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Directing the Wandering Mind

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Abstract

Mind wandering—a mental phenomenon characterized by the spontaneous shift of attention away from external stimulation toward self-generated thought—has been consistently shown to have a negative impact on learning, yet little is known about how to reduce or redirect the experience in educational settings. In this article, I distinguish between approaches to directing mind wandering that focus on either the detection of lapses of attention (reactive) or restructuring of the learning environment (proactive) and argue that proactive approaches avoid issues of implementation that currently limit reactive approaches. I then review emerging research on a proactive approach to reducing and redirecting mind wandering that involves interpolating lecture-based content with brief memory tests, and further elaborate on the benefits of interpolated testing in other educationally relevant contexts. I conclude by highlighting that proactive approaches to creating attentive learning environments will also need to take into account characteristics of the individual learner.

Keywords

mind wandering, attention, interpolated testing

Mind wandering is a ubiquitous mental phenomenon that occurs when attention becomes disengaged from the external environment and directed toward internally generated thoughts (Smallwood & Schooler, 2006, 2015). The experience of mind wandering can be relatively innocuous during daily activities such as reading the morning newspaper and may even confer benefits by bringing back to conscious awareness details of unresolved goals (Smallwood & Andrews-Hanna, 2013). However, there are also various contexts, such as traditional educational settings, in which lapses of attention result in adverse outcomes (Szpunar, Moulton, & Schacter, 2013). This article examines whether it is possible to counteract the negative impact of spontaneous bouts of inattentive mind wandering on learning.

Recently, there has been a surge in research geared toward detecting and refocusing lapses of attention that result in mind wandering. The various approaches that have been adopted by researchers can be classified as either reactive or proactive (Bixler & D'Mello, 2015). Reactive approaches focus on developing methods for detecting lapses of attention as they occur during learning and, in some cases, attempting to use that information to provide feedback to learners about their state of attention or performance. Those interested in reactive detection have studied variability in task performance (Adam, Mance, Fukuda, & Vogel, 2015); physiological responses, such as those measured by fMRI (deBettencourt, Cohen, Lee, Norman, & Turk-Browne, 2015); and a variety of phenomena related to eye gaze, including blinking and pupil dilation (Franklin, Broadway, Mrazek, Smallwood, & Schooler, 2013; Smilek, Carriere, & Cheyne, 2010). Because people do not always know when they are mind wandering (Schooler et al., 2011), reactive approaches hold promise for the development of technologies that can be used to refocus attention during learning. For instance, Pham and Wang (2015) recently developed a novel mobile application that used camera-based photoplethysmography sensing to infer heart rate from measurements of fingertip transparency as learners viewed video-recorded lectures on their smartphone devices. Based on indices of heart rate variability derived from their mobile application, the authors were able to accurately predict (i.e., above chance) the occurrence of mind wandering and performance. Although these findings are promising, one (current) limitation of this and other related work (e.g., Bixler & D'Mello, 2015) is that such

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measurements are typically calculated off-line, after learning, and it remains to be seen whether physiological- and/or performance-based feedback about mind wandering can be reliably implemented in real time in ecologically valid educational settings.

Proactive approaches, on the other hand, avoid the above-noted issues associated with detecting mind wandering and instead aim to develop educational materials that encourage attentive processing and support learning. One such approach that has recently gained traction is the act of interpolating study with brief memory tests. In this article, I focus on this emerging line of research and (a) provide a brief overview of the methods and hypothesized benefits associated with interpolated testing, (b) demonstrate how and discuss why interpolated testing reduces spontaneous bouts of inattentive mind wandering during learning from lecture-based content, (c) consider the utility of interpolated testing in other educationally relevant settings and the need for future work to assess the role of mind wandering in these contexts, and (d) conclude by highlighting that proactive approaches to curbing the negative impact of mind wandering on learning will need to take into account not only the structure of the learning environment, but also characteristics of the individual learner.

Interpolated Testing

The act of retrieving information from memory has positive consequences for long-term retention (Roediger & Butler, 2011). The benefits of testing can arise as a direct result of retrieval practice or indirectly via improvements in learning that accompany testing but are not due to retrieval practice per se (e.g., using feedback from tests to determine which material requires further study). While considerable research has been devoted to pinpointing direct benefits of testing, less attention has been paid to indirect benefits (Roediger & Karpicke, 2006).

One indirect benefit of testing that has received recent attention is the learning of new information following testing, which is commonly revealed in experiments that interpolate exposure to study materials with brief memory tests. In a standard interpolated-testing paradigm, participants are asked to learn two or more subsets of information (e.g., word lists) and are told that each subset will be randomly followed by an opportunity either to complete a memory test or to engage in some control activity (Pastötter & Bäuml, 2014). This standard paradigm typically includes at least two groups of participants: one group that is tested after each subset of materials (tested group) and one other group that is tested only after the final subset of materials (nontested group). In addition, all groups are commonly informed that there will be a final cumulative test after some delay following initial exposure to (and testing of) study materials.

Studies using the standard interpolated-testing paradigm have consistently demonstrated that introducing tests during study improves learning of new information presented later in the study sequence (i.e., tested participants learn more than non-tested participants; Pastötter & Bäuml, 2014). Researchers have offered a number of theories as to how interpolated testing supports learning, including facilitating attentive post-test processing of new information (Pastötter, Schicker, Niedernhuber, & Bäuml, 2011; Weinstein, Gilmore, Szpunar, & McDermott, 2014) and supporting discrimination processes during subsequent retrieval of new post-test information (Chan & McDermott, 2007; Lehman, Smith, & Karpicke, 2014; Szpunar, McDermott, & Roediger, 2008). Critically, for present purposes, if interpolated testing supports new learning by facilitating attentive processing, then it stands to reason that the manipulation should serve to reduce spontaneous bouts of inattentive mind wandering.

Interpolated Testing and Mind Wandering

To examine the relation between interpolated testing and mind wandering, Szpunar, Khan, and Schacter (2013; Experiment 2) carried out a study during which participants were asked to learn from a 21-minute excerpt of an introductory statistics lecture. The lecture was parsed into four segments, and the authors employed the standard interpolated-testing paradigm, comparing learning among a group of participants who responded to short-answer questions after each segment of the lecture (tested group) with learning among two groups who were tested only after the fourth and final segment of the lecture (a re-exposure group, who saw the answers to test questions without having answered them, and a math control group, who completed a math distractor task following the first three segments of the lecture). Participants in all groups completed a final cumulative short-answer test. Additionally, participants in all groups were asked to indicate whether or not they were mind wandering at one random point of each segment of the lecture.

As with prior work that has examined mind wandering in the context of learning from video-recorded lectures (Risko, Anderson, Sarwal, Engelhardt, & Kingstone, 2012), Szpunar, Khan, and Schacter (2013) reported a strong negative association between mind wandering and learning. Importantly, and consistent with the finding that interpolated testing may facilitate attentive processing (Weinstein et al., 2014), the authors found that interpolated testing reduced mind wandering and increased learning (as indexed by performance on the test for material from the final segment of the lecture and the final cumulative memory test; see also Szpunar, Jing, & Schacter, 2014). Although promising, these findings left open questions about whether this manipulation would be effective for the learning of other lecture materials, particularly those that participants might find more engaging than a statistics lecture.

Recently, Jing, Szpunar, and Schacter (2016) applied the interpolated-testing manipulation with a 40-minute excerpt of a public health lecture that was parsed into eight 5-minute segments. The authors conducted two experiments comparing learning across groups of participants who either engaged in free recall following each lecture segment (tested group) or restudied their lecture slides following the first seven segments of the lecture and were tested following the eighth and final segment of the lecture (restudy control group). During a final cumulative test, all participants were asked to recall everything they had learned in the lecture and were also required to elaborate on points covered by specific slides from the lecture.

In the first experiment, Jing et al. (2016) asked participants in both the tested and restudy groups to indicate whether or not they were mind wandering at one random point during each segment of the lecture. Although interpolated testing increased final-segment test and final cumulative test performance, there were no differences across groups in terms of overall levels of mind wandering. Nonetheless, the authors found that whereas there was a strong negative association between mind wandering and learning for students in the restudy group, there was no such association for students in the tested group. This latter finding suggested that students in the tested and restudy groups might have been mind wandering in different ways and that a more fine-grained measure of mind wandering might serve to elucidate the disparate relations between mind wandering and learning across groups.

In a second experiment, Jing et al. (2016) probed attention by asking participants to indicate whether their bouts of mind wandering were related to the content of the lecture (e.g., involving something from an earlier part of the lecture or something from their lives that was relevant to the lecture) or unrelated to the content of the lecture (e.g., involving something from their lives that was irrelevant to the lecture or zoning out). The authors showed that students in the tested group were more likely then students in the restudy group to mind wander about lecture-related content and less likely to mind wander about lecture-unrelated content. Notably, Jing et al. (2016) also reported data indicating that reductions in mind wandering observed in prior studies using a statistics lecture were largely restricted to lecture-unrelated content, suggesting that interpolated testing serves to primarily reduce bouts of inattentive mind wandering. Finally, it is interesting to note that lecture-related mind wandering was positively associated with learning. This finding dovetails with recent demonstrations indicating that, in some cases, mind wandering may facilitate as opposed to impair performance (Baird et al., 2012; Randall, Oswald, & Beier, 2014).

Although various theories of mind wandering have been proposed (Smallwood, 2013), it is generally agreed that task engagement should be negatively associated with mind wandering (Smallwood & Andrews-Hanna, 2013; Smallwood & Schooler, 2015). In the research outlined above, students were initially told that the occurrence of testing would be random; however, expectations likely change as a result of experience. Indeed, Weinstein et al. (2014) showed that expectations of future testing in an interpolated-testing paradigm subsided in the absence of reinforcement of testing during learning. Hence, the perceived need to sustain a high level of attention for impending test questions (i.e., task engagement) may have been lowered for non-tested participants and invited bouts of inattentive mind wandering. At the same time, it is possible that an executive mental representation of the task set or goal for completing interpolated tests becomes diminished in the absence of reinforcement (see Vandierendonck, 2016). Future work will need to further discriminate possible relations between the role of learner expectations of testing and the quality of mental representation for task instructions of testing.

Future Directions: Extensions to Other Contexts

Do the benefits of interpolated testing on learning from lecture-based content extend to other pedagogical settings? A small but quickly growing literature has emerged that is focused on testing the benefits of clicker technology for learning in classrooms. Although no studies have implemented a standard interpolated-testing manipulation in the classroom, some recent work has compared interpolated testing during a lecture to testing only at the end of the lecture (for all lecture content). Using this modified design, Mayer et al. (2009) showed that interpolated testing was associated with a small but significant boost in performance across an entire semester (but see Weinstein, Nunes, & Karpicke, 2016). Notably, similar results have been reported in the context of classroom manipulations that implement interpolated testing using response cards rather than clicker technology (Kellum, Carr, & Dozier, 2001). Although various authors have suggested that interpolated testing in these contexts may benefit learning via gains in attentional control (Heward, 1994), no relevant work has examined associations with mind wandering.

Similarly, an extensive literature on adjunct questioning, the practice of asking students questions during the course of reading, has demonstrated a benefit for comprehension when questions follow as opposed to precede relevant text material (Rothkopf & Bisbicos, 1967; see also Wissman & Rawson, 2015; Wissman, Rawson, & Pyc, 2011). These data further suggest that the anticipation of testing facilitates learning in the context of reading. Whether or not the benefits of adjunct questioning for learning and comprehension are in part mediated by reductions in mind wandering remains to be tested in the literature.

Conclusions: Interactions Between Context and Characteristics of the Learner

A more complete picture of the extent to which proactive approaches such as interpolated testing improve attention and learning will also require considerations of characteristics of the individual learner. For instance, it has been well established that people who possess high levels of attentional control are better able to limit their off-task mind wandering in the context of demanding activities (Kane & McVay, 2012), and preliminary evidence indicates that attention-training regimens can reduce mind wandering and improve academic outcomes (Mrazek, Franklin, Phillips, Baird, & Schooler, 2013). Whether the maintenance of task engagement over time via manipulations such as interpolated testing serves to support attentive processing for all learners or whether such manipulations are more or less beneficial for learners with high or low attentional control remains to be elucidated in the literature. In addition to individual differences in cognitive ability, it is likely that factors associated with personal past experience, such as background knowledge, will also be important to consider. Along these lines, Xu and Metcalfe (2016) recently demonstrated that learners with high levels of background knowledge tend to mind wander more when materials are too easy and that learners with low levels of background knowledge tend to mind wander more when materials are too difficult (for relevant discussion, see Seli, Risko, & Smilek, 2016). Elucidating the manner in which the environment, the individual, and their interactions encourage inattentive mind wandering and approaches for restructuring those conditions to support learning represents a fruitful avenue for future research.

Recommended Reading

Immordino-Yang, M. H., Christodoulou, J. A., & Singh, V. (2012). Rest is not idleness: Implications of the brain's default mode for human development and education. *Perspectives on Psychological Science*, *7*, 352–364. An important article discussing the possible benefits of mind wandering in educational settings.

Pastötter, B., & Bäuml, K.-H. (2014). (See References). Provides a recent review of the various benefits of interpolated testing on learning.

Smallwood, J., Fishman, & Schooler, J. W. (2007). Counting the cost of an absent mind: Mind wandering as an underrecognized influence on educational performance. *Psychonomic Bulletin & Review*, *14*, 230–236. An informative overview of the impact of mind wandering on reading and learning in educationally relevant contexts not covered here.

Smallwood, J., & Schooler, J. W. (2015). (See References). Provides an up-to-date overview of research and theory about the science of mind wandering.

Szpunar, K. K., Moulton, S. T., & Schacter, D. L. (2013). (See References). A thorough review of the impact of mind wandering in classroom and online settings.

Declaration of Conflicting Interests

The author declared no conflicts of interest with respect to the authorship or the publication of this article.

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