participants completed 288 experimental trials. In total, the task took roughly 15 minutes to complete.

[5]As noted below, due to a computer error, data from one participant from Sample 2 were not available. As such, the descriptive statistics reported here for Sample 2 do not include data from this participant.

[6]Note: In preregistering our sample size for Sample 2, as a result of a typo, we erroneously indicated that the sample size would be 150 instead of 105 (the sample size from Sample 1).

The Sustained Attention to Response Task (SART)—On each SART trial, a single digit was presented for 2 seconds in the center of the monitor, after which time an encircled "x" mask was presented for 1 second (total trial duration = 3 seconds). For each block of 9 trials, a single digit (1–9) was randomly chosen without replacement, and was presented in white on a black background (Robertson et al., 1997). The digits were presented in Courier New font, and digit sizes were randomly varied across all trials, with equal sampling of five possible font sizes (120, 100, 94, 72, and 48 points). Participants were instructed to respond (by pressing the spacebar) to each GO digit (i.e., digits 1–2, and 4–9) and to withhold responses to each NOGO digit (i.e., 3). In addition, participants were instructed to respond as quickly as possible while maintaining a high level of accuracy (Robertson et al., 1997). Lastly, participants were told that, while completing the SART, they should self-catch any mind wandering they experienced by pressing the "M" key whenever they became aware of their mind wandering (e.g., Baird, Smallwood, Fishman, Mrazek, & Schooler, 2013). In cases where participants self-caught their mind wandering, they were asked to indicate whether the mind wandering they were experiencing was intentionally or unintentionally engaged (Seli, Ralph, et al., 2017; Seli, Risko, Smilek, & Schacter, 2016).[7] After 18 practice trials, participants completed 450 experimental trials. In total, participants took roughly 25 minutes to complete the SART.

At this point, it is important to note that, in addition to providing a measure of monitoring/ meta-awareness, self-caught rates of mind wandering also provide an indirect index of one's frequency of mind wandering: Indeed, people who mind-wander more frequently will have more instances during which they can self-catch their mind wandering, and as such, those who more frequently mind-wander may also more frequently self-catch their mind wandering (Smallwood & Schooler, 2006). Thus, one potential problem with examining rates of self-caught mind wandering is that, rather than exclusively index of people's monitoring behaviors, this measure might also reflect individual differences in rates of mind wandering. Ideally, then, when examining the relation between self-caught rates of mind wandering during the SART and time-checking behaviors during the PM task, we would account for people's overall tendency to mind-wander, and then statistically control for this measure. To this end, as in Zedelius et al. (2015), in addition to instructing participants to self-catch their mind wandering, we also intermittently presented 18 thought probes during the SART. When a probe was presented, the SART temporarily stopped and the participant was presented the following instruction: "Which of the following responses best characterizes your mental state JUST BEFORE this screen appeared?" The possible response options were: "1. On task," and "2. Mind wandering." If participants indicated that they were mind wandering, they received a second probe screen, asking "Which of the following best characterizes your MIND WANDERING?" with response options "1.

[7]We indexed the intentionality of self-caught and probe-caught mind wandering to allow us to attempt to replicate previous work by Seli, Cheyne, Xu, Purdon, and Smilek (2015) and Seli, Ralph, et al., 2017 (see the Supplemental Materials). However, insofar as our primary question was concerned (i.e., Do people who more frequently monitor/self-catch their mind wandering more frequently monitor the passage of time in the PM task?), as can be seen in our preregistration, we did not make any specific predictions about the potentially unique roles that intentional and unintentional self-caught mind wandering might play in predicting time-checking behavior. Thus, for the primary analyses of interest, reported below, we examine "overall" rates of self-caught mind wandering, collapsing across intentional and unintentional types. However, in our exploratory analyses (below), we explored the possibility that intentional and unintentional self-caught mind wandering might be uniquely associated with rates of time checking during the PM task.

Intentionally mind wandering” and “2. Unintentionally mind wandering” (for detailed instructions, see Seli, Risko, & Smilek, 2016)[8]. Inclusion of self-caught and probe-caught indices of mind wandering allowed us to conduct a regression analysis in which we predicted time-checking behaviors (obtained during the PM task) with self-caught and probe-caught mind wandering (obtained during the SART) to control for individual differences in overall rates of mind wandering (Zedelius et al., 2015).

Finally, upon completing the SART (at the end of the experiment), participants were presented a single-item question to assess their level of motivation to perform well on both the SART and the time-based PM task (Seli, Cheyne, et al., 2015; Unsworth & McMillan, 2013). In particular, they were asked to respond to the following question, “How motivated were you to do well on the tasks in this experiment?” and they did so by selecting a response option on a 1–10 Likert scale ranging from 1 (not at all motivated) to 10 (extremely motivated). Importantly, if, as predicted, we were to observe a positive correlation between rates of self-caught mind wandering and rates of time checking, it could be the case that motivation completely accounts for this relationship: Indeed, participants who are more motivated to perform well might be more inclined to (a) self-catch their mind wandering during the SART and (b) more frequently check in on the passage of time during the PM task. To rule out this possibility, we statistically controlled for participant motivation when examining the relation between self-caught mind wandering and time-checking behaviors.

Measures

Time-based PM task and manmade/natural judgment task—Given our interest in people’s tendency to monitor their ongoing latent goals, the primary measure of interest yielded by the time-based PM task was the number of times people pressed “T” to check the passage of time. Secondary measures (see also the Supplemental Materials) included (a) accuracy on the manmade/natural judgment task and (b) accuracy on the time-based PM task. Accuracy on the manmade/natural task was calculated as the proportion of trials on which participants correctly identified a manmade object (e.g., CAR) as manmade, and a natural object (e.g., ORANGE) as natural. With respect to performance on the PM task, as in Vanneste, et al. (2016), we computed a temporal accuracy score for each participant. To this end, we assigned 4 points for a response that was made precisely at each 1-minute interval, 3 points for a response made ±1 second of the 1-minute interval, 2 points for a response made ±2 seconds of the 1-minute interval, 1 point for a response made ±3 seconds of the 1-minute interval, and 0 points for all other responses.[9] We then summed these points for each participant. The maximum score a participant could obtain was 56 (i.e., 14 one-minute intervals * a maximum of 4 points per interval).

[8]As with the self-caught measure of mind wandering, we indexed the intentionality of probe-caught mind wandering to allow us to conduct exploratory analyses (reported in the Supplemental Materials) examining the relations among intentional and unintentional probe-caught mind wandering and other measures yielded by our two tasks. However, whether probe-caught mind wandering occurred with or without intention was not directly relevant to the primary question of interest in the present study, and as such, in the analyses reported below, we examined overall rates of intentional and unintentional probe-caught mind wandering (which collapsed across intentional and unintentional types).

[9]There were a few cases where participants pressed the “+” key more than once while within the ±3-second window surrounding each 1-minute interval (this occurred 1.23% of the time). In these cases, when computing each participant’s temporal accuracy score, we selected the single response associated with the highest possible score (for example, if a participant pressed the “+” key 3 seconds prior to the 1-minute interval, and then again, 1 second prior to the same 1-minute interval, we assigned the participant points for the most accurate response, which, in this example, is the 1-second response; i.e., 3 points).

The SART—Because we were interested in people's tendency to monitor their ongoing latent goals, the primary measure of interest collected during the SART was the number of times that participants self-caught their mind wandering (irrespective of whether such self-caught mind wandering occurred intentionally or unintentionally). In addition, as noted above, we wanted to control for overall rates of mind wandering when examining the relation between rates of self-caught mind wandering and rates of time checking, and as such, we presented participants with 18 thought probes throughout the SART. Probe-caught rates of mind wandering were calculated as the proportion of times participants reported mind wandering (both intentional and unintentional mind wandering) to the thought probes. Moreover, task-based motivation (assessed following completion of the SART) was calculated as each participant's response (1–10) to the single-item motivation question. Secondary measures for the SART (which are reported in the Supplemental Materials) included NOGO errors, GO-trial response times (RTs), and omissions. NOGO errors occurred when participants failed to withhold their response to the digit 3. GO-trial RTs were the mean response latencies for all GO trials (i.e., digits 1–2 and 4–9) on which a response was made. Omissions occurred when participants failed to produce a response to a GO trial.

Procedure

Participants read and signed an informed consent form, after which they completed a brief demographic questionnaire asking them about their age, sex, and handedness. The researcher then provided participants with instructions pertaining to the time-based PM task. Participants first completed a practice session of the PM task to ensure they understood the instructions. During this practice session, in addition to ensuring that the participants understood how to complete the manmade/natural judgment task, the researcher (a) instructed participants to press the "T" button to familiarize them with the digital clock component of the task, and (b) reminded them to do their best to press the "+" key every time 1 minute passed during the experimental session. The researcher then left the room while the participants completed the full experimental session of the PM task. After completing this task, the researcher returned to the room to provide instructions pertaining to the SART. Participants then completed a practice session of the SART, after which they completed a full experimental session of the SART (during which time the researcher was again absent). After completing both tasks, participants were prompted to respond to a single-item question asking about their motivation to perform well during the experimental session.

Results

We report the descriptive statistics (both for Sample 1 and Sample 2), for all primary measures of interest, in Table 1 (descriptive statistics for secondary measures are reported in the Supplemental Materials). In examining the psychometric properties of our primary measures, we found that, in both samples, skewness and kurtosis values exceeded acceptable ranges (skewness >2, kurtosis> 4; Kline, 1998) for rates of time checking and self-caught mind wandering. To normalize these values, we used a rank-based inverse normal transformation, which minimizes the effects of outliers while also maintaining the standard

Type I error rate and increasing power (Templeton, 2011). Critically, this transformation effectively normalized the time-checking and self-caught mind wandering data in both of our Samples (skewness <2, kurtosis< 4; Kline, 1998). Thus, for all analyses reported hereafter, we used transformed values for time checking and self-catching.

Next, for both Samples 1 and 2, we examined the Pearson product-moment correlation coefficients for our primary measures. As can be seen in Table 2, across both samples, there was a non-significant correlation between time checks during the PM task and probe-caught mind wandering during the SART, as well as a non-significant correlation between rates of self-caught and probe-caught mind wandering during the SART. As in previous work (Seli, Cheyne, et al., 2015; Unsworth & McMillan, 2013), across both samples, we observed a significant negative correlation between rates of probe-caught mind wandering and motivation. Most critically, both in Sample 1 and in Sample 2 we observed a significant positive correlation between rates of self-caught mind wandering (during the SART) and rates of time checking (during the PM task).

As noted above, when considering the relation between rates of self-caught mind wandering and time checking, it is important to (a) statistically control for rates of overall mind wandering to remove the shared variance between self-caught and probe-caught rates of mind wandering, and (b) control for participant motivation, as it could be the case that participants who are more highly motivated to perform well on the laboratory tasks are also more likely to self-catch their mind wandering during the SART and to check the time during the PM task. Although probe-caught mind wandering and motivation were not significantly associated with self-caught mind wandering in either of our samples (which suggests that removing their shared variance would have little influence on the relation between self-caught mind wandering and time checks), there is the possibility of suppression, and as such, we wanted to formally test this possibility. Thus, next, we conducted a hierarchical regression analysis (one for each sample) examining the relation between self-caught mind wandering and time checking while controlling for rates of probe-caught mind wandering and participant motivation. As can be seen in Table 3, even when controlling for rates of probe-caught mind wandering and participant motivation, rates of self-caught mind wandering remained significantly positively associated with rates of time checking, both in Sample 1 and Sample 2. Importantly, this result is consistent with the notion that people's proclivity to self-catch their mind wandering and their ability to remember to perform a task in the future are both associated with the same general attentional monitoring system.

Combined Analysis (Samples 1 and 2)

Across Sample 1 and Sample 2 we found that, after controlling for individual differences in participants' rates of mind wandering and task-based motivation, rates of self-caught mind wandering during the SART were positively associated with rates of time checking during the time-based PM task. Next, to evaluate the full body of evidence for this effect, we combined the datasets from Samples 1 and 2 and conducted the same set of analyses reported above.

We report the descriptive statistics for all primary measures of interest from the Combined Sample (Sample 1 and Sample 2) in Table 4. We again found that skewness and kurtosis values exceeded acceptable ranges (skewness >2, kurtosis> 4; Kline, 1998) for rates of time checking and self-caught mind wandering, and again used a rank-based inverse normal transformation (Templeton, 2011), which effectively normalized these data (skewness <2, kurtosis< 4; Kline, 1998). Thus, for all analyses reported hereafter for the Combined Sample, we used transformed values for time checking and self-catching.

We report the Pearson product-moment correlation coefficients for our primary measures in Table 5. As can be seen in Table 5, we observed the same pattern of results found in Samples 1 and 2, with the most critical finding being a significant positive correlation between rates of self-caught mind wandering and rates of time checking.

Next, we conducted a hierarchical regression analysis examining the relation between self-caught mind wandering and time checking while controlling for rates of probe-caught mind wandering and participant motivation. Critically, as seen in Table 6, we again found that when controlling for rates of probe-caught mind wandering and participant motivation, rates of self-caught mind wandering were significantly positively associated with rates of time checking.

Exploratory Analyses

Although our primary focus in the present study was on the relation between people's propensity to self-catch their mind wandering and their propensity to "check in" on a PM task, our study yielded additional data that allowed us to conduct some potentially informative exploratory analyses examining the relations among rates of self-caught mind wandering and performance measures. First, we were afforded the opportunity to explore the possibility that rates of self-caught mind wandering (i.e., the sum of the rates of intentional and unintentional self-caught mind wandering) were associated with (a) accuracy on the PM task, (b) accuracy on the manmade/natural judgment task, and (c) performance on the SART (both in terms of NOGO errors and GO-trial RTs). Second, we were able to explore the possibility that intentional and unintentional types of self-caught mind wandering might uniquely predict rates of time checking. Given that these analyses were purely exploratory (and hence, the effect sizes unknown), to maximize power, we conducted these analyses while using the full body of data collected across Samples 1 and 2 ($N = 209$).

In examining the psychometric properties of the different performance measures (see Table 7), we found that skewness and kurtosis values exceeded acceptable ranges (skewness >2, kurtosis> 4; Kline, 1998) for numerous measures (all except PM accuracy). To normalize these values, we used a rank-based inverse normal transformation, which effectively normalized all the previously non-normal data (skewness <2, kurtosis< 4; Kline, 1998; see Table 7). Thus, for the correlational/regression analyses reported below, we included transformed values obtained for the previously non-normal measures.

Although we were particularly interested in examining a subset of the correlations among our exploratory measures, for the sake of completeness, in Table 8, we report the Pearson product-moment correlation coefficients for all the aforementioned exploratory measures.

Rates of self-caught mind wandering and task performance

In examining the correlations presented in Table 8, we first turned out attention to the correlation assessing the relation between PM accuracy and rates of self-caught mind wandering. Interestingly, results of the analysis revealed a significant positive relation between PM accuracy and overall self-caught mind wandering, $r = .280$, $p < .001$, indicating that people who more frequently self-caught their mind wandering tended to achieve higher PM accuracy than did people who less frequently self-caught their mind wandering. Next, we examined the potential relation between accuracy on the manmade/natural judgment task and rates of self-caught mind wandering. Here, we observed a significant positive relation, $r = .337$, $p < .001$, which indicated that people who more frequently self-caught their mind wandering also tended to perform better on the manmade/natural judgment task. Importantly, both of these results were obtained even when conducting partial correlation analyses that statistically controlled for participants' levels of motivation, which indicates that motivation levels do not account for these relations.

Next, we examined the possibility that rates of self-caught mind wandering were associated with SART performance, both in terms of NOGO Errors and GO-trial RTs. However, rather than simply interpret the zero-order relations between each of these measures and self-caught mind wandering (see Table 8), we instead conducted a regression analysis in which we predicted rates of self-caught mind wandering with both SART measures entered as simultaneous predictors. Importantly, such an analysis controls for the shared variance between the speed at which people responded to GO trials and their error rates on NOGO trials, which in turn provides a more appropriate measure of SART performance (Seli, Jonker, Cheyne, & Smilek, 2013). Results of this analysis revealed that, when controlling for the shared variance between NOGO errors and GO-trial RTs, GO-trial RTs were significantly negatively associated with rates of self-caught mind wandering, $\beta = -.205$, $SE = 0.003$, $p = .004$, whereas the relation between NOGO errors and self-caught mind wandering was not significant, $\beta = .073$, $SE = 4.43$, $p = .301$ (again, this pattern held even when statistically controlling for participant motivation). Interestingly, given that the SART instructions emphasize an equal focus on speed and accuracy, this finding indicates that participants who more frequently self-caught their mind wandering during the SART also tended to perform better on the SART.

Intentionality of self-caught mind wandering and time-checking behaviors

Lastly, we explored the possibility that intentional and unintentional self-caught mind wandering might uniquely predict rates of time checking. To this end, we conducted a hierarchical regression analysis predicting rates of time checking with rates of intentional and unintentional types of self-caught mind wandering while controlling for rates of probe-caught mind wandering and participant motivation. Interestingly, as seen in Table 9, we found that, when controlling for rates of probe-caught mind wandering and participant motivation, rates of unintentional, but not intentional, self-caught mind wandering were significantly positively associated with rates of time checking. This finding appears to make good sense: In cases where people intentionally engage in mind wandering, they are presumably less likely to monitor and terminate this process, given that the process is initiated with deliberation. Thus, in line with previous research (see Seli, Risko, Smilek, & Schacter, 2016, for a review), this finding provides further support for the claim that it is important to distinguish between intentional and unintentional types of mind wandering.

Discussion

The present results provide a clear demonstration that there exists a relation between people's propensity to self-catch their bouts of mind wandering (in particular, bouts of unintentional mind wandering) and their propensity to monitor an ongoing latent task. Although the observed relations were modest, they are consistent with the possibility that (a) there is a general underlying tendency to monitor one's consciousness, environment, and other concurrent latent tasks, and that (b) the rate at which different people engage in such monitoring is relatively consistent across these different contexts.

Potential attenuation of the relation between self-catching and time-checking

In considering the relatively modest correlations observed between rates of self-caught mind wandering and time-checking, it is worth speculating on a few reasons as to why we did not detect a correlation of a greater magnitude in the present study. First, the stimuli in the manmade/natural judgment task were presented at a fixed rate. Importantly, presenting these stimuli at a fixed rate may have, in some cases, prompted participants to strategically count the stimuli in the service of allowing them to estimate the passage of time, which could have dampened the correlation between rates of time-checking and self-catching. To minimize this concern in future work, we suggest that researchers present these stimuli at an irregular rate.

Another potential source of attenuation of the observed correlation between rates of self-catching and time checking is that, while monitoring for mind wandering during the SART, there may have been instances during which participants' monitoring systems "checked in," but (correctly) failed to detect any mind wandering. Critically, in such instances, although participants would have exhibited monitoring, there would be no indication of such monitoring. Although our data cannot speak to this issue, to examine this possibility, researchers could – as in recent work by Rummel, Smeekens, and Kane (2016) – probe participants throughout their ongoing tasks to determine whether they are explicitly thinking about their PM intention (in this case, thinking about catching/terminating their mind wandering). However, even this method may not effectively address the issue at hand because it may be that people implicitly monitor for bouts of mind wandering, in which case, instances of monitoring will not be available for conscious report.

Notwithstanding the potential sources of attenuation listed here, we still observed a significant relation between rates of self-catching and time-checking, which suggests the possibility that, if anything, the present findings may be underestimating the relation between these two measures.

Self-catching as a method to reduce mind wandering and minimize its negative consequences

In a growing body of work, researchers have attempted to identify methods of remediation that can be used to combat mind wandering in settings in which its occurrence might have detrimental effects. However, to date, this research has been met with somewhat limited success (but see Mrazek et al., 2013; Seli, Schacter, Risko, & Smilek, under review), and the search for methods of remediation remains a key area of interest in the field. One perhaps obvious, yet largely overlooked, way to reduce mind wandering (particularly the unintentional type) is to "catch" oneself in the act and subsequently terminate the process and refocus one's attention on the task at hand (Zedelius et al., 2015). People's ability to self-catch mind wandering is important because, by allowing an individual to terminate the process of mind wandering, self-catching should in turn minimize the serious consequences that often result from this cognitive state (Schooler, 2002; Smallwood & Schooler, 2006; Zedelius et al., 2015). Consistent with this view, as we observed in our exploratory analyses, people who more frequently self-caught their mind wandering (during the SART) also tended to perform better on (a) the SART, (b) the manmade/natural judgment task, and (c) the time-based PM task. These findings, in conjunction with recent work showing that self-catching can be increased by providing people with incentives to increase meta-awareness (Zedelius et al., 2015), suggest that making self-catching a focal point of research aimed at developing methods of remediation for mind wandering will be an important area of future research.

When considering potential methods with which to improve people's ability to monitor their mind wandering, it is important to note that research from the PM literature has shown that certain interventions can be used to improve people's ability to monitor their latent goals during PM tasks. For instance, Cook, Marsh, and Hicks (2005) hypothesized that people's ability to successfully complete a time-based PM task could be improved in cases where cues are used to prompt them to check in on their latent prospective goal. To examine this possibility, participants completed three separate task phases during the experiment: in the first, they made pleasantness ratings for a list of words; in the second, they provided answers to demographic questions; in the third, they reported the number of syllables in each of a series of words. In addition to completing these ongoing tasks, participants were instructed to produce a time-based response after 6 minutes, but before 7 minutes, had elapsed during the experiment. Critically, whereas some participants were instructed to anticipate the occurrence of the 6–7-minute response window during the third phase of the task (while making syllable ratings), others were not provided any information linking the task-phase to the occurrence of the response window. As anticipated, the researchers found that time-based responding was superior in cases where information about the response window was provided (for similar finding, see Altgassen et al., 2015). In a related study, Neroni, Gamboz, and Brandimonte (2014) examined the possibility that instructing participants to simulate themselves completing a PM task, prior to its occurrence, might improve subsequent performance on the actual task. In line with their expectations, Neroni et al. found that simulating the completion of an event-based PM task did indeed lead to improved performance on this task (for related work, see Bugg, Scullin, & McDaniel, 2013; Chasteen, Park, & Scwarz, 2001; McDaniel, Howard, & Butler, 2008).

Taken together, the foregoing findings suggest the interesting possibility that that these (and other, similar) interventions aimed toward improving PM performance might be used to increase people's ability to monitor their conscious states for episodes of mind wandering, which could in turn allow them to terminate bouts of mind wandering before they lead to performance decrements.[10] Such techniques could be exceptionally important because, if they could be implemented in real-world safety-critical settings in which the consequences of mind wandering are often dire, numerous tragic accidents/errors might be avoided. Thus, in future research aimed at minimizing the occurrence of mind wandering, we not only encourage researchers to increase their focus on the self-catching process (which might offer a relative easy and effective way to minimize the serious negative consequences of mind wandering), but to also consider the literature examining methods used to improve PM performance, as these methods may be effective at improving people's ability to self-catch their mind wandering.

In considering the possibility that certain interventions might be used to increase people's self-catching tendencies, it is worth considering the fact that numerous studies have found that holding a PM intention in mind tends to impair people's performance on their ongoing task (e.g., Hicks, Marsh, & Cook, 2005; Smith, Hunt, McVay, & McConnell, 2007). Given this well-established finding, one potential concern with our suggestion that researchers should focus on methods that can improve people's ability to monitor their latent goals/self-catch their mind wandering is that such an increased focus on self-catching might in fact be associated with performance costs (which would clearly be counterproductive). To the contrary, however, in our exploratory analyses, we found that people who more frequently monitored/self-caught their mind wandering during the SART tended to show *superior* SART performance, as well as *superior* performance on the ongoing (manmade/natural) task, and the time-based-PM task. Interestingly, then, these findings appear to suggest a more nuanced account of the consequences of maintaining PM intentions. In particular, they suggest that an important factor to consider in this context is the specific PM intention that one has in mind: If an individual's PM intention pertains to a task that is not relevant to her ongoing task (as is almost invariably the case in the extant PM literature), then one might reasonably assume that an increased focus on this PM intention will lead to performance costs on the ongoing task (e.g., Hicks et al., 2005, Smith et al., 2007). If, however, the PM intention pertains to self-catching/terminating mind wandering, then although maintenance of this PM intention may interfere with the ongoing task to some extent (and as such, lead to performance costs), it may also facilitate performance on the ongoing task because it would allow people to more frequently terminate their task-unrelated thoughts and refocus on the ongoing task. As such, there may be a net-positive effect of monitoring for mind wandering on ongoing task performance. Given this interesting possibility, we suggest that future research focuses on this more nuanced account of ongoing-task performance costs resulting from the maintenance of a PM intention.

[10]It is, however, important to note interventions aimed at improving PM performance might be task-specific, and hence, fail to transfer to other tasks. Thus, future research will be needed to examine this possibility.

Alternative causal explanations for the relation between self-catching and time-checking

At this point, it is important to note that much of the foregoing discussion (and much of the discussion in the extant literature on PM) is based on the assumption that there is a monitoring system that is responsible for actively tracking the progress of people's various prospective goals (e.g., Cona, Arcara, Tarantino, & Bisiacchi, 2012; Mioni & Stablum, 2014; Oksanen, Waldum, McDaniel, & Braver, 2014). On this view, in the context of the present study, the working assumption regarding causality is that an active monitoring system triggers PM-related actions (self-catching mind wandering in the case of the SART, or producing a button press at one-minute intervals in the case of the manmade/natural judgment task). However, given that our data are correlational in nature, it is worthwhile to consider other casual possibilities.

One particularly intriguing alternative possibility, which we refer to as the *natural fluctuation hypothesis*, is that naturally occurring fluctuations in consciousness might prompt people to monitor/evaluate their prospective goals, which in turn impels them to act upon their PM intentions (or latent goals). That we all experience natural fluctuations in our conscious states (i.e., fluctuations in the content to which we attend) is supported by introspective evidence as well as the growing literature on mind wandering. One possible reason for this fluctuation is that the human brain is wired such that it does not spend an indefinite period of time focused on any one thought, task, goal, or musing, but rather, that humans have a variability mechanism that causes them to disengage their attention from a focal train of thought after a given period of time. It is at this point of transient disengagement that people may be prompted to evaluate other, competing (latent) goals. According to this hypothesis, in the case of time-based PM tasks, if a latent PM goal is sufficiently competitive for one's attentional resources, then when an individual experiences a period of transient disengagement from her ongoing task, this latent goal may become active in her mind (which would then permit her to fulfill her PM goal). Alternatively, if other latent goals, or "current concerns" (e.g., making dinner plans, or attempting to resolve a past conflict; Klinger, 1971, 1999, 2009) are stronger competitors for one's attentional resources, then during a period of transient disengagement, these goals may instead co-opt her attention (leading to what researchers frequently refer to as task-unrelated thought, or "mind wandering"). Critically, because the proposed variability mechanism does not permit humans to spend an indefinite period of time focused on any one thought, these newly acquired thoughts will eventually (during a subsequent period of transient disengagement) exit conscious awareness, and the process of evaluating competing latent goals (or current concerns) will again occur during the transition of thoughts.[11] Importantly, then, according to this hypothesis, an ongoing monitoring system does not play a causal role in generating PM actions; rather, it is a transient shift in attention away from one's focal task that compels him to evaluate and act upon his other, competing latent goals, one of which might be a PM intention. In considering the present results through the lens of this hypothesis, it may be that there are individual differences in the rate at which people experience fluctuations in consciousness, and hence, differences in their tendency to act upon their latent goals/PM

[11]There is also the possibility that during a period of transient disengagement, a person will refocus his attention on the task from which his attention was just disengaged, given that the task is sufficiently competitive for his resources.

intentions. Given the speculative nature of this hypothesis, however, it is clear that future research will be needed to evaluate its veracity.

Of course, as is the case with all correlational research, another alternative possibility is that some third variable is responsible for the observed relations between rates of self-catching and time-monitoring. For example, perhaps people with higher working-memory capacities are more inclined to (a) self-catch their mind wandering, and (b) monitor the passage of time during the manmade/natural judgment task. Thus, moving forward, it will be important for researchers to examine these (and perhaps other) alternative causal explanations for the link between self-catching mind wandering and monitoring PM intentions.

Concluding Remarks

Our findings suggest that individual differences in the propensity to check in on the contents of the mind are related to individual differences in checking in on the passage of time during a PM task. Importantly, this link suggests the possibility that already established methods that have been used to improve PM may have utility in cases where researchers seek to increase self-catching, and in turn, reduce the oft serious consequences of mind wandering. Finally, our results suggest the interesting possibility that there exists a general monitoring system that is involved in checking internal thoughts and monitoring ongoing tasks and goals (although future research is needed to more definitely draw this conclusion). Moving forward, we suggest that research should examine (a) the potential effectiveness of PM-based methods of remediation in the domain of mind wandering, and (b) the generality of the monitoring system as well its neural correlates.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Psychometric Properties (both before and after transformation) for Primary Measures for Sample 1 (N = 105) and Sample 2 (N = 104)

		Before transformation				After transformation			
		M	***SD***	**Skewness**[1]	**Kurtosis**[2]	***M***	***SD***	**Skewness**[1]	**Kurtosis**[2]
Sample 1	Time checks	63.30	44.90	2.29	6.76	64.31	44.35	0.07	−0.27
	Self-caught mind wandering	8.73	10.37	2.23	6.83	9.16	9.79	0.31	−0.57
	Probe-caught mind wandering	.38	0.23	0.36	−0.40	-	-	-	-
	Motivation	6.19	2.06	−0.43	−0.22	-	-	-	-
		M	*SD*	Skewness[3]	Kurtosis[4]	*M*	*SD*	Skewness[3]	Kurtosis[4]
Sample 2	Time checks	51.09	34.79	2.15	7.39	51.89	34.32	0.07	−0.29
	Self-caught mind wandering	9.49	11.03	2.08	5.45	9.93	10.46	0.29	−0.55
	Probe-caught mind wandering	.37	0.25	0.42	−0.73	-	-	-	-
	Motivation	6.46	2.15	−0.46	−0.35	-	-	-	-

Note.

[1] Std. Error = .236,

[2] Std. Error = .467,

[3] Std. Error = .237,

[4] Std. Error = .469

Table 2

Pearson Product-Moment Correlation Coefficients for Primary Measures for Sample 1 (above diagonal; N = 105) and Sample 2 (below diagonal; N = 104)

	Time Checks	Self-caught mind wandering	Probe-caught mind wandering	Motivation
Time Checks	-	.205*	.076	.022
Self-caught mind wandering	.221*	-	.017	.097
Probe-caught mind wandering	.049	.145	-	−.265**
Motivation	−.042	.021	−.406***	-

Note.

* $p < .05$,

** $p < .01$,

*** $p < .001$ 2-tailed

Table 3

Hierarchical Multiple Regression Analysis Predicting Time Checking with Self-Caught Mind Wandering (SC MW) Controlling for Probe-Caught Mind Wandering (PC MW) and Motivation for Sample 1 (top panel; N = 105) and Sample 2 (bottom panel N = 104)

		B	*SE*	β	*t*	*p*	R^2_{Δ}	p_{Δ}
	PC MW	16.81	19.62	.088	0.857	.394		
	Motivation	0.978	2.200	.045	0.444	.658		
							0.008	.676
Sample 1	PC MW	15.04	19.34	.078	0.778	.439		
	Motivation	0.506	2.178	.024	0.232	.817		
	SC MW	0.912	0.442	.201	2.062	.042		
							0.040	.042
	PC MW	5.207	14.87	.038	0.350	.727		
	Motivation	−0.428	1.740	−.027	−0.246	.806		
							0.003	.860
Sample 2	PC MW	−0.401	14.79	−.003	−0.027	.978		
	Motivation	−0.769	1.712	−.048	−0.449	.654		
	SC MW	0.731	0.324	.223	2.256	.026		
							0.048	.026

Table 4

Psychometric Properties (both before and after transformation) for Primary Measures in the Combined Sample (N = 209)

	Before transformation				*After transformation*			
	M	***SD***	**Skewness**[1]	**Kurtosis**[2]	***M***	***SD***	**Skewness**[1]	**Kurtosis**[2]
Time checks	57.22	40.56	2.31	7.54	57.73	40.29	0.05	−0.18
Self-caught mind wandering	9.11	10.68	2.14	5.92	9.45	10.12	0.31	−0.49
Probe-caught mind wandering	.37	0.24	0.38	−0.60	-	-	-	-
Motivation	6.33	2.10	−0.43	−0.32	-	-	-	-

Note.

[1]Std. Error = .168,

[2]Std. Error = .335

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Table 5

Pearson Product-Moment Correlation Coefficients for Primary Measures (N = 209)

	Self-caught mind wandering	Probe-caught mind wandering	Motivation
Time Checks	.214**	.066	−.020
Self-caught mind wandering		.076	.058
Probe-caught mind wandering			−.341***

Note.

** $p < .01$,

*** $p < .001$, 2-tailed

Table 6

Hierarchical Multiple Regression Analysis Predicting Time Checking with Self-Caught Mind Wandering (SC MW) Controlling for Probe-Caught Mind Wandering (PC MW) and Motivation (N = 209)

	B	*SE*	β	*t*	*p*	R^2_{Δ}	p_{Δ}
PC MW	11.24	12.37	.067	0.909	.365		
Motivation	0.052	1.417	.003	0.037	.971		
						0.004	.635
PC MW	7.396	12.19	.044	0.607	.545		
Motivation	−0.332	1.394	−.017	−0.238	.812		
SC MW	0.844	0.273	.212	3.091	.002		
						0.044	.002

Table 7

Psychometric Properties (both before and after transformation) for Exploratory Measures (N = 209)

	Before transformation				After transformation			
	M	***SD***	**Skewness**[1]	**Kurtosis**[2]	***M***	***SD***	**Skewness**[1]	**Kurtosis**[2]
Self-caught MW	9.11	10.68	2.14	5.92	9.45	10.12	0.31	−0.49
Intentional self-caught MW	2.48	4.16	2.91	9.98	2.73	3.65	0.67	−0.44
Unintentional self-caught MW	6.63	8.21	2.21	6.29	6.93	7.70	0.36	−0.52
Manmade/Natural accuracy	0.94	0.10	−5.10	31.02	0.94	0.10	−0.03	−0.18
PM accuracy	41.19	14.00	−1.63	2.04	-	-	-	-
Time checks	57.22	40.56	2.31	7.54	57.73	40.29	0.05	−0.18
NOGO errors	0.18	0.16	2.24	7.41	0.19	0.16	0.13	−0.10
GO RTs	679.62	222.11	4.49	30.75	682.37	220.84	0.05	−0.17

Note.

[1] Std. Error = .0.168,

[2] Std. Error = 0.335;

MW = mind wandering, PM = prospective memory; RTs = response times

Table 8

Pearson Product-Moment Correlation Coefficients for Exploratory Measures (N = 209)

	1	2	3	4	5	6	7	8
1. Overall self-caught MW	-							
2. Intentional self-caught MW	.742***	-						
3. Unintentional self-caught MW	.949***	.530***	-					
4. Manmade/Natural accuracy	.337***	.189**	.332***	-				
5. PM accuracy	.280***	.148*	.273***	.447***	-			
6. Time checks	.214**	.132	.223***	.189**	.563***	-		
7. NOGO errors	.025	.014	.034	−.275***	−.211**	−.096	-	
8. GO RTs	−.188**	−.125	−.186**	−.331***	−.163*	.025	.233***	-

Note.

* $p < .05$,

** $p < .01$,

*** $p < .001$, 2-tailed;

MW = mind wandering, PM = prospective memory; RTs = response times.

Table 9

Hierarchical Multiple Regression Analysis Predicting Time Checking with Intentional and Unintentional Self-Caught Mind Wandering (SC MW) Controlling for Probe-Caught Mind Wandering (PC MW) and Motivation (N = 209)

	B	*SE*	β	*t*	*p*	R^2_Δ	p_Δ
PC MW	11.24	12.37	.067	0.909	.365		
Motivation	0.052	1.417	.003	0.037	.971		
						0.004	.635
PC MW	8.898	12.316	0.053	0.722	.471		
Motivation	−0.571	1.412	−0.030	−0.404	.687		
Intentional SC MW	−0.026	0.918	−0.002	−0.028	.977		
Unintentional SC MW	1.190	0.430	0.227	2.767	.006		
						0.050	.005