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Individual differences in mind wandering while reading predict lower rates of analogical transfer☆

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ABSTRACT

Mind wandering has been argued to both impair and facilitate performance on complex cognitive tasks such as those encountered in the classroom. On the one hand, mind wandering may prevent students from fully encoding and remembering to-be-learned information. On the other hand, mind wandering may allow learners to consider to-be-learned information in the light of other contexts and situations. The current study examined the relationship between individual differences in mind wandering while reading and performance on an analogical reasoning task that required participants to recognize similarities between an unsolved problem and information presented in a set of passages. Across two studies, we found no evidence that participants who mind wandered more performed better on the reasoning task than participants who mind wandered less. In fact, the opposite pattern was observed, suggesting that the propensity to mind wander may put individuals at a disadvantage when it comes to analogical reasoning.

1. Introduction

Mind wandering is defined as shifts in attention to internal thoughts unrelated to an ongoing primary task. Often associated with future goals (Smallwood & Schooler, 2006) and thoughts about one's self (Schooler, Reichle, & Halpern, 2004), mind wandering is a ubiquitous phenomenon, taking place approximately half of our waking lives (Giambra, 1995; Killingsworth & Gilbert, 2010) and permeating a wide range of tasks (e.g., vigilance tasks; e.g., McVay & Kane, 2009; SAT; e.g., Mrazek et al., 2012) and contexts, including—and perhaps especially—the classroom (e.g., Bunce, Flens, & Neiles, 2010; Cameron & Giuntoli, 1972; Johnstone & Percival, 1976; Lindquist & McLean, 2011). Most often, mind wandering is associated with detrimental outcomes, as, by definition, it detracts from one's engagement in a primary task. There are instances, however, in which mind wandering may be considered beneficial, such as when one needs to shift attention away from unimportant or inconsequential tasks to focus instead on what one actually cares about. In this way, mind wandering may provide both advantages and disadvantages (for a review, see Mooneyham & Schooler, 2013).

With regard to the disadvantages, it stands to reason that occupying cognitive resources with unrelated thoughts would impair performance on a primary task. Thus, individuals with a greater tendency to mind wander may perform particularly poorly on tasks that require undivided attention. One of the most extensively studied examples of this kind of detriment is in the context of reading comprehension. If participants are given a passage to read, for example, and are occasionally prompted with thought-probes asking them to report what they were thinking about just prior to the probes, individuals who report mind wandering more tend to exhibit relatively reduced levels of reading comprehension compared to individuals who report mind wandering less (Schooler et al., 2004; Smallwood, Beach, Schooler, & Handy, 2008; Smallwood, McSpadden, Luus, & Schooler, 2008). Given that comprehension skills are critical in educational settings, the propensity to mind wander may therefore serve as a significant obstacle to learning in the classroom.

Mind wandering has also been shown to correlate negatively with performance on a variety of basic cognitive tasks related to executive control, such as those measuring sustained attention (go/no-go task; Manly, Robertson, Galloway, & Hawkins, 1999), working memory (complex span task; Mrazek et al., 2012), and general fluid intelligence (Raven's Progressive Matrices; Mrazek et al., 2012). These relative deficits may play a significant role in educational contexts, as they have been shown to predict GPA, SAT scores, and educational attainment (e.g., Alloway & Alloway, 2010; Engle, Tuholski, Laughlin, & Conway, 1999; Rohde & Thompson, 2007; St Clair-Thompson & Gathercole, 2006; Steinmayr, Ziegler, & Träuble, 2010). The extent to which mind wandering affects educational outcomes directly, however, is unclear, though it does seem likely that mind wandering would have at least some potential to interfere with students' ability to carry out the types of tasks and activities critical for learning.

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In contrast, there are instances in which an individual's ability to mind wander, or engage in task-unrelated thoughts, can be considered beneficial. Mind wandering, for example, may afford opportunities to disengage from tedious (but necessary) tasks while concurrently engaging in more self-relevant and beneficial thought processes (Mooneyham & Schooler, 2013). Indeed, there is evidence that mind wandering is more prevalent when current task demands are low compared to when they are high. Although doing laundry may be a necessary chore, for example, it is also a relatively undemanding task for which the costs of mind wandering are likely to be minimal. In such situations, having the capacity to engage in task-unrelated (but personally important) thoughts while performing the primary task may reflect an adaptive form of multitasking. In support of this idea, Baird, Smallwood, and Schooler (2011) found that participants mind wandered more about future-focused thoughts and personally-relevant goals when they were given a relatively low-demanding task than when they were given a relatively high-demanding task. Interestingly, participants with high working memory ability were particularly likely to engage in this type of future-oriented mind wandering, suggesting that mind wandering may, in some instances, reflect the implementation of goal-directed cognitive processes.

A link between mind wandering and creativity has also been suggested. In a study by Baird et al. (2012), participants were asked to think of unusual uses for a variety of objects, a task that has been used extensively to measure divergent thinking (Unusual Uses Task; Guilford, 1957). After initial attempts to generate uses for the objects, participants engaged in either a demanding task, an undemanding task, rested for an equivalent amount of time, or took no break at all. The undemanding task yielded the highest rates of mind wandering (though not necessarily of task-related thoughts). All participants were then asked to continue to think of uses for the objects. Participants who engaged in the undemanding task—and thus mind wandered the most—exhibited the greatest improvement in performance on the creativity task, presumably because they benefited most from the mind-wandering filled incubation period.

1.1. Goals of the current study

The current study sought to further explore the consequences of mind wandering in the contexts of learning and creative problem solving. Our specific goal was to examine the potential relationship between mind wandering and analogical transfer. Analogical transfer is characterized by the process of identifying meaningful correspondences between disparate situations and drawing inferences from one situation to inform another (Gentner, 1983; Gick & Holyoak, 1980; 1983). If a person learns that a given strategy or procedure is effective in one context, for example, they may be able to transfer that strategy or procedure to another context. The ability to engage in analogical transfer has been argued to be a primary mechanism underlying creative problem solving, and has been assumed by some to be at the heart of learning and intelligence (e.g., Spearman, 1923).

At present, it is unclear exactly how mind wandering might affect the ability to notice and take advantage of analogies. If mind wandering facilitates the making of connections between ideas and thoughts not directly related to the primary task, then individuals who mind wander may be well-suited to engage in the relational processing necessary to make such connections. Performance on analogical reasoning tasks is often limited by the extent to which there is superficial overlap between the source and the problem (Dunbar, 2001; Gentner, Ratterman, & Forbus, 1993; Ross, 1989). When superficial overlap is low, participants are unlikely to explicitly connect the source to the problem, thus preventing them from being able to use the more critical structural overlap to solve the problem. By allowing an individual to partially disengage from a primary task, mind wandering may facilitate the ability to notice structural similarities between that task and some other problem or situation encountered in a superficially-distinct context, thereby facilitating analogical transfer. In other words, mind wandering may be a mechanism by which to connect ideas that share structural overlap without needing to rely on superficial overlap. Without mind wandering, people may be inclined to stay within a more limited contextual space and thus fail to recognize or take advantage of analogy.

Other considerations suggest that mind wandering may serve as an obstacle to analogical transfer. To solve a problem via analogy, one needs to notice the connection between the source and target, as well as effectively map the source to the target. The ability to do this has been argued to be impaired in individuals who have underdeveloped or deficient executive control abilities (e.g., Cho et al., 2010; Morrison et al., 2004; Richland, Morrison, & Holyoak, 2006; Viskontas, Morrison, Holyoak, Hummel, & Konwlton, 2004; Waltz, Lau, Grewal, & Holyoak, 2000). Moreover, the quality of the representation that a person develops when encoding a potential source can determine the likelihood of being able to use that source to solve a new problem (Bearman, Omerod, Ball, & Deptula, 2011; Catrambone & Holyoak, 1989; Gick & Holyoak, 1983), and the quality of the inferences and representations one generates from text is often limited among individuals with deficits in executive control (Friedman & Miyake, 2000; Turner & Engle, 1989). To the extent that individuals who mind wander have impairments in executive control (e.g., Kane et al., 2007; McVay & Kane, 2010, 2012; Unsworth & McMillan, 2013), such individuals may not be able to take full advantage of an analogy even if they are more likely to actually consider analogous situations when trying to solve a given problem.

To address our research question, a two-phase study was devised, with the first phase intended to measure individual differences in the propensity to mind wander while reading and the second phase intended to measure individual differences in spontaneous analogical transfer. We opted to measure each individual difference variable separately to ensure that the measuring of mind wandering behavior (using thought probes) did not influence the way in which participants engaged in the reading task needed to measure analogical transfer. Participants were first asked to read a text passage while occasionally being prompted to report what they were thinking about. Presumably, some participants would be more likely to mind wander than others, allowing us to measure individual differences in the propensity to mind wandering while reading. Then, in a separate phase of the study, participants were given reasoning problems to complete, one of which was Duncker's (1945) radiation problem. The radiation problem has been used extensively in research on analogical reasoning (e.g., Francis, 1999; Gick & Holyoak, 1980, 1983; Holyoak & Koh, 1987), and is ideal for current purposes because participants are unlikely to solve the problem without being exposed to the solution via analogy. After failing to solve the radiation problem, participants were given a series of short passages to read, some of which contained a situation analogous to the radiation problem. Finally, participants were given a second chance to solve the radiation problem.

If mind wandering does facilitate analogical transfer, then participants exhibiting high levels of mind wandering should be more likely to notice and take advantage of the connections between the passages and the radiation problem, thus making them more likely to solve the problem than participants exhibiting low levels of mind wandering. If the costs of mind wandering are too great relative to this potential benefit, however, then a negative correlation might be observed, such that high levels of mind wandering would actually be associated with a reduced likelihood of solving the problem.

2. Study 1

2.1. Method

2.1.1. Participants

A total of 102 University of California, Santa Cruz (UCSC) undergraduates ($M_{age} = 19.5$) participated for course credit. The study consisted of two phases: the first measured individual differences in mind

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