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Mindwandering While Reading Not Only Reduces Science Learning But Also Increases Content Misunderstandings

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More frequent mindwandering has been shown to reduce overall text comprehension. However, are mindwanders also more likely to generate incorrect associations based on what they have read? This question is especially critical for science learning, as errors in understanding can resonate through future learning efforts. Across 2 experiments, participants read a science text and were asked to generate a causal essay response related to the text, in addition to completing a sentence recognition test. Participants who reported more mindwandering not only demonstrated lower levels of correct understanding overall, but also included more misunderstandings in their essay responses. Mediational analyses suggest that the production of misunderstandings was tied to less available correct knowledge, and not demand characteristics at time of test. The results from these experiments suggest that mindwandering does not just prohibit correct memory for text, but also produces a negative learning effect in the form of textual misunderstanding.

General Audience Summary

Perhaps unsurprisingly, research has shown that when people mindwander away from the task at hand, they remember less correct information about what they were supposed to be learning. However, does mindwandering also cause people to instead learn more incorrect information, or perhaps connect what they were learning in wrong ways? In other words, are they not only learning less correct information, but simultaneously learning more of the incorrect information they should be trying to avoid? To explore this question, in two experiments participants read a science text and were evaluated on how much they mindwandered during reading. Both of the current studies found that when readers mindwander, they not only remember fewer correct concepts, but also demonstrate more misunderstandings of the material. Thus, not only are they less able to tell you correct information, but what little they do know is incorrect. This represents a double impact of mindwandering, which ultimately results in poorer overall understanding of the material. The findings of this study are broadly applicable to all settings that require people to learn information from text, whether in the classroom or on-the-job. Finally, this also suggests that it is especially important to design teaching materials that discourage mindwandering, so as not to put individuals at a huge disadvantage moving forward.

Keywords: Mindwandering, Misunderstanding

Recent research has identified a stable and ubiquitous phenomenon known as mindwandering (also referred to as mindless reading or perceptual decoupling), in which individuals mentally drift away from the task-at-hand and instead focus on internal task-unrelated information. Most agree that this type of behavior is not uncommon, and may even occur as frequently as on-task thought (Killingsworth & Gilbert, 2010). The frequency of mindwandering is also sensitive to individual variation or

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differences across numerous dimensions. For example, more dysphoric individuals tend to mindwander more (Smallwood, O'Connor, Sudbery, & Obonsawin, 2007), and those individuals higher in working memory capacity also seem to mindwander less (Rummel & Boywitt, 2014; Unsworth, McMillan, Brewer, & Spillers, 2012). Similarly, older adults also seem to mindwander less, perhaps suggesting a role of prior knowledge or experience on the likelihood of exhibiting such behavior (Giambra, 1989).

However frequent, the occurrence of this behavior can be detrimental to performance, especially in tasks that require the management and focusing of consciousness. Declines in performance due to increased mindwandering have been observed in multiple contexts, including simple attentional tasks (McVay & Kane, 2009; Smallwood, McSpadden, & Schooler, 2007), and also more complex tasks like driving (He, Becic, Lee, & McCarley, 2011), standardized test performance (Mrazek et al., 2012), and even mood regulation (Killingsworth & Gilbert, 2010; Smallwood, Fishman, & Schooler, 2007; Smallwood, McSpadden, et al., 2007; Smallwood, O'Connor, et al., 2007). Relevant for the current study, mindwandering has also been implicated in the processing and comprehension of textual information (McVay & Kane, 2012; Naylor & Sanchez, 2018; Smallwood, McSpadden, & Schooler, 2008), and as such could have significant implications for learning in educational settings, and specifically in the STEM domains (Smallwood, Fishman, et al., 2007). For example, if one accepts the suggestion that off-task thought occurs nearly as frequently as on-task thought (e.g., Killingsworth & Gilbert, 2010), reducing this behavior in an educational setting to just half of this expected amount (i.e., from 50% to 25%) would be equivalent to adding nearly 45 full school days of additional learning opportunity for students (estimate drawn for data obtained from NCES, 2018). In an age of constant cuts to educational funding and enrichment opportunities for students, acknowledging the potential impact of mindwandering (and more importantly, how to address it) could produce immediate and lasting impacts on the quality of education.

Text Comprehension, Errors in Learning, and Mindwandering

More so than a simple memory exercise in which a participant is asked to remember static pieces of information (e.g., list learning), expository text comprehension represents a distinct cognitive activity where the successful usage and integration of information is valued above rote memorization (Kintsch, 1994). In other words, the goal of reading (especially in science) is to not only remember correct information, but also integrate this knowledge to build an appropriate mental model of instructional material. This process of understanding expository text requires readers to simultaneously manage multiple factors in addition to the representation of the text itself. For example, the degree of domain prior knowledge, text expectations, and even superficial characteristics of how the text is presented can all influence what a reader takes away from a given reading (Kintsch & Yarbrough, 1982; Mayer, 1984; Ozuru, Dempsey, & McNamara, 2009; Zwaan, 1994).

While developing understanding is the primary goal when reading in science, an important consideration is how to best measure whether or not this understanding has taken place. Typically, readers are asked to demonstrate their knowledge by completing some kind of summative assessment in one of several traditional forms. These assessments range from somewhat simple recognition tasks (i.e., multiple-choice tests, true-false tests) to more complex free recall tasks (i.e., essay responses, short answers), and these measures are often used in concert. However, across nearly all types of assessments, positive evidence of understanding is explicitly prioritized. For example, multiple-choice tests are scored for how many correct responses are provided, and essay or short answer responses are often evaluated only on how many correct ideas or concepts are contained within a given response. However, this positive-focused approach neglects a critical aspect of evaluating mental models formed while learning science from text: namely, the negative or erroneous information that might also exist within learner's representations. By considering these misunderstandings, in addition to the amount of correct information in the response, it should be possible to more accurately diagnose readers' true understanding of the text and target scientific phenomenon. This represents a shift in focus away from considering the mere *quantity* of correct information in a given response, to instead evaluating the overall *quality* of knowledge demonstrated, which includes aspects of both correct and incorrect information (Kendeou & van den Broek, 2005).

Especially in science learning, these incorrect connections of knowledge represent a critical problem for all learners (Perkins & Simmons, 1988). It is important to note that these erroneous connections or concepts, are not simply mistakes or slips in understanding (e.g., I meant to select answer A, but accidentally circled B), but instead represent systematic and identifiable misunderstandings of information (Moore et al., 1997). For example, after reading a text about global warming, the idea that the different seasons of the year are produced by variations in Earth's distance from the sun is a conceptual misunderstanding relating learned relevant information (i.e., the sun's rays, how they strike Earth, and the seasons) in a fundamentally inappropriate way. Note that this is not a simple error in response, but instead a pervasive and robust misconnection of knowledge, and a misunderstanding of how this scientific process works. Not only do such misunderstandings demonstrate that learners do not grasp the target information as well as they perhaps should, but the presence of these misunderstandings can lead to the formation of more pervasive and deeply held misconceptions about the content area (Feltovich, Coulson, & Spiro, 2001; Graham, Berry, & Rowlands, 2013; Smith, Disessa, & Roschelle, 1994). Learners often hold on to such incorrect frameworks staunchly (Guzzetti, Snyder, Glass, & Gamas, 1993), and as such these misunderstandings potentially resonate through multiple learning opportunities by promoting future maladaptive processing based on this erroneous information (Kendeou & van den Broek, 2005; van den Broek & Kendeou, 2008).

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