Where Students' Minds Go:

Exploring the Effects of Mind Wandering in a Classroom Setting

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Abstract

Mind wandering is a universal phenomenon which has been shown by research to have a negative impact on task-related performance. These findings may have strong implications in education; however, few studies have adequately explored the relationship between mind wandering and performance in a real-world classroom setting. Six hundred fifty-four psychology undergraduates provided intermittent thought probe reports throughout two in-class lectures, timed at the beginning and middle of the semester. We found a positive correlation between the on-task thought response rate and final course grade, and a negative correlation between final course grade and all off-task thought responses. As well, there was a significant increase in the overall mind wandering rate from the first half to the second half of class sessions. Finally, we found a negative correlation between task-related interference responses and course grades, and device-related mind wandering responses and grades. These findings support previous research indicating a negative relationship between mind wandering, particularly technology-based mind wandering, and performance, and suggest that different types of mind wandering may have differing effects on retention.

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It is estimated that we spend approximately 30% of our time thinking about something other than what we are doing (Kane et al., 2007, 2017). This shift from sensory input or the task at hand has been labeled many ways, such as *task-unrelated thoughts* (e.g. Filler & Giambra, 1973) and *task-unrelated images and thoughts* (e.g. Giambra, 1995). Commonly known as *mind wandering*, this experience represents a decoupling of attention away from a primary mental or physical task, or some other external stimulation, to internal stimulation (McVay & Kane, 2010a; Singer, 1966; Smallwood & Schooler, 2006).

Although mind wandering is a universal experience, individual differences do exist; this variation has been studied in relation to a number of cognitive variables, most notably working memory capacity (Kane, Brown, McVay, Silvia, Myin-Germeys, & Kwapil, 2007; Kane & McVay, 2012). Of particular interest is the attentional control aspect of working memory capacity (Engle, 2001; Kane, Bleckley, Conway, & Engle, 2001), as mind wandering denotes a shift in attention from external to internal stimulation (above) that can have a negative impact on task-related performance.

Mind wandering occurs in multiple contexts (e.g., Killingsworth & Gilbert, 2010; McVay, Kane, & Kwapil, 2009) and has been studied numerous times in relation to task performance, showing that as mind wandering occurs, performance on a primary task suffers (e.g., McVay & Kane, 2009; McVay & Kane, 2012; Smallwood, Fishman, & Schooler, 2007; Unsworth & McMillan, 2013). According to the *control failures concerns* theory, mind wandering is partly the result of a failure in executive control (McVay & Kane, 2010b). Thoughts unrelated to the task at hand are automatically and continuously cued by incoming

stimuli; when the internal interference produced by these thoughts exceeds the capacity of the executive control system, mind wandering (with the associated decoupling of attention from the primary task) occurs.

While these findings have ramifications in many areas of our lives, the impact of mind wandering on learning is of growing interest, especially given the societal importance of educational attainment. Recent studies on the effects of mind wandering in an educational context have mostly supported the research reviewed previously. It has been found that mind wandering occurs in a simulated lecture environment at a rate equal to or slightly greater than the average in daily-life activities (e.g., Linquist & McLean, 2011; Risko, Anderson, Sarwal, Engelhardt, & Kingstone, 2011); however, recent research by Wammes, Boucher, Seli, Cheyne, and Smilek (2016) has found that mind wandering occurs in a real-world lecture setting at a lower rate than reported in laboratory settings.

Risko et al. (2011), Linquist and McLean (2011), and Wammes et al. (2016) all measured instances of mind wandering through the use of randomized thought-probes throughout a lecture, either as a video shown in a lab setting (Risko et al.), as part of an in-class (Linquist & McLean), or in a real-world lecture setting (Wammes et al.). Although both Wammes et al. and Linquist and McLean conducted their research in a classroom setting, only Wammes et al. collected mind wandering data during actual course-related lectures. Aside from participation in the study, students had little motivation to learn the presented material in the Linquist and McLean lectures, whereas learning the material in the Wammes et al. study was necessary for success in the course. The results of these mind wandering probe sessions were then analyzed in relation to performance on lecture-related tests, with the tests occurring directly after the presented material (Risko et al.), at the mid-term and end-of-semester points (Linquist & McLean), or both

(Wammes et al.); all studies found a decline in test scores connected to an increase in self-reported mind wandering, with mind wandering thought to result in impoverished learning of the presented material.

Research previous to Wammes et al. (2016) utilizing mind wandering probes in lecture environments has used simple yes-no response options to gauge mind wandering (e.g. Linquist & McLean, 2011; Risko et al., 2011). Wammes et al. provided participants with three response options instead: they were listed as not mind wandering, mind wandering intentionally, or mind wandering unintentionally. However, the content of reported mind wandering episodes was not collected in any of the previous studies.

Additionally, previous research on mind wandering has not accounted for off-task—but—on-topic instances of mind wandering, which could have potentially been coded as on-task thinking (i.e. not mind wandering) depending on the phrasing of the response instructions or on individual interpretation given the limited options available. On-topic mind wandering is defined here as thoughts or images related to the primary task, such as thoughts about how well the individual is understanding the material or thoughts otherwise related to the material, while off-topic mind wandering is defined as thoughts or images unrelated to the task at hand, such as thoughts about the classroom environment or upcoming obligations. In a recent study by Hollis and Was (2016), the response options were expanded with a choice provided to capture instances of mind wandering related to the material presented (off-task but on-topic), in this case thoughts that were about the participant's own understanding of the material. This category was meant to evaluate a type of task-related interference, which is defined by McVay and Kane (2009) as an intermediary between pure on-task and off-task thoughts; however, while the frequency of this type of intermediary was evaluated in addition to pure on-task and off-task

thinking, the effects of this type of off-task, on-topic mind wandering on academic performance were not analyzed (Hollis & Was, 2016). Additional studies have also investigated this type of off-task, on-topic mind wandering (namely thoughts related to performance on or understanding of the presented material) but none were conducted in a classroom setting and other types of on-topic mind wandering, such as thoughts related to the presented material, were not included in the analyses (Smallwood & Schooler, 2006; Unsworth & McMillan, 2013).

Many types of task-unrelated mind wandering have been analyzed previously, with technology-related mind wandering being of particular interest to educational researchers: technology is a constant in our modern world and the classroom is no different in that respect. Technology-related mind wandering is defined as thoughts or images unrelated to the presented material that have to do with technology, such as email, social media, or text messaging. Hollis and Was (2016) also collected data specifically on technology-related instances of mind wandering and found that this type of mind wandering represented the highest percentage of off-task thinking. These results were not drawn from data collected in a real-world classroom setting, however, and the effects of this type of mind wandering were not analyzed in relation to academic performance.

The current study attempts to provide a more in-depth exploration of the issue. Its goal is to determine the relationships between academic performance and various types of mind wandering as reported in a real-world classroom lecture environment. It will seek to analyze the differences in effect between off-topic and on-topic mind wandering as well as the potential impact of technology-related mind wandering. These variables will also be examined by their relation to time spent in the classroom.

Much of the previous research on mind wandering in relation to the passage of time has shown a positive correlation between the two, meaning that as time spent on a cognitive task increases so does reported mind wandering (McVay & Kane, 2009; Smallwood, Riby, Heim, & Davies, 2006), an observation also known as a vigilance decrement. More specifically, Risko et al. (2011) found evidence of this time-related increase in mind wandering in the context of attending to a video lecture in a laboratory setting; however, Wammes et al. (2016) found a *decrease* in mind wandering over the course of real-world lectures, indicating that the previously observed vigilance decrement may be influenced by setting. According to Wammes et al., this could be due to the setting itself. A negative relationship has been shown between motivation and rate of mind wandering, with higher motivation being associated with fewer reported instances of mind wandering (Unsworth & McMillan, 2013); it is possible that a real-world classroom setting, with real-world consequences for learning the presented material, could be inherently more motivating than a laboratory or simulated classroom setting. Situational interest, a related concept, has also been shown to have a negative correlation with reported mind wandering, with Unsworth and McMillan (2016) and Hollis and Was (2016) both finding a negative relationship between interest and mind wandering. Additionally, Hollis and Was (2016) found a negative relationship between situational interest and performance, as measured by post-lecture quizzes. Taken together, this suggests that situational interest may have an effect on mind wandering in a lecture setting and thus may influence lecture-related comprehension and performance.

Methods

Participants

Participants were 654 undergraduate students enrolled in introductory psychology courses at the University of North Carolina at Greensboro. Through their instructors, students were offered extra credit for their participation in the study. Consent was acquired during the initial phase of the study as well as for each in-class probe assessment.

Procedure

Data collection consisted of an initial online questionnaire, two in-class probe assessments, and a final online questionnaire. The in-class probes were conducted once in the beginning of the semester (before the first exam) and once in the middle of the semester; in-class probe packets for both probe assessments included, on one side, thought probe response options and, on the other side, a questionnaire and a single consent item to provide permission for the day's collected data to be used in the research study.

In order to have their data counted from the in-class probe sessions, participants were required to complete the initial online questionnaire prior to the first classroom visit, as well as the consent line item included on the reverse side of the thought-probe response sheet. As an alternative to their participation in this study, students were also given the opportunity to complete an assignment worth an equal amount of extra credit points.

At the beginning of classes with thought-probe assessments, participants were given a response packet with instructions to disregard all pages except the thought-probe response sheet on the front. Five minutes prior to the beginning of class, a video recording was started. At class time, the principal researcher addressed the class. Participants were reminded that, in order to have their data used (and in order to receive extra credit for their participation) it was required that they had already completed the initial online consent form and questionnaire. Participants were given the option of completing the in-class probe without having their data used, either by

not previously completing the initial online questionnaire and consent form or by not signing the consent line included with the in-class probe packet.

Participants were then directed to the thought probe response sheet and told that, at random intervals during the class period, they would hear a bicycle bell ring from the back of the lecture hall. The sound of the bell was meant to act as a signal for participants to immediately take stock of what they had been thinking about in the instant right before the bell rang. It was explained by a metaphor of the flashbulb for a camera going off that preserved the instant just before the bell. They were instructed to choose the response on the thought probe response sheet that most accurately reflected their thoughts in that instant.

To ensure participants responded to the probes in the correct order, a research assistant sat in the front of the classroom and held up a numbered sign corresponding to the numbered probe on the sheet that needed to be used.

The probes were timed from the beginning of the class and sounded at pre-determined random times throughout the lecture. If a scheduled probe would sound in the middle of the instructor's sentence, or during a student's question, the researchers delayed the bell until the end of the sentence or question. After the lecture, instructors were asked to set aside ten minutes for the completion of the in-class response sheet.

Measures

Thought probe response sheet. The response sheet was divided into twelve individual probes, with each probe containing all six response options. Classes that lasted for seventy-five minutes contained nine probes, while classes that lasted for sixty minutes contained six probes. At class time, the principal researcher explained the options as follows:

- On-Task / On-Lecture – for thoughts about the in-the-moment lecture, discussion, or video, or a focus on the instructor and/or immediate class task at hand
- Off-Lecture / On-Topic – for thoughts that weren't about the lecture at the moment, but were about a relevant intro-psych topic that was connected to the current one, or that they'd been reminded of by the lecture
- Off-Lecture / On-Own-Understanding – for thoughts about how well or how poorly they were understanding the material presented in class
- Off-Lecture / Internal-Thoughts / Images – for thoughts that were internally focused and unrelated to the lecture, such as plans they had for later, things that had recently happened, personal concerns or worries, or daydreams
- Off-Lecture / External-Events / People – for thoughts about lecture-unrelated things happening in the room, the people around them, or thoughts about the room itself
- Off-Lecture / External-Device – for thoughts about what was on their phone, laptop, or tablet screens

In-class response sheet. The in-class response sheet collected data on class interest, class time spent media multi-tasking, note-taking behavior, seating position within the room, and expected grade in the course.

Online questionnaires. The online questionnaires consisted primarily of self-reports (detailing habits such as note-taking or multi-tasking, as well as prior interest in psychology) and a modified personality assessment, all of which will be used in the larger mind wandering study but are not analyzed here. In addition, the online questionnaires also collected data on situational interest, measured using a shorter version of the situational interest survey created by Linnenbrink-Garcia, Durik, Conley, Barron, Tauer, Karabenick & Harackiewicz (2010).

Grade data. Grade data was collected from instructors at the end of the semester, consisting of exam grades and overall final grade in the course. In the current study, only the final course grade data will be used, reflecting z-scores calculated within each class (to account for grading differences among instructors).

Results

The two main areas of interest for this study are the analysis of mind wandering as a function of time within each class meeting, and the correlation between the various mind wandering probe responses and overall class performance. In addition, the effects of mind wandering at different class times was analyzed in relation to overall class performance, and the relationships between the various mind wandering probe responses and the post-semester situational interest survey responses were also calculated.

Vigilance decrement was analyzed using data from the in-class probe response sheets, focusing on the overall rate of mind wandering in the first half versus the second half of class sessions. A paired samples *t*-test revealed that there was a significant difference in the overall mind wandering rate between the first half ($M = 0.217$, SD = 0.214) and the second half ($M = 0.275$, SD = 0.235) of classes; $t(654) = -6.104$, $p < .001$. These results suggest an increase in mind wandering as a function of time in a classroom setting.

A Pearson product-moment correlation coefficient was computed to assess potential relationships between the total course grade and rate of reported mind wandering in the first half of class, as well as between total course grade and reported mind wandering in the second half of class. There was a negative correlation between grades and mind wandering rates during the first half of class, $r(654) = -0.09$, $p = 0.021$. There was a numerically larger negative correlation between grades and mind wandering rates in the second half of class, $r(654) = -0.18$, $p < .001$.

Additionally, a chi-square test of independence was calculated comparing these correlations. A significant difference, $x^2(3) = 147.465$, $p < .001$, was found. Reported mind wandering predicted total grade better during the second half of class than it did during the first half.

The various types of mind wandering responses were each analyzed to determine their potential relationship with performance as measured by the final course grade. A Pearson product-moment correlation coefficient was calculated, finding a positive correlation between the on-task thought response rate and final course grade, $r(654) = 0.19$, $p < .001$, suggesting that the final course grade increases with the increase in the rate of reported on-task thoughts. There was a negative correlation between final course grade and all off-task thought responses, $r(654) = -0.15$, $p < .001$ as well as individually between task-related interference responses and grade, $r(654) = -0.1$, $p = 0.015$ and device-related mind wandering responses and grade, $r(654) = -0.14$, $p < .001$. Non-significant correlations were also found between final course grade and on-topic/off-task, $r(654) = -.03$, $p = 0.481$, internal, $r(654) = -.06$, $p = 0.110$, and external, $r(654) = -.05$, $p = 0.231$, thought responses.. Together, these findings suggest a decrease in final course grade with the increase of reported thought responses other than on-task.

A Pearson product-moment correlation coefficient was also calculated to measure the potential relationships between the six thought types and the average post-semester situational interest as determined by survey response. While no significant relationships were discovered between on-topic/off-task responses or task-related interference responses and situational interest, a positive correlation was found between on-task thought responses and situational interest, $r(654) = 0.27$, $p < .001$. A negative correlation was found between all task-unrelated thought responses and situational interest, $r(654) = -0.29$, $p < .001$; negative correlations were also found individually for internal, $r(654) = -0.17$, $p < .001$, external, $r(654) = -0.11$, $p = 0.013$,

and device, $r(654) = -0.21$, $p < .001$, task-unrelated thought responses. These findings suggest an increase in later situational interest with the increase of on-task thoughts and a decrease in later situational interest with the increase of task-unrelated thoughts, particularly in technology-related mind wandering.

Discussion

Due to its association with lowered retention (McVay & Kane, 2009; McVay & Kane, 2012; Smallwood, Fishman, & Schooler, 2007; Unsworth & McMillan, 2013), the phenomenon of mind wandering is of particular interest to the study of learning in academic settings. The specifics of how and why mind wandering occurs have been studied in simulated and real-world classroom contexts with differing results (Linquist & McLean, 2011; Risko et al., 2011; Wammes et al., 2016). Although all of the noted studies have shown a decrease in lecture-related performance related to the increase of reported mind wandering, the recent study by Wammes et al. conducted in a real-world classroom setting has not replicated previous research showing an increase in mind wandering with time spent in lecture (Linquist & McLean, 2011; Risko et al., 2011).

While the current study did find evidence for a vigilance decrement, showing an increase in mind wandering as a function of time, this could potentially be the result of motivation differences: participants in the Wammes et al. study were given lecture-based quizzes at the end of each class, which possibly affected their motivation to attend to the lecture, particularly during the later portion of the class approaching the quiz. Motivation has been shown to have an impact on rates of reported mind wandering, with higher motivation being associated with less mind wandering (Unsworth & McMillan, 2013).

In addition, this study found a larger negative correlation between total course grade and reported mind wandering during the second half of classes, compared to the first, suggesting that mind wandering negatively affects grades more during the second half of a class. Without further study, the cause of this cannot be easily isolated, though one possible reason could be the type of material presented in the first half versus the second half of classes: instructors may have presented newer, test-relevant material in the second half of classes or may have presented material that built upon material presented in the first half of classes.

While there has been much research done showing a negative correlation between reported mind wandering and performance, potential relationships between various types of mind wandering and performance have not been as extensively studied. Although intentional versus unintentional mind wandering was examined in Wammes et al. (2016), there has been little other delimitation of the specific types of mind wandering occurring in a real-world classroom setting, or their potentially differing effects on performance.

In the current study, participants were provided with two responses meant to collect data on task-related mind wandering, such as thoughts related to the lecture presented or thoughts related to their own understanding of the material. It was initially thought that task-related mind wandering may inhibit performance more so than purely on-task thinking due to the decoupling of attention required to shift focus from external to internal stimuli, but that this effect should not be as harmful as purely off-task thinking, as construction of an adequate situation model would not impair future task-related attention control. The current study did find a negative correlation between task-related mind wandering responses and final course grade; this negative correlation was also smaller in magnitude than the negative correlation found between purely off-task thought responses and final course grade.

Participants were also provided with a technology-related mind wandering response option during in-class probes, meant to capture instances of task-unrelated thoughts or images related to technology such as email, social media, or texting. The current study found a negative correlation between technology-related thought responses and final course grade. This was the largest negative correlation found for all of the individual off-task response options. These findings replicate previous research showing that technology-related instances of mind wandering make up the largest portion of reported off-task thinking (Hollis & Was, 2016) and suggest that technology-related mind wandering has the greatest impact on performance out of the reported types of mind wandering. Participants who frequently engage in technology-related mind wandering may be more likely to engage in technology-related multi-tasking during class, which could potentially result in a greater decoupling of attention for a longer period of time,

Finally, participant interest in the course material was collected at the end of the study. A positive correlation was found between on-task thought responses and post-course interest, while a negative correlation was found between off-task thought responses and post-course interest. Individually, negative correlations were found for internal, external, and technology-related thought responses, with the largest negative correlation found between technology-related thought responses and post-course interest. While pre-course interest information was collected at the beginning of the study, its analysis was not included in this study, making it difficult to draw conclusions in regards to the effects of mind wandering on total interest; however, taken alone, the post-course interest data suggests that mind wandering may have a negative effect on interest in the material being presented, with technology-related mind wandering having the largest impact on interest, or that a lower initial level of interest increases the rate of mind wandering, particularly technology-related mind wandering.

Investigating different types of mind wandering prevalent in the classroom will enable researchers to further understand how these types of mind wandering could vary depending on context as well as how this variation relates to performance and time on task. Given the divergent results of Wammes et al. (2016) in regards to the occurrence of mind wandering in a real-world versus laboratory lecture setting, information on the types of mind wandering common during a lecture may also provide insight as to why mind wandering could occur at a lower rate in this particular real-world setting. Future directions for mind wandering research could therefore focus on the various types of mind wandering that occur, what variations there are in those types depending on the setting, and what effect technology-related mind wandering specifically has on classroom performance.

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