Mind Wandering and Online Learning: How Working Memory, Interest, and Mind Wandering Impact Learning from Videos

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Abstract

This study investigated mind wandering during video lectures in an online course. Working memory capacity and interest were also considered. Higher mind wandering predicted lower performance. Lower working memory capacity predicted higher mind wandering. Higher interest predicted lesser mind wandering. Social media and technology accounted for 29% of off-task thinking.

Keywords: Mind-wandering; task unrelated thoughts; working memory

Introduction

Wandering minds often lead to performance and accuracy errors on the primary activity, especially if the activity was demanding and required concentration (e.g. McVay & Kane, 2009; McVay & Kane, 2012b; Unsworth & McMillian, 2012). Given the propensity for the mind to wander and related performance deficits, investigating individual differences in mind wandering and the impact on performance seemed particularly relevant in an educational setting.

As Unsworth, Brewer and Spillers (2012) and Lindquist and McLean (2011) provided evidence of mind wandering in the traditional classroom context. Technology use in the same setting can also contribute to distraction; interactions with Facebook, laptop-use and mobile devices during in-class lectures created deficits in academic performance (Fried, 2008; Junco, 2012; Wood et al., 2012).

Additionally, self-reported, heavy media multitaskers had difficulty filtering non-essential information and lower task-switching accuracy than non-multitasking counterparts;

Ophira, Nassb and Wagner (2009) proposed these multitaskers were also unaware of the determents of multitasking to attentional accuracy. Interactions with media and technology multitasking can distract and create deficits in performance; as such, the current study expanded the existing set of off-task thinking probes to include: *thinking about or using another technology. (ex) texting; checking Facebook*.

Given the research on mind wandering in a variety of contexts, steps to advance mind wandering research forward should be taken at the intersection of these findings: online education. This study evaluated individual differences in mind wandering while subjects watch video lectures in an online course and analyzed how these factors influenced academic performance.

Mind Wandering and Working Memory

The relationship between WMC and mind wandering has long been researched due to the principle that those with a higher WMC were less prone to distraction (mind wandering) during a demanding task. Working memory refers to attentional control used to maintain a goal and avoid distraction; greater WMC means greater attentional capacity used to avoid distraction and maintain a goal (Engle, 2002; McVay & Kane, 2010). Subjects who performed poorly on WMC tasks were unable to maintain task goals and therefor experienced more goal-neglect errors (McVay & Kane, 2010). WMC predicted performance on higher-order cognitive tasks, such as reading comprehension tasks and general fluid intelligence tests (Engle, 2002). Complex span tasks used to measure WMC were related to goal maintenance and competition resolution. These characteristics of assessment lend to evaluating individual differences in mind wandering, as both referred to mechanisms that keep access to a primary goal intact when faced with distracting or irrelevant information (McVay & Kane, 2010).

Mrazek et al. (2012) evaluated if WMC tests were confounded by mind wandering; that is, if mind wandering during WMC tests diminished results on those measures. They also evaluated mind-wandering correlations to WMC, general aptitude and SAT scores. In the first experiment, subjects were probed for on-task or off-task thoughts (ranging from 1 = completely on-task to 5 = completely on unrelated concerns) at unpredictable intervals while completing operation span (OSPAN), reading span (RSPAN) and spatial span (SSPAN) tasks, as measures of WMC.

Performance on individual tasks and across tasks was negatively related with the number of mind wandering instances, meaning subjects with lower WMC had greater instances of off-task thoughts. Results were replicated in a second study; additional measurements of anxiety and task-related interference were not related to WMC. In a third study, half of the participants were promised financial incentives to increase performance on the OPSAN task.

The same negative correlation between mind wandering and WMC was reported. However, those who received financial incentives were less likely to mind wander than those without incentives and thereby improve performance on the OSPAN task; in this regard, it seemed that mind wandering disrupted performance on WM memory tasks. In the final study, subjects received thought probes during a Raven's Progressive Matrices test and an OPSAN task; those results were related to the predictability of SAT scores to investigate the generality of TUTs disrupting performance. Mind wandering was negatively related to WMC and gF performance. Mind wandering during these lab studies was also predictive of SAT scores; nearly half of the shared variance among WMC, gF and SAT scores was accounted for by mind wandering.

Interest

Benefits of interest and learning have long been studied. Schiefle and Krapp (1996) noted that in 30 years of research, it is well documented that topic interest and learning from text were significantly related. In their study, subjects interested in the text experienced increases in free recall and also increases in elaborative propositions and main ideas, which indicates in increased depth of learning. An association between interest and online video may share a similar relationship to merit the investigation in the present study.

Unsworth and McMillan (2012) examined individual differences in mind wandering, WMC, interest, motivation, topic experience and their relationship with reading comprehension. Subjects completed OSPAN, RSPAN and SSPAN tasks, read the half of one textbook chapter and received six mind-wandering probes during the reading task. Subjects then completed a reading comprehension test. Following the comprehension test, subjects answered two questions on interest (*How interested were you in the topic of the text?* and *How interested are you in this topic in general?),* two questions on motivation (*How motivated were you to do well on the task?* and *How much did your overall motivation influence your performance on the test?*), and three questions on prior knowledge. Subjects with low WMC reported more mind wandering while reading than those with high WMC. Less interested and less motivated subjects mind wandered more than interested, motivated subjects. Motivation mediated the relationship between interest and mind wandering – individuals who were not interested were also not motivated and had higher rates of MW. WMC was unrelated to interest.

The Present Study

In this study, we investigated the relationship among mind wandering, working memory capacity and interest in online learning, and we examined how these factors influenced class performance. As reviewed, previous research indicated that during demanding tasks, mind wandering had a negative impact on performance. But the current study extended the scope of inquiry to evaluate mind wandering and interest in a fully online classroom, while also considering working memory capacity as a latent variable. If McVay and Kane (2010) are correct in stating that "whatever mechanisms are responsible for lapses of attention, then, they appear to be stable across people, tasks, contexts and time" (p. 326), then the same relationships presented in previous research should be consistent with the findings in the current study. Higher levels of mind wandering should predict lower levels of WMC and lower levels of academic performance. Unsworth and McMillan (2012) did not report a direct effect of interest on mind wandering, but the present study re-evaluated this relationship. Perhaps the varying context (watching a video in an online classroom vs. reading a text chapter in a lab setting) will influence the relationship between interest and mind wandering in a novel way.

Participants completed three complex span tasks, responded to mind-wandering probes while watching two online video lectures (introductions to advertising and public relations) and rated interest in the presented topics. Structural equation modeling was used to explore these relationships and their influence on academic performance. In addition, the current set of mind wandering probes was expanded to examine reports of distractions related to social media (e.g. Facebook) and technology (e.g. texting).

In the context of online learning, three novel research questions were evaluated in this study: (1) Does mind wandering mediate the relationship between WMC and academic performance? (2) Does interest influence mind wandering? and (3) Do interactions with social media and technology distract on-task thinking?

Methods

Participants

153 undergraduates at a large Midwestern state university received extra course credit to participate in the study. Four participants were missing data and eight participants experienced technical problems with a complex span task and submitted incomplete data; these incomplete sets were removed from the analysis.

After completing each span task, participants were asked if they wrote down any letters and how many letters they wrote down (to help complete the span task with greater accuracy). If a participant reported any letters or failed to answer the question, that span task was removed from the analysis. Maximum likelihood estimates of means and intercepts were used to complete missing span task data. Any subject missing more than one span task was eliminated from the study. The percent of total missing data was 4.76% in span task scores. In total, 126 subjects were included in the final analysis.

Materials and Procedure

Interest Participants were asked an adapted version of the interest measures presented in Unsworth and McMillan (2012). Participants responded 1 (*Not at all interested*) -5 (*Very interested*) to the following questions before and after video 1 and video 2:

Video 1: How interested are you in Public Relations?
Video 2: How interested are you in Advertising?

Complex Span Tasks Participants downloaded and completed three complex span (RSPAN, OSPAN and SSPAN) tasks modified from Bailey (2012). All WMC measures were collected via Mac and PC desktop applications authored in Revolution LiveCode. Data was stored in a MySQL database. WM span scores were calculated using partial-credit scoring (see Conway et al., 2005; Was, Rawson, Bailey and Dunlosky, 2011).

Mind Wandering: Video 1 and Video 2 Videos used in this study were actual course videos featured in a fully online course. Both videos were filmed in an HD studio with the same production setup. Video 1 was a 13:08 minute introduction to Public Relations. Video 2 was a 12:49 minute introduction to Advertising. Both videos featured the same lecturer delivering the lecture directly to the camera.

Videos were streamed online. After starting the videos, participants could not pause, restart or stop playback. Participants were informed that they would be asked questions throughout the video. They were encouraged to set aside 15 minutes and complete a video in one sitting. Participants were also informed that they would receive a quiz immediately after the video.

Mind-wandering probes were programmed to appear four times during playback. During a probe, the video stopped and a sound beeped to alert a prompt on the screen. After responding to the probe, the video automatically resumed playback. Interest was collected before and after each video. Following the last interest measure, participants answered a four-question quiz. After completing the quiz, participants were asked if they would like to rewatch the video or close the window and exit. See Table 1 for the video playback schedule.

Table 1: Mind Wandering Probe Schedule

		TUT1	TUT2	TUT3	TUT4				
Interest 1	Start Video	**3:15** MW Probe 1	**6:30** MW Probe 2	**9:45** MW Probe 3	**13:08** MNW Probe 4	End Video	Interest 2	Quiz1	Rewatch Prompt
		Pause	Pause	Pause	Pause				

Mind Wandering Probes While watching the video, participants received four mind wandering probes that asked them to classify thoughts from the last five seconds. Response 1 was evaluated as on-task.

In the last 5 seconds, what were you just thinking about?

1. *The video.*
2. *How well I'm understanding the video.*
3. *A memory from the past.*
4. *Something in the future.*
5. *Current state of being. (ex) I'm feeling hungry*
6. *Thinking about or using another technology. (ex) texting; checking Facebook.*
7. *Other.*

Academic Performance Academic performance was measured using two post-video quaizzes. Quiz1 and Quiz 2 scores represent percent accurate across a four-item, multiple-choice quiz given immediately after video 1 and video 2. Total Points indicate the total points earned in the course.

Results

Descriptive Statistics

Table 2 displays the descriptive statistics for the 12 observed variables. RSPAN displays the partial-credit score on the reading complex span task; OSPAN, the operation span task; and SSPAN, the spatial span task.

TUT1 and TUT2 represent mean scores from 0 – 1 based on self-reported responses to four mind wandering probes on video 1 and video 2 respectively. Using the same classifications as previous research (McVay & Kane, 2012a; Unsworth & McMillian, 2012), response 1 (*the video)* was coded as on-task; response 2 (*how well I'm understanding the video*) was coded as task-related interference (TRI); responses 3-7 (*off-task / task unrelated thoughts*) were coded as task-unrelated thoughts (TUTs). The higher a TUT1 or TUT2 score, the more a subject experienced task unrelated thoughts.

Interest1 and Interest2 represent the sum of interest measures before and after video 1 and video 2. Higher scores represent greater levels of interest.

Quiz1 and Quiz 2 scores represent percent accurate across a four-item, multiple-choice quiz given immediately after video 1 and video 2. Total_Points indicate the total points earned in the course.

TRI1 and TRI2 represent the sum of responses (*how well I'm understanding the video*) to the mind wandering probes across video1 and video2 respectively.

TUT and Interest Scores Across Measures

In terms of interest measured before and after watching videos 1 and 2, results of a paired-samples t-test indicated that there was no significant difference between

Table 2: Descriptive Statistics of 16 Observed Variables

Variable	M	SD	Range
RSPAN	.81	.16	.11 – 1
OSPAN	.77	.24	.03 – 1
SSPAN	.90	.14	.21 – 1
TUT1	.44	.27	0 – 1
TUT2	.42	.33	0 – 1
TRI1	.91	.97	0 – 4
TRI2	.70	.93	0 – 4
Interest1	6.62	1.75	2 – 10
Interest2	6.77	1.88	2 – 10
Quiz1	.74	.27	0 – 1
Quiz2	.78	.27	0 – 1
Total_Points	1257.9	285.51	78 – 1562

Interest1 before (M = 3.34, SD = .87) and after (M = 3.28, SD =1.00),

t(125) = 1.05, p = .30. In addition, there was no significant difference between Interest2 before (M = 3.42, SD = .96) and after (M = 3.35, SD = 1.08), t(125) = 1.00, p = .32.

A paired-samples t-test indicated that there was no significant difference between TUT1 (M = .44, SD = .27) and TUT2 (M = .42, SD = .33), t(125) = .99, p = .32. However, there was a significant difference between Task-Related Interference TRI1 (M = .91, SD = .97) and TRI2 (M = .70, SD = .93), t(125) = 2.37, p = .02.

Mind Wandering Frequencies

Subjects reported on-task thinking 36.9% of the time, task-related interference 20.1% of the time and experienced off-task thinking 43.0% of time. Technology-related thoughts represented the highest level of off-task thinking at 12.5%.

Structural Equation Modeling

The primary interest in the study was the relationship among WMC, mind wandering (TUTs) and academic performance. The hypothesized model shown in Figure 1 provided a good fit to the data, $\chi2$ (17, N = 126) = 22.38, p = .137; RMSEA = .055; CFI = .973. In the tested model, the estimated standardized direct effects of mind wandering (TUTs) on academic performance were β = -.43. The estimated standardized direct effects of WMC on academic performance were β = .41. The estimated standardized direct effects of WMC on mind wandering (TUTs) were β = -.27.

SEM: Topic Interest A second focus on this study examines influence of topic interest on mind wandering in the relationships among WMC, mind wandering (TUTs) and academic performance. The hypothesized model shown in Figure 2 provided a good fit to the data, $\chi2$ (31, N = 126) =

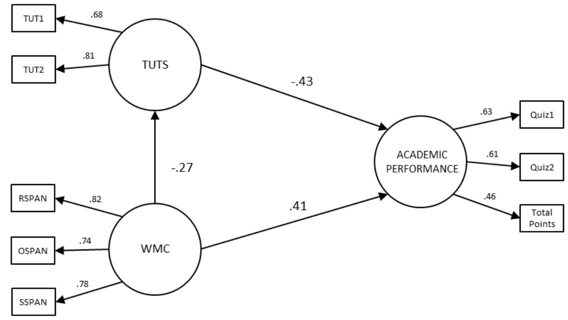

Figure 1. Structural equation model predicting academic performance with mind wandering and WMC.

48.41, p = .024; RMSEA = .067; CFI = .938. In the tested model, the estimated standardized direct effects of mind wandering (TUTs) on academic performance were β = -.45. The estimated standardized direct effects of WMC on academic performance were β = .40. And the estimated standardized direct effects of WMC on mind wandering (TUTs) were β = -.26. The estimated standardized direct effects of topic interest on mind wandering (TUTs) were β = -.66.

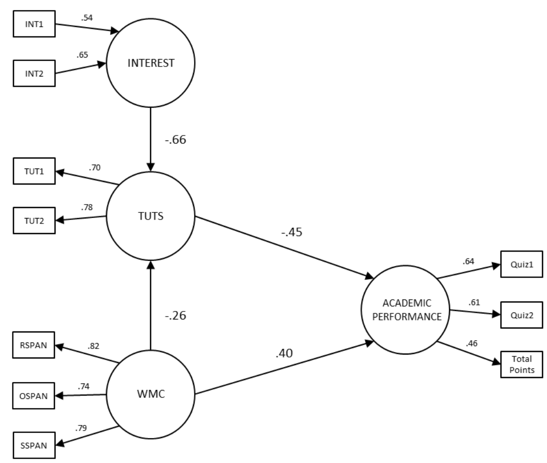

Figure 2. Structural equation model predicting academic performance with mind wandering and WMC with the effect of topic interest on mind wandering.

Discussion

The current study replicated existing research by predicting the deficits in performance related to higher mind-wandering rates and extended the literature to the context of online learning, topic interest (in digital media), achievement goal orientations, real-world academic performance and new considerations for task-related interference. At a baseline, the current findings were in line with previous findings in which WMC modestly predicted mind wandering with correlations around -.20 or about 5%

of the unique variance in self-reported TUTs (Kane & McVay, 2012); in the present study, the estimated standardized effects of WMC on mind wandering ranged from β = -.26 to β = -.29 across models. Overall, higher rates of mind wandering were related to lower academic performance, lower WMC, lower topic interest and lower mastery approach goal orientations.

In terms of consistency across measures, there was no significant difference between topic interest before and after each video, and there was no significant difference in self-reported TUT rates across videos. No significant difference in TUT rates was consistent with previous findings and supported the claim that "whatever mechanisms are responsible for lapses of attention, then, they appear to be stable across people, tasks, contexts and time" (McVay & Kane, 2010, p. 326).

Subjects reported on-task thinking 36.9% of the time, task-related interference 20.1% of the time and experienced off-task thinking 43% of time, which was consistent with reported findings that individuals mind wander 30-50% of the time in daily life (Killingsworth & Gilbert, 2010; McVay & Kane, 2012b; Levinson, Smallwood, & Davidson, 2012). Subjects categorized probed responses in the provided categories 91.9% of the time, only responding *other* in 8.1% of all responses. The information in probed self-reports may also be advantageous over a scaled response in terms of identifying the cause of distraction; for example, this study introduced a new off-task probe, *thinking about or using another technology.* These technology-related thoughts represented the highest level of off-task thinking; 29.1% of off-task thoughts were *thinking about or using another technology*, which represented 12.5% of all responses. As a result, including this probe should be considered in future mind-wandering research and inform treatments designed to reduce mind-wandering behaviors.

The structural equation model of most critical focus and importance, illustrated in Figure 1, replicated previous research with nearly equal estimated standardized effects of WMC on mind wandering and estimated standardized effects of WMC on performance (Kane & McVay, 2012; McVay & Kane, 2012a; McVay & Kane, 2012b; Unsworth & McMillan, 2012). In this case, the literature can be extended from mind-wandering during reading and reading comprehension to include mind wandering during online learning and academic performance. Higher levels of mind wandering created deficits (lower levels) of academic performance. And higher levels of WMC predicted lower levels of mind wandering. The amount of mind wandering variance accounted in the two models was 35% and 46% respectively. A similar percentage of performance explained was presented in previous findings; other factors, such as mood, stress, mindfulness and topic experience may also influence mind wandering and performance (Kane et al., 2007; Smallwood, Fitzgerald, Miles & Phillips, 2009; Mrazek, Smallwood & Schooler, 2012; Kane & McVay, 2012; Unsworth & McMillan, 2012).

Topic interest in the present study extended the existing literature beyond text reading to new findings in digital media. Unsworth and McMillan (2012) proposed that topic interest did not directly predict mind wandering; however, interest predicted mind wandering. Lindquist and McLean (2011) presented only a marginal (r = -.14, p < .01) negative correlation between course interest and mind-wandering rates during a 40-minute, traditional lecture. However, in the present study, the estimated standardized total effects of interest on TUTs were (β = -.66) or 44% of the variance in mind wandering. Higher interest in the video topics was significantly related to lower rates in mind wandering. Interest in the topics presented in the videos was measured before and after two video trials; whereas, interest in the Unsworth and McMillan (2012) study was only measured after reading with considerations for the topic of the text and the topic in general. Perhaps the difference in findings is related to the method of measuring topic interest or expectations in interest are different for digital media, compared to reading or traditional lectures.

Conclusion

As reported in previous findings, increased mind wandering was associated with lower WMC and deficits in performance. The current study extended the existing literature from reading comprehension to real-world online learning and academic performance. Measurements of topic interest in digital media and achievement goal orientations may also be evaluated in future research.

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