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On the link between mind wandering and task performance over time

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ABSTRACT

Here we test the hypothesis that fluctuations in subjective reports of mind wandering over time-on-task are associated with fluctuations in performance over time-on-task. In Study 1, we employed a singleton search task and found that performance did not differ prior to on- and off-task reports, nor did individual differences in mind wandering predict differences in performance (so-called standard analytic methods). Importantly however, we find that fluctuations in mind wandering *over time* are strongly associated with fluctuations in behavior. In Study 2, we provide a replication of the relation between mind wandering and performance over time found in Study 1, using a Flanker interference task. These data indicate (1) a tight coupling between mind wandering and performance over time and (2) that a temporal-analytic approach can reveal effects of mind wandering on performance in tasks where standard analyses fail to do so. The theoretical and methodological implications of these findings are discussed.

1. Introduction

As most undergraduates would likely attest, the difficulty associated with paying attention, say, during a lecture, depends on both the difficulty of the material being lectured on, but also, and perhaps more importantly, on the amount of time one is required to attend. It has been argued that the longer we are required to perform a given task, the more likely it is that our minds will wander to task-unrelated thoughts (Smallwood, 2010; Smallwood & Schooler, 2006). In addition, there has been much work devoted to exploring the consequences of mind wandering on behavior in a wide range of tasks and contexts such as reading (e.g., Feng, D'Mello, & Graesser, 2013; Thomson, Besner, & Smilek, 2013), driving (He, Becic, Lee, & McCarley, 2011), and remembering (Riby, Smallwood, & Gunn, 2008; Thomson, Smilek, & Besner, in press), to name a few. Surprisingly, however, with a few notable exceptions (Cunningham, Scerbo, & Freeman, 2000; McVay & Kane, 2012; Smallwood et al., 2004), there is very little empirical evidence linking increases in mind wandering over time-on-task with changes in performance over time-on-task. Understanding the relation between attention and performance *over time* holds not only theoretical importance for the study of sustained attention and pedagogy, but is also of practical importance to human factors researchers striving to mitigate performance decrements that are observed when humans monitor largely automated systems for extended periods (so-called 'vigilance tasks', e.g. radar monitors, security screeners). The purpose of the present work is to more closely examine the link between changes in mind wandering and performance over time.

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To date, examinations of mind wandering (defined as task-unrelated thought – TUT) over time-on-task have focused almost exclusively on general group-level trends. For example, Teasdale et al. (1995) found that subjective reports of TUT were more frequent in the second half of both perceptual-motor and memory tasks relative to the first half. In addition, practice with either task resulted in higher reports of TUT. Similarly, in a visual-discrimination task with low target probability (i.e. a 'vigilance' task), Cunningham et al. (2000) found that over the course of the session, self-caught instances of TUT increased in frequency. Importantly, it was also shown that as TUT increased over time-on-task, there was a commensurate increase in response time (RT) and decrease in detection accuracy for target events. A similar relation was observed by McVay and Kane (2012), who found that increases in TUT over time in a vigilance task (i.e., a sustained attention task in which very few trials require a response) were accompanied by increases in both mean RT and RT variability on correct detections. Likewise, it has been shown that instances of TUT are greater in the second half of the Sustained Attention to Response Task (SART; Robertson, Manly, Andrade, Baddeley, & Yiend, 1997) relative to the first, while response errors (commission errors) also increase from the first to second half of the task (Smallwood et al., 2004). And finally, in the context of a classroom lecture, Risko, Anderson, Sarwal, Engelhardt, and Kingstone (2012) found that 'off-task' responses to thought probes were greater in the second half of the lecture relative to the first, while memory for the presented material decreased from the first half to the second. Taken together, the available evidence points to two consistent observations: (1) When one is required to maintain the focus of attention on an external task for extended periods of time, episodes of mind wandering (defined in the laboratory as 'task-unrelated' thought) become more frequent; and (2) performance seems to decline as a function of time across a range of tasks.

The foregoing observations suggest that performance changes over time-on-task are tightly related to increases in mind wandering over time. Indeed, it may be the case that our inability to maintain a high level of performance over time in many task contexts may owe directly to an increase in the tendency to engage in mind wandering. Bolstering this claim is evidence showing that overall rates of reported mind wandering predict performance in tasks such as the SART (Manly, Robertson, Galloway, & Hawkins, 1999; Robertson et al., 1997), Metronome Response Task (MRT; Seli, Cheyne, & Smilek, 2013), and semantic encoding (Thomson et al., in press). However, it has never been shown that changes in performance *over time-on-task* have a direct relation to changes in mind wandering *over time-on-task*. As a result, it has been argued that instances of off-task thought and performance decrements over time are largely independent (Head & Helton, in press) and that performance declines owe to something else entirely, such as the depletion of information processing resources (Caggiano & Parasuraman, 2004; Smit, Eling, & Coenen, 2004). In addition, there remains the possibility that any relation between performance and mind wandering over time results from some other variable, such as a reduction in the efficiency of resource distribution processes between on- and off-task thought over time (see Thomson et al., 2013). Clearly, more work is needed to establish a tight coupling between performance decrements over time-on-task and increases in mind wandering over time.

The primary goal of the present work was to more closely examine the correspondence between performance changes and mind wandering changes as they occur over time. Specifically, we sought to examine this correspondence at the level of individual traits, namely, examining whether individuals who show a greater increase in mind wandering over time-on-task also concomitantly show a greater change in performance over time. In addition, we sought to examine whether fluctuations in task-unrelated thought over a session *within* an individual predict fluctuations in performance over time within the same individual.

Our secondary goal was a methodological one. Examining the direct relation between mind wandering and performance over time-on-task has the added benefit of providing an additional analytic technique that might reveal an association between mind wandering and performance even when other analytic methods (e.g., comparing performance prior to 'on' and 'off' task reports, or individual differences (correlational) methods) fail to do so. We examine these issues in two different laboratory tasks, namely, a singleton search task and a Flanker interference task.

2. Study 1

In Study 1 we examined the relation between mind-wandering changes and performance changes over time-on-task in a simple visual search task. We chose to use a singleton (i.e., a 'pop-out') search task because it is an easy task that is likely to promote high rates of subjective reports of off-task thought (Forster & Lavie, 2009). We also expected the monotony and low demand (in terms of attentional resources) of the task to promote changes in both mind wandering and (consequently) performance over time-on-task. If so, we planned to make use of temporal changes in behavior to better elucidate the link between mind wandering and performance.

The easy pop-out search task was also useful with respect to our secondary methodological goal. Pop-out search is known to be much easier than conjunction search (Treisman & Gelade, 1980) and is argued to unfold in an entirely 'bottom-up' manner (Theeuwes, 1991; Theeuwes, 1992 – but see Thomson & Milliken, 2012, 2013). Accordingly, we expected that the extremely low demands on attentional resources would leave performance largely unaffected when participants report being 'on-task' relative to when they report being 'off-task', or when overall rates of mind wandering are correlated with performance at the individual difference level. However, we hoped to still observe a general relation between mind wandering and performance when assessed as a function of time-on-task. That is, if both mind wandering rates and performance (response time and accuracy) change over time-on-task, then there may be a direct relation between the two.