How Reading Difficulty Influences Mind-Wandering:

The Theoretical Importance of Measuring Interest

by

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Author's Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

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Abstract

In many situations, increasing task difficulty decreases thoughts that are unrelated to the task (i.e., mind-wandering; see Smallwood & Schooler, 2006, for a review). However, Feng, D'Mello, and Graesser (2013) recently reported a discrepant finding in the context of reading. They showed that increasing the objective reading difficulty of passages (by decreasing word frequency and complicating sentence structure) actually *increased* mind-wandering. The primary goal of this work was to gain insight into the mechanism that drives this positive relation between objective reading difficulty and mind-wandering. This effect is investigated over three chapters. Chapter 1 demonstrates that the effect of objective difficulty on mind-wandering is confounded by differences in passage section-length between easy and hard passages when they are presented one sentence at a time. Chapter 2 more broadly explores the possibility that distinctive processing influences subjective impressions of passage difficulty and interest (which may consequently influence mind-wandering). And Chapter 3 shows that mind-wandering increases over time spent reading, which may be related to decreasing subjective interest. This research builds to the conclusion that subjective interest is of central theoretical importance to research on difficulty and mind-wandering: A manipulation designed to influence the difficulty of a task may also influence participants' subjective interest in the task, which may in turn influence their tendency to mind-wander.

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Chapter 1

Does objective difficulty affect mind-wandering?

Students are all too familiar with the realization that their thoughts have come untethered from their coursework and drifted elsewhere. Such instances of mind-wandering have been found to impair reading comprehension (Franklin, Smallwood, & Schooler, 2011; Feng, D'Mello, & Graesser, 2013; Reichle, Reineberg, & Schooler, 2010; Schooler, Reichle, & Halpern, 2004; Smallwood, Fishman, & Schooler, 2007; Smallwood, McSpadden, & Schooler, 2008; Unsworth & McMillan, 2013). Given that reading comprehension is integral to learning throughout one's education, it is important for research to elucidate factors that influence mind-wandering while reading. This present work focused on two such factors: difficulty and interest.

Reading comprehension is but one of many domains in which mind-wandering is costly (see Mooneyham & Schooler, 2013, for a review). In the laboratory, mind-wandering impairs attention (e.g., Manly, Robertson, Galloway, & Hawkins, 1999; McVay & Kane, 2009; McVay & Kane, 2012a; Seli, Cheyne, & Smilek, 2013; Smallwood, Beach, Schooler, & Handy, 2008; Robertson, Manly, Andrade, Baddeley, & Yiend, 1997), oddball detection (Barron, Riby, Greer, & Smallwood, 2011), visual search (Thomson, Seli, Besner, Smilek, 2014), and random number generation (Teasdale et al., 1995). Mind-wandering also impairs lecture comprehension (e.g., Risko, Anderson, Sarwal, Engelhardt, & Kingstone, 2012) and test performance (e.g., Lindquist & McLean, 2011; Mrazek et al., 2012; Unsworth, McMillan, Brewer, & Spillers, 2012; Wammes, Seli, Cheyne, Boucher, & Smilek, 2016).

Smallwood and Schooler (2006) posited that mind-wandering impairs performance on tasks requiring executive/working memory resources because both draw from the same pool of resources. This *executive-resource hypothesis* is supported by fMRI research showing that mind-wandering is associated with activity in the brain's executive network (Christoff, Gordon, Smallwood, Smith, & Schooler, 2009). Converging evidence comes from a long line of experiments showing that mind-wandering rates decrease as task demands increase (Antrobus, Singer, & Greenberg, 1966; Giambra, 1995; Mason et al., 2007; Smallwood, Nind, & O'Connor, 2009; Smallwood, Obonsawin, & Reid, 2003; Sousa, Carriere, & Smilek, 2013; Stuyven & Van der Goten, 1995; Teasdale, Proctor, Lloyd, & Baddeley, 1993; Teasdale et al., 1995; Thomson, Besner, & Smilek, 2013).

In the same vein, increased presentation rates—which increase processing demands—are associated with reduced mind-wandering during various cognitive tasks (Antrobus, 1968; Giambra, 1995; Jackson & Balota, 2012; Teasdale et al., 1993). And increased practice/time on task—which decrease processing demands via automaticity (Smallwood et al., 2003)—leads to increased mind-wandering during several vigilance (Antrobus, Coleman, & Singer, 1967; Cunningham, Scerbo, & Freeman, 2000; McVay & Kane, 2012a), sustained attention (Smallwood et al., 2004), perceptual motor (Teasdale et al., 1995), and memory (Mason et al, 2007; Smallwood et al., 2003; Teasdale et al., 1995) tasks.

These converging results supporting the executive resource hypothesis suggest that there is a straightforward relation between task difficulty and mind-wandering: As task difficulty increases, mind-wandering ought to decrease because the task requires more resources. Indeed, researchers who have manipulated task difficulty (while controlling relevant factors such as presentation rate) have typically found support for this assumption (see Filler & Giambra, 1973; Forster & Lavie, 2009; Grodsky & Giambra, 1990; McKiernan, D'Angelo, & Kaufman, 2006; McVay, Kane, & Kwapil, 2009). For example, Forster and Lavie (2009) found that individuals mind-wandered less frequently during a hard vs. easy letter detection task.

Based on this prior research, one would expect a comparable pattern of results in the context of reading—that individuals should mind-wander less frequently as passage difficulty increases due to higher processing demands. Strikingly, however, prior research has revealed either no effect of reading difficulty on mind-wandering (e.g., Giambra & Grodsky, 1989; Grodsky & Giambra, 1990; Fulmer, D'Mello, Strain, & Graesser, 2015), or a significant effect in the opposite direction (Feng et al., 2013; Mlls et al., 2013; Mills, D'Mello, & Kopp, 2015). For example, Feng et al. (2013) found higher levels of self-reported mind-wandering for objectively hard passages than for objectively easy passages. I will first summarize Feng et al.'s methodology and the explanation that they gave for this intriguing result. I will then propose an alternate explanation that will be investigated in this chapter.

For their objectively hard passages, Feng et al. (2013) used eight passages from the Nelson Denny Reading Comprehension test, version E (Brown, Bennett, & Hanna, 1981) that were, on average, approximately 250 words long. They designed easy versions of these passages by "simplifying the syntactic structures of sentences and substituting low-frequency words with high-frequency ones" (p. 588). In terms of the Flesch-Kincaid scale (FK; Klare, 1974)—a reading grade metric that takes into account the average number of words per sentence and the average number of syllables per word—Feng et al. noted that the hard versions of their passages had a higher average FK grade level (10.9) than the easy versions (8.9). Their participants read four objectively easy passages and four objectively hard passages (in alternating order) that were each presented one sentence at a time. Participants advanced one sentence at a time using the spacebar. Each passage had 2-7 "thought probes". Probes appeared after sentences that pertained to multiple-choice comprehension questions, which followed each passage. These thought probes asked participants to indicate whether they were mind-wandering while reading the previous sentence.

Feng et al. (2013) framed their main result—that participants mind-wandered more while reading objectively hard vs. easy passages—in terms of Smallwood, et al.'s (2007) *cascade model of inattention*, which posits that one's failure to construct a situation model (i.e., an internal representation, or narrative, of the text; Zwaan, Langston, & Graesser, 1995) may lead to increased mind-wandering and task disengagement. Feng et al. argued that the higher mind-wandering rates for objectively hard passages suggest that participants may have struggled to construct situation models for those passages relative to objectively easy passages. Moreover, Feng et al. found that participants had marginally significantly lower comprehension scores for the objectively hard passages, which they also argued was consistent with their interpretation that participants were less successful at constructing a situation model for objectively hard vs. easy passages.

Before considering Feng et al.'s (2013) account further, it is important to note that a positive association between difficulty and mind-wandering has typically not been found in experiments in which passages were presented in full pages (e.g., Giambra & Grodsky, 1989; Grodsky & Giambra, 1990; Fulmer et al., 2015). In contrast, the robust result obtained by Feng et al. (2013; Mills et al., 2013) were observed when passages were presented one sentence at a time. These contrasting results suggest that presenting passages one sentence at a time may somehow bolster the effect of objective difficulty on mind-wandering. That is, there may be a particular aspect of sentence presentation that enhances this effect relative to page presentation. One possibility is that, because passages with higher FK grade levels tend to have longer sentences than passages with lower FK grade levels, when passages are presented one sentence at a time, those with higher FK grade levels are presented in longer sections of text than those with lower FK grade levels.[1] Conversely, when passages are presented one page at a time, each section is approximately the same length regardless of objective difficulty.

In this chapter, I examined two possible explanations for why longer sections of text may increase mind-wandering rates relative to shorter sections in the sentence presentation mode. First, longer sections may be more difficult to study because they place greater demands on working memory when passages are presented one sentence at a time (re-reading previous sentences is not permitted in the sentence presentation paradigm). Returning to Feng et al.'s (2013) "situation model" account, perhaps the inability to re-read in the sentence presentation mode may result in participants being less successful in constructing a situation model for objectively hard vs. easy passages. Conversely, for page presentation, the ability to re-read could help participants build a situation model, particularly when reading objectively hard passages, which may narrow the gap in mind-wandering between objectively hard and easy passages. The possible influence of re-reading will be considered in the General Discussion of this chapter.

A second possibility is that longer sections may be perceived as less *interesting*, which could decrease task engagement. Prior research has typically observed an inverse relation between text interest and mind-wandering (Dixon & Bortolussi, 2013; Giambra & Grodsky, 1989; Krawietz, Tamplin, & Radvansky, 2012; Smallwood et al., 2009; Unsworth & McMillan, 2013; though see Fulmer et al., 2015; Grodsky & Giambra, 1990 for nonsignificant effects). When passages are presented one sentence at a time, the objectively hard passages may be perceived as less interesting than the objectively easy passages due to their longer sections of

[1] Using a paired-sample *t*-test, I examined the average number of words per sentence/screen in Feng et al.'s (2013) materials. As expected, their FK hard passages had significantly more words per sentence/screen (M = 19.45, SD = 3.51) than did their FK easy passages (M = 14.61, SD = 1.94), $t(7) = -4.59$, $p = 0.002$.

text, leading to more mind-wandering for the objectively hard passages. Conversely, when passages are presented across equally long sections (e.g., pages), objectively easy and objectively hard passages may be perceived as comparably interesting, which may also equate mind-wandering rates.

In sum, I hypothesized that the effect of objective difficulty on mind-wandering (Feng et al., 2013; Mills et al., 2013) is confounded by objectively hard passages having longer sections of text than objectively easy passages when passages are presented one sentence at a time. The first goal of this research was to test for this possible confound. Experiment 1 replicated the effect of objective reading difficulty on mind-wandering using the sentence presentation mode. Experiments 2-4 teased apart the effects of objective difficulty and section length on mind-wandering by equating the length of sections in which easy and hard passages were presented (e.g., full pages). As anticipated, equating passage section length significantly attenuated the effect of objective difficulty on mind-wandering. Last, Experiments 5 and 6 demonstrated a robust effect of section length while controlling for objective difficulty. Thus, to foreshadow, the results were consistent with the hypothesis that the effect of objective difficulty on mind-wandering is, to a large extent, a function of passage section length.

The second goal of this research was to explore the extent to which this apparent effect of section length on mind-wandering was related to participants' impressions of the subjective difficulty and subjective interestingness of passages with longer vs. shorter sections. In each experiment, participants provided subjective ratings of passage difficulty and interestingness. First, I predicted that objectively hard passages would be perceived as both more difficult and less interesting than objectively easy passages in the sentence presentation mode. Second, I expected that equating section length between objectively easy and hard passages would reduce or eliminate these differences in subjective difficulty and interest, which would constitute further evidence that the section length differences underlie the effect of objective difficulty on mind-wandering. And third, I anticipated that both factors—increased difficulty and decreased interest—would be associated with increased mind-wandering. Expressed in terms of Smallwood et al.'s (2007) cascade model, individuals may not only struggle to construct situation models for passages that they perceive as difficult (Feng et al., 2013), but they may also be unmotivated to construct situation models for passages that they perceive as uninteresting.

Experiment 1

In Experiment 1, I examined the effect of objective difficulty on mind-wandering by adopting the sentence-by-sentence presentation mode used in prior research (Feng et al., 2013; Mills et al., 2013). As in Feng et al. (2013), I used a Flesch-Kincaid readability manipulation. Participants read four objectively easy (FK grade 9) and four objectively hard (FK grade 17) passages, each of which contained four randomly "thought probes", which assessed mind-wandering. Though probes (see, e.g., Antrobus, 1968; Giambra, 1995; Schooler et al., 2004) determine the frequency of mind-wandering by periodically interrupting a task and asking participants to report their thoughts. Following each passage, participants answered four multiple-choice comprehension questions and gave subjective ratings of passage difficulty and interestingness.

I had four main predictions. First, participants would mind-wander more frequently while reading objectively hard vs. easy passages (replicating Feng et al., 2013). Second, they would have worse reading comprehension for objectively hard vs. easy passages (a result that was marginally significant in Feng et al.). Third, objectively hard passages would be rated as more difficult and less interesting that objectively easy passages. And fourth, differences in mind-wandering rates across easy and hard passages would be related to differences in subjective difficulty ratings across easy and hard passages and to differences in subjective interest ratings across easy and hard passages.

Method

Participants

To determine our sample size, we conducted a priori power analysis using the statistical software G*Power (Erdfelder, Faul, & Buchner, 1996), which revealed that 147 participants were needed to have high statistical power (0.95) to reliably find a small effect (Cohen's *d* =

0.3). We therefore ran a robust sample in this experiment: One hundred and fifty-five students from the University of Waterloo participated and were compensated with course credit.

Reading Materials

To enhance the generalizability of the results, twelve passages were derived from Wikipedia (http://en.wikipedia.org) articles on a wide variety of topics: the galaxy, Pompeii, Sartre, Rachmaninoff, geology, Formula 1 sponsorships, the battle of Trafalgar, prions, string theory, polysaccharides, securitization, and electromagnetic radiation. I anticipated that these topics would yield a broad range of subjective difficulty and interest ratings.

The easy and hard versions of each passage were designed by modifying: a) the number of words/sentence, and b) the number of syllables/word, by using synonyms with fewer/more syllables. (For an example, see Appendix A for the easy and hard versions of the galaxy passage.) Table 1 shows the text difficulty manipulation and estimated grade levels for the easy and hard passage versions. Confirming the effectiveness of the reading difficulty manipulation, the estimated grade level of the hard versions was significantly higher than the estimated grade level of the easy versions (ps < 0.001) according to three metrics: Flesch-Kincaid (Klare, 1974), Automated Readability Index (Kincaid, Fishburne Jr., Rogers, & Chissom, 1975), and Pearson Reading Maturity (Nelson, Perfetti, Liben, & Liben, 2012).[2] Importantly, the content of the two versions was closely matched, as was word count (easy versions: M = 514.92, SD = 8.95; hard versions: M = 514.83, SD = 7.93).

[2] FK grade level is derived from two factors: the number of words per sentence and the number of syllables per word. The Automated Readability Index is also calculated from surface level features. The Pearson Reading Maturity Metric incorporates both surface features and deep features such as word meaning and frequency.

Table 1. *Passage attributes of the objectively easy and hard versions of the 12 passages. Means shown (with SDs). All t-statistics are based on paired-sample t-tests with 11 degrees of freedom. Word count and content was controlled across the easy and hard passage versions.*

	Easy passages	Hard passages	*t*	*p*	Cohen's *d*
Difficulty manipulation					
Words/sentence	12.52 (1.35)	30.37 (2.10)	63.75	< 0.001	10.13
Characters/word	5.00 (.15)	5.19 (.17)	7. 37	< 0.001	1.21
Number of sentences	41.42 (4.52)	17.00 (1.04)	23.30	< 0.001	7.44
Estimated grade levels					
Flesch-Kincaid grade	9.00 (.21)	17.03 (.19)	127.18	< 0.001	40.93
Automated Readability	10.93 (.94)	13.54 (.93)	17.33	< 0.001	2.78
Pearson Reading Maturity	11.28 (.71)	13.65 (.40)	13.42	< 0.001	4.12

Procedure

Participants were tested in groups of up to 6. Each participant was seated in front of a 15'' or 17'' monitor. A research assistant instructed participants to turn off their phones and not to communicate with each other during the experiment. The research assistant then left the room for the duration of the experiment so that participants would not feel pressured to avoid mind-wandering during the task.

The experiment was programmed in Eprime 2.0. All text was in black, 18-pt. Arial font on a white background. An instruction screen informed participants that they would be presented several passages, occasionally report thoughts while reading, and answer comprehension questions following each passage. Eight passages were randomly selected from the pool of 12 (four easy versions and four hard versions). Either the even-numbered passages were easy and the odd-numbered passages were hard, or vice-versa.[3] Passage order did not impact the statistical significance of any results.

Passages were presented one sentence at a time. Participants pressed the spacebar to advance sentences, and could not go back to previous sentences. Thought probes (four per passage) appeared immediately after sentences that pertained to comprehension questions that followed each passage (see below). The only criterion for probe placement was that two thought probes appeared in the first half of sentences in each passage, and two probes appeared in the second half. In this manner, thought probes were spread out in each passage, but did not have a predictable pattern. The probe asked participants whether they were "a) thinking about the passage (i.e., focused on reading)," or "b) thinking about something else." Due to a programming error, thought probes occasionally did not appear. On average, participants received 15.18 thought probes across the four easy passages and 15.67 thought probes across the four hard passages.[4]

After reading each passage, participants gave subjective ratings using 11-point Likert scales. Regarding passage difficulty, they were asked "How *difficult* was the *topic* of the

[3] Passage conditions were block-counterbalanced in all subsequent experiments.
[4] Twenty-six participants had 14 easy and 16 hard thought probes, nineteen participants had 15 easy and 15 hard thought probes, fifty-six participants had 15 easy and 16 hard thought probes, thirty-two participants had 16 easy and 15 hard thought probes, and twenty-two participants had 16 easy and 16 hard thought probes. In total, then, forty-one participants had an equal number of thought probes for easy and hard passages (i.e., either 15-15 or 16-16).

passage you just read?" and "How *difficult* was the *writing style* of the passage you just read?" (0 = not at all difficult; 10 = extremely difficult). Regarding passage interest, they were asked: "How *interesting* was the *topic* of the passage you just read?" and "How *interesting* was the *writing style* of the passage you just read?" (0 = not at all interesting; 10 = extremely interesting). Question order was random.

Following the subjective ratings, participants were given four multiple-choice comprehension questions (see the SM), and were instructed to type in the letter (a, b, c, or d) corresponding to the "most correct" answer. Questions were identical in the two passage difficulty versions. After answering the comprehension questions, the next passage appeared. The experiment ended after participants had read all eight passages or one hour had elapsed.[5] Appendix B presents passage reading times.

Results

First, I analyzed group differences in mean mind-wandering rates, comprehension scores, and subjective ratings (difficulty and interest) between objectively easy and hard passages. I then ran regression analyses to explore whether differences in subjective ratings between objectively easy and hard passages were predictive of differences in mind-wandering rates between these two conditions, at the level of the individual.

Mind-wandering

Table 2 shows average MW rates for the objectively easy and hard passages. MW rates were significantly higher for hard passages, $t(154) = 5.54$, $p < 0.001$, $d = 0.42$. The 41 participants who received an equal number of thought probes (see Footnote 4) also had significantly higher mind-wandering rates for hard passages ($M = 0.44$, $SE = 0.04$) than for easy

[5] In each experiment, at least 98% of participants finished all of the passages. Participants who read at least 6 passages were included in the analyses. Excluded participants are noted in each Results section.

passages (*M* = 0.33, *SE* = 0.03), $t(40) = 3.46$, $p = .001$, $d = 0.35$. Thus, it would appear that the disparity in thought probes did not meaningfully influence MW rates (as is confirmed in subsequent experiments, which fixed this issue).

Table 2. *Mean mind-wandering rates (with SEs) for objectively easy and objectively hard passages in Experiments 1-4.*

Experiment	Easy passages	Hard passages
Exp. 1 (sentences)	.325 (.018)	.426 (.021)
Exp. 2 (pages)	.294 (.018)	.294 (.019)
Exp. 3 (sentences)	.280 (.021)	.401 (.025)
Exp. 3 (pages)	.277 (.024)	.283 (.024)
Exp. 4 (section length equal)	.350 (.027)	.376 (.026)

Reading comprehension

Two comprehension questions were invalid (they did not have a correct answer). When computing participants' mean comprehension scores, responses to the two invalid questions were excluded. Participants' mean comprehension scores are displayed in Table 3. Reading comprehension was significantly better for easy passages than for hard passages, $t(154) = 2.42$, $p = 0.02$, $d = 0.23$, though the effect size was small.

Table 3. *Mean proportion of comprehension questions answered correctly (with SEs) for objectively easy and objectively hard passages in Experiments 1-4.*

Experiment	Easy passages	Hard passages
Exp. 1 (sentences)	.531 (.013)	.492 (.014)
Exp. 2 (pages)	.487 (.011)	.495 (.011)
Exp. 3 (sentences)	.551 (.017)	.505 (.018)
Exp. 3 (pages)	.498 (.017)	.525 (.017)
Exp. 4 (section length equal)	.509 (.016)	.512 (.015)

Subjective ratings

Participants' mean subjective ratings are shown in Table 4. As hypothesized, they rated the writing style of the (objectively) hard passages as significantly more difficult than the writing style of the (objectively) easy passages, $t(154) = 6.67$, $p < 0.001$, $d = 0.52$. Somewhat unexpectedly, they also rated the topics of the hard passages as significantly more difficult than those of the easy passages, $t(154) = 3.19$, $p = 0.002$, $d = 0.26$, even though content was identical across passage difficulty levels. In terms of the interest measures, participants rated hard passages as having significantly less interesting writing than easy passages, $t(154) = 2.57$, $p = 0.01$, $d = 0.23$, and significantly less interesting topics, $t(154) = 3.98$, $p < 0.001$, $d = 0.37$.

Table 4. *Mean subjective ratings (with SEs) of objectively easy and objectively hard passages in Experiment 1 and 2.*

Experiment	Easy passages	Hard passages
Experiment 1 (sentences)		
Writing difficulty	3.25 (.14)	4.16 (.14)
Topic difficulty	4.17 (.14)	4.63 (.14)
Writing interest	4.01 (.14)	3.61 (.14)
Topic interest	4.52 (.15)	3.82 (.15)
Experiment 2 (pages)		
Writing difficulty	4.19 (.13)	4.42 (.13)
Topic difficulty	4.81 (.13)	4.84 (.13)
Writing interest	3.65 (.12)	3.74 (.12)
Topic interest	4.01 (.12)	4.25 (.13)

Associations between subjective rating difference scores and MW difference scores

Here I explored the extent to which the difference in MW rates between objectively hard versus easy passages were related to differences in subjective difficulty ratings and differences in subjective interest ratings. First, I examined the correlations between the mean difference scores (mean hard passages – mean easy passages) for each of these factors. Notably, there were strong correlations between the mean difference scores of the difficulty measures (writing and topic), $r(154) = .66$, $p < 0.001$, and the two interest measures (writing and topic), $r(154) = .79$, $p < 0.001$. Composite subjective difficulty scores were computed by averaging each participant's two difficulty ratings (writing and topic) for each passage, and composite subjective interest scores were computed in the same manner. Then, mean difference scores were computed for the composite subjective difficulty ratings and the composite subjective interest ratings, which were used in the analyses below.[6]

Table 5 shows the Pearson correlation coefficients between the mean difference scores (between the hard and easy passages) for subjective difficulty, subjective interest, mind-wandering, and comprehension. Mean difference scores for mind-wandering were significantly associated with mean difference scores both for subjective difficulty and for subjective interest. There also was a strong negative correlation between the mean difference scores for subjective difficulty and subjective interest, suggesting that more difficult passages tended to be perceived as less interesting.

[6] Composite subjective difficulty and subjective interest scores were used to avoid multicollinearity issues that would arise if mean difference scores of the two difficulty ratings and the two interest ratings were included in the regression analysis to predict mean MW difference scores.

Table 5. *Correlation coefficients between the averaged difference scores (hard passage average - easy passage average) for the composite subjective measures (difficulty, interest), mind-wandering, and reading comprehension in Experiment 1.*

	Difficulty	Interest	Mind-wandering	Comprehension
Difficulty	-			
Interest	-.467**	-		
Mind-wandering	.427**	-.516**	-	
Comprehension	-.182*	.317**	-.303**	-

* $p < 0.05$, ** $p < 0.001$

Next, I conducted a multiple linear regression to determine whether subjective difficulty mean difference scores and subjective interest mean difference scores were significant predictors of MW mean difference scores. As anticipated, the regression model explained a significant proportion of the variance in the MW mean difference scores, $R^2 = 0.31$, $F(2, 152) = 34.20$, $p < 0.001$. The intercept was significant, $b = 0.05$, $t(154) = 3.11$, $p = 0.002$. Subjective difficulty mean difference scores and subjective interest mean difference scores both were significant predictors of MW mean difference scores [$b = 0.03$, $t(154) = 3.12$, $p = 0.002$, and $b = -0.05$, $t(154) = -5.32$, $p < 0.001$, respectively].

These results suggest that participants mind-wandered more while reading objectively hard passages when they were perceived as more difficult *and* when they were perceived as less interesting. The larger beta weight for subjective interest mean difference scores is also suggestive that subjective interest may have been more strongly related to mind-wandering than was subjective difficulty. Note that this larger beta weight for subjective interest mean difference scores did not arise due the range of subjective difficulty mean difference scores being narrower than those of the subjective interest mean difference scores (i.e., a "restricted ranged" issue). The range of subjective difficulty mean difference scores (10.13) was comparable in size to the range of subjective interest mean difference scores (11.25).

Although these data are consistent with the possibility that perceptions of high difficulty and low interest lead to increased mind-wandering, another plausible explanation is that participants' perceptions of difficulty and interest were influenced by the extent to which they mind-wandered while reading each passage. That is, participants may have rated objectively hard passages as more difficult and less interesting than objectively easy passages because they recalled mind-wandering more while reading the objectively hard passages. In short, it is not possible to determine from the present correlational data whether perceptions of difficulty/interest influenced mind-wandering or vice-versa. (Indeed, this same caveat applies to all subsequent experiments in this work.) This issue is raised again in the General Discussion.

Discussion

Participants mind-wandered more frequently while reading objectively hard passages than objectively easy passages, replicating prior results (Feng et al., 2013; Mills et al., 2013). Participants also had worse reading comprehension for the hard passages, and rated them as being more difficult and less interesting. Regression analyses of the differences scores indicated that differences in both subjective difficulty and subjective interest between hard and easy passages were predictive of differences in mind-wandering. Thus, it would appear that the effect of objective difficulty on mind-wandering arises not only when hard passages are experienced as more difficult than easy passages, but also when they are experienced as less interesting.

However, as noted in the Introduction, the effect of objective difficulty on mind-wandering may be confounded by the fact that, in the sentence presentation mode, hard passages had more words per screen than easy passages (see Table 1). That is, it may be that section length—rather than objective difficulty—influences mind-wandering. If this were the case, then presenting easy and hard passages in roughly equally long sections of text ought to reduce or eliminate the effect of objective difficulty on mind-wandering (as well as the concomitant effects on comprehension, subjective difficulty, and subjective interest). This possibility was investigated in Experiment 2.

Experiment 2

Experiment 2 was a conceptual replication of Experiment 1, in which passages were presented one page at a time (across two pages) rather than one sentence at a time. Presenting passages one page at a time equated the number of words that appeared per screen in the easy (M = 256.96, SD = 11.18) and hard (M = 256.92, SD = 17.01) passage versions, $t(23) = 0.02$, p = 0.99. If differences in objective difficulty drove the effects on mind-wandering, reading comprehension, and subjective ratings obtained in Experiment 1, then the page presentation mode ought to yield an identical pattern of results. If, however, differences in passage *section length* underlay the effects in Experiment 1, then these effects ought to be eliminated in Experiment 2.

As in Experiment 1, I also examined here whether, at the level of the individual, differences in mind-wandering across easy and hard passages were related to differences in subjective difficulty ratings and to differences in subjective interest ratings across easy and hard passages. Although I predicted that objective difficulty would not influence mind-wandering at the group level, I still anticipated differences at the individual level based on the following logic. Consider that each participant was randomly assigned four objectively easy passages and four objectively hard passages. Any given participant may experience the objectively hard passages as more difficult/less interesting than the objectively easy passages, or vice-versa. Individuals who experienced the hard passages as more difficult/less interesting than the easy passages would be expected to mind-wander more frequently while reading hard passages, whereas individuals who perceived the easy passages as more difficult/less interesting than the hard passages would be expected to mind-wander more often while reading easy passages.

Method

Participants

One hundred and sixty-four students from the University of Waterloo participated in exchange for course credit.

Reading Materials

The same set of twelve passages and comprehension questions as in Experiment 1 were used here (including the same two erroneous comprehension questions).

Procedure

The procedure was largely identical to Experiment 1. Participants read eight randomly selected passages (four objectively easy and four objectively hard), and the same subjective measures and comprehension questions followed each passage. Each passage had two pages, with two paragraphs per page. Unlike Experiment 1, probe timing was random. A probe appeared 10-30 s following the onset of each page. Immediately following their response, participants were returned to the same page. A prompt appeared in brackets above the text instructing them to continue reading from where they left off. Participants pressed the spacebar to advance to the second page/end of the passage. They could not advance until they responded to the thought probe.[7]

[7] Given that each page was at least 230 words long, participants would have to have read at least 460 words per minute (wmp) to have outpaced the thought probe, which always appeared within 30 s. Previous research (Codding, Kleinmann, & Tucker, 2003) testing students' reading comprehension reported an average rate of reading of 230.83 wpm (*SD* = 55.84 wpm). Assuming that participants in the present experiment read at similar rates as those in Codding et al., instances in which our participants finished reading a page before the thought probe appeared ought to have been quite rare.

Results

One participant was excluded for reading fewer than 6 passages, leaving 163 participants whose data were analyzed. Including this participant did not impact the statistical significance of any results.

Mind-wandering rates

Table 2 shows participants' mean self-reported MW rates. MW rates for hard passages did not differ significantly from MW rates for easy passages, $t(162) = 0.10$, $p = 0.92$.

Reading comprehension

As with Experiment 1, participants' responses to the two invalid comprehension questions were excluded. Mean proportions of correct responses are shown in Table 3. They did not differ significantly across easy and hard passages, $t(162) = 0.60$, $p = 0.55$. Reading comprehension in both conditions was significantly greater than chance (ps < 0.001).

Subjective ratings

Table 4 displays participants' mean subjective ratings. Participants rated the writing style of objectively hard passages as marginally more difficult than that of easy passages, $t(162) = 1.94$, $p = 0.054$, $d = 0.14$. Ratings of topic difficulty, topic interestingness, and writing interestingness did not differ significantly between objectively hard and easy passages (all ps > 0.10). These results support the hypothesis that, in the sentence presentation mode used in Experiment 1, objectively hard passages were perceived as more difficult and less interesting than easy passages because they were presented in longer sections of text. Using page presentation to control for passage section length mitigated these effects considerably.

Associations between subjective rating difference scores and MW difference scores

Composite ratings were calculated for subjective difficulty and subjective interest, as described in Experiment 1. Table 6 shows the correlation coefficients between the mean difference scores (hard passage mean – easy passage mean) for subjective difficulty, subjective interest, mind-wandering, and comprehension scores. As in Experiment 1, mean differences in mind-wandering between hard and easy passages were significantly associated with mean differences in both subjective difficulty and subjective interest, which were themselves significantly correlated.

Table 6. *Correlation coefficients between the averaged difference scores (hard passage average - easy passage average) for the composite subjective measures (difficulty, interest), mind-wandering, and reading comprehension in Experiment 2.*

	Difficulty	Interest	Mind-wandering	Comprehension
Difficulty	-			
Interest	-.497**	-		
Mind-wandering	.335**	-.553**	-	
Comprehension	-.140†	.242*	-.157*	-

† $p < 0.10$, * $p < 0.05$, ** $p < 0.001$

I then conducted a multiple regression with participants' mean subjective difficulty difference scores and mean subjective interest difference scores as the predictors and their mean MW difference scores as the criterion. As anticipated, the regression model explained a significant proportion of the variance in the MW mean difference scores, $R^2 = 0.31$, $F(2, 160) =$

36.11, $p < 0.001$. The intercept was nonsignificant, $b = 0.01$, $t(162) = 0.64$, $p = 0.52$. Subjective interest mean difference scores significantly predicted MW mean difference scores, $b = -0.07$, $t(162) = -6.80$, $p < 0.001$, but subjective difficulty mean difference scores did not, $b = 0.01$, $t(162) = 1.04$, $p = 0.30$.[8]

Thus, although the objective difficulty manipulation did not influence MW at the group level, mean differences (between objectively easy and hard passages) in subjective difficulty and subjective interest were still associated with mean differences in MW at the individual level. However, unlike Experiment 1—in which mean differences in both subjective interest and subjective difficulty were significant predictors of mean differences in MW—only mean difference in subjective interest was a significant predictor in Experiment 2. These results tentatively suggest that participants' mind-wandering may have been more strongly related to their impressions of passage interestingness than to their impressions of passage difficulty.

Discussion

Experiment 2 presented passages one page at a time rather than one sentence at time (Experiment 1). This methodological change appears to have been pivotal. The effects of objective reading difficulty on mind-wandering and reading comprehension observed in Experiment 1 were eliminated in Experiment 2. Moreover, the differences in participants' ratings of subjective difficulty and subjective interest (which were related to the difference in mind-wandering in Experiment 1), were greatly diminished by full page presentation. These contrasting results were consistent with the hypothesis that hard passages induce more mind-

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[8] The range of subjective difficulty mean difference scores (10.75) was again comparable in size to the range of subjective interest mean difference scores (8.50), suggesting that the lower beta weight for the subjective difficulty mean difference scores did not reflect a range restriction issue. This was the also the case for the subsequent experiments in this work.

wandering than easy passages in the sentence presentation mode because the hard passages are presented in longer sections of text than the easy passages, not because they have a higher FK grade.

As in Experiment 1, mind-wandering difference scores (across objectively easy and hard passages) were significantly correlated with both subjective difficulty difference scores and subjective interest difference scores. But unlike Experiment 1, only subjective interest difference scores was a significant predictor of mind-wandering difference scores, which is consistent with the possibility that differences in subjective interest across easy and hard passages were more strongly related to differences in mind-wandering across easy and hard passages than were differences in subjective difficulty.

Experiment 3

The results of the first two experiments suggested that the effect of objective difficulty on mind-wandering is confounded by passage section-length. When this confound was removed in Experiment 2 (by presenting objectively easy and hard passages in equivalently long pages), the objective difficulty manipulation did not influence mind-wandering. It is conceivable, however, that other methodological differences between sentence and page presentation (unrelated to passage section lengths) led to the disparate pattern of results. For example, probe timing and placement differed between these presentation modes. And sentence presentation had more thought probes per passage than did page presentation (i.e., 4 vs. 2). Also, thought probes appeared at fixed places in the sentence presentation mode, but at random time intervals during full-page presentation.

The aim of Experiment 3 was to attempt replicate the results of the first two experiments while controlling differences in thought probe presentation between the sentence presentation mode and the page presentation mode. Participants were randomly assigned to a presentation mode (sentence vs. page), and thought probe presentation was equated across these two modes. Replicating the results of the first two experiments would rule out the possibility that the effect of objective difficulty on mind-wandering in the sentence presentation mode is somehow related to thought probe timing or placement. Ruling out this alternative possibility would increase the support for the hypothesis that differences in passage section length drive the effect of objective difficulty on mind-wandering.

Randomly assigning participants to a presentation mode in this experiment had the added benefit of allowing me to analyze for differences in mind-wandering, reading comprehension, and subjective ratings between presentation modes. In line with my hypothesis that section length influences mind-wandering, I predicted that the differences in the MW rates between hard and easy passages would be significantly larger for sentence presentation than for page presentation (in which I anticipated a nonsignificant difference). I also expected that differences in reading comprehension and subjective ratings would be significantly larger for sentence vs. page presentation. These results would be consistent with the possibility that differences in section length underlie the effects of objective reading difficulty on mind-wandering.

I also anticipated that, in both the sentence and page presentation conditions, differences in mind-wandering across easy and hard passages would be significantly related to differences in subjective difficulty and subjective interest across easy and hard passages. Based on the results of Experiments 1 and 2, I anticipated that the relation between subjective interest and mind-wandering would be stronger than the relation between subjective difficulty and mind-wandering.

Method

Participants

Two hundred students from the University of Waterloo participated in exchange for course credit.

Reading Materials

The same 12 passages and comprehension questions were used. Revisions fixed the two previously invalid comprehension questions.

Procedure

Participants were randomly assigned to the page or the sentence presentation condition. The page presentation procedure was identical to that used in Experiment 2. The sentence presentation condition was based on the procedure used in Experiment 1, with modifications to the number and timing of thought probes to equate these factors across presentation conditions. Mirroring the page presentation condition, two thought probes were presented per passage, and at the same approximate times—a random 10-30 s following the beginning of the passage and 10-30 s following the mid-point of the passage (which corresponded to the end of the first page).

Notably, thought probes still always occurred immediately following sentences in the sentence presentation condition. That is, after the random 10 -30 s had elapsed, the thought probe did not appear until participants pressed the spacebar to move on to the next sentence. A second difference between the two passage presentation conditions was that participants in the sentence presentation condition could "outpace" the thought probes if they read the passages very rapidly (i.e., participants could reach the middle/end of the passage before the thought probe was scheduled to appear). As it turned out, this was not a serious problem: Participants missed, on average, only 1.53% of thought probes due to rapid responding.[9] In the page presentation condition, this was not an issue because participants could not advance pages until the thought probe appeared.

Results

Two participants (one in each presentation condition) were excluded for having read fewer than 6 passages. An additional participant was excluded for missing 14 of the 16 thought probes and therefore having insufficient mind-wandering data. This left 197 participants whose data were analyzed.

Mind-wandering

Table 2 displays mean MW rates. A mixed model ANOVA, with Objective reading difficulty as a within-subject factor and Presentation as a between-subjects factor, revealed a

[9] Missed probes were treated as missing data.

significant interaction, $F(1, 195) = 14.45$, $MSE = 0.02$, $p < 0.001$, $\eta^2 = 0.07$. Consistent with my hypothesis, MW rates were significantly higher for hard passages vs. easy passages for sentence presentation, $t(97) = 5.87$, $p < 0.001$, $d = 0.52$,[10] but not for page presentation, $t(98) = -0.29$, $p = 0.78$, $d = 0.03$.

Reading comprehension

Mean comprehension scores are shown in Table 3. As expected, a mixed-model ANOVA yielded a significant Objective reading difficulty x Presentation interaction, $F(1, 195) = 6.54$, $MSE = 0.02$, $p = 0.01$, $\eta^2 = 0.03$. Comprehension scores were significantly higher for easy passages than hard passages for sentence presentation, $t(97) = 2.21$, $p = 0.03$, $d = 0.26$, but not for page presentation, $t(98) = -1.38$, $p = 0.17$, d = 0.16.

Subjective ratings

Mean subjective ratings are shown in Table 7. For each subjective measure, a mixed-model ANOVA was conducted, parallel to those above. For writing difficulty, the ANOVA yielded a significant Objective reading difficulty x Presentation interaction, $F(1, 195) = 6.83$, $MSE = 1.29$, $p = 0.01$, $\eta^2 = 0.03$. As expected, participants rated hard passages as having significantly more difficult writing than easy passages in the sentence presentation condition, $t(97) = 5.02$, $p < 0.001$, $d = 0.54$, but this difference was only trending in the page presentation condition, $t(98) = 1.74$, $p = 0.09$, $d = 0.16$. For topic difficulty, the Objective writing difficulty x Presentation interaction was nonsignificant, $F(1, 195) = 2.14$, $MSE = 1.57$, $p = 0.15$, $\eta^2 = 0.01$. Nevertheless, as predicted, participants rated hard passages as having significantly more difficult

[10] Interestingly, in the sentence presentation condition, participants missed a significantly higher proportion of thought probes for hard passages ($M = 0.027$, $SE = 0.008$) than for easy passages ($M = 0.004$, $SE = 0.002$), $t(97) = 2.81$, $p = 0.006$, $d = 0.37$. (A thought probe was missed when rapid responding resulted in participants "outpacing" the time that the thought probe was scheduled to appear.) This result suggests that participants were more likely to skim the hard passages than the easy passages. See Chapter 3 for more detailed reading time analyses.

topics than easy passages in the sentence presentation condition, $t(97) = 3.52$, $p = 0.001$, $d = 0.38$, but not in the page presentation condition, $t(98) = 1.43$, $p = 0.16$, $d = 0.15$.

Table 7. *Mean subjective ratings (with SEs) of objectively easy and objectively hard passages in Experiments 3 and 4.*

Experiment	Easy passages	Hard passages
Experiment 3 (sentences)		
Writing difficulty	3.22 (0.15)	4.08 (0.18)
Topic difficulty	4.44 (0.17)	5.07 (0.16)
Writing interest	4.13 (0.16)	3.75 (0.16)
Topic interest	4.64 (0.18)	4.02 (0.16)
Experiment 3 (pages)		
Writing difficulty	4.23 (0.18)	4.50 (0.16)
Topic difficulty	4.84 (0.17)	5.10 (0.17)
Writing interest	3.54 (0.15)	3.50 (0.14)
Topic interest	4.05 (0.19)	4.01 (0.17)
Experiment 4 (section length equal)		
Writing difficulty	3.60 (0.15)	3.90 (0.16)
Topic difficulty	4.37 (0.16)	4.43 (0.16)
Writing interest	3.83 (0.15)	3.60 (0.14)
Topic interest	4.19 (0.18)	3.96 (0.17)

For writing interestingness, the Objective writing difficulty x Presentation interaction was nonsignificant, $F(1, 195) = 2.25$, $MSE = 1.26$, $p = 0.14$, $\eta^2 = 0.01$. But once again, hard passages were rated as having significantly less interesting writing than easy passages in the sentence presentation condition, $t(97) = 2.29$, $p = 0.02$, $d = 0.23$, but not in the page presentation condition, $t < 1$. Last, for topic interestingness, there was a borderline significant Objective reading difficulty x Presentation interaction, $F(1, 195) = 3.90$, $MSE = 2.16$, $p = 0.050$, $\eta^2 = 0.02$. Hard passages were rated as having significantly more interesting topics than easy passages in the sentence presentation condition, $t(97) = 3.09$, $p = 0.003$, $d = 0.34$, but not in the page presentation condition, $t < 1$. Overall, the results were largely consistent with my prediction that the difference in subjective ratings of objectively easy vs. hard passages would be larger for sentence presentation than for page presentation.

Associations between subjective rating difference scores and MW difference scores

As in the previous experiments, I averaged each pair (writing, topic) of difficulty and interest measures to create composite scores, which were used in the analyses below. Separate analyses are reported for participants in the sentence presentation condition and for participants in the page presentation condition. Table 8 shows the correlation coefficients between the mean difference scores (hard passage mean – easy passage mean) for subjective difficulty, subjective interest, mind-wandering, and comprehension scores. In each presentation condition, mean differences in mind-wandering between hard and easy passages were significantly associated with mean differences in both subjective difficulty and subjective interest, which themselves were significantly correlated.

I then conducted a multiple regression in which participants' mean subjective difficulty difference scores and mean subjective interest difference scores predicted their mean MW difference scores. In the sentence presentation condition, the regression model explained a significant proportion of the variance in the MW difference scores, $R^2 = 0.21$, $F(2, 95) = 12.64$, $p < 0.001$. The intercept was significant, $b = 0.09$, $t(97) = 4.36$, $p < 0.001$. Mean subjective interest difference scores significantly predicted mean MW difference scores, $b = -0.06$, $t(97) = -4.28$, $p < 0.001$, but mean subjective difficulty difference scores did not, $b = 0.004$, $t(97) = 0.28$, $p = 0.78$. These results suggest that participants mind-wandered more while reading objectively hard passages when they were perceived as less interesting, but not when they were perceived as more difficult. Note in Table 4 that the standard errors for participants' difficulty ratings were comparable in size to the standard errors for their interest ratings. Thus, the smaller correlations between difficulty ratings and mind-wandering (compared to the correlations between interest ratings and mind-wandering) cannot be attributed to difficulty ratings having a more restricted range compared interest ratings.

In the page presentation condition, the results of the regression analysis were virtually identical. The regression model explained a significant proportion of the variance in the MW difference scores, $R^2 = 0.27$, $F(2, 96) = 17.71$, $p < 0.001$. The intercept was nonsignificant, $b = 0.002$, $t(98) = 0.12$, $p = 0.90$. Subjective interest mean difference scores significantly predicted MW mean difference scores, $b = -0.06$, $t(98) = -3.97$, $p < 0.001$, but subjective difficulty mean difference scores did not, $b = 0.01$, $t(98) = 0.36$, $p = 0.72$. Even though there was no overall mean difference in MW rates between objective difficulty conditions, differences in mind-wandering across easy and hard passages were still significantly related to difference in subjective interest across easy and hard passages (at the individual level).

Table 8. *Correlation coefficients between the averaged difference scores (hard passage average - easy passage average) for the composite subjective measures (difficulty, interest), mind-wandering, and reading comprehension in Experiment 3 (sentence presentation condition and page presentation condition).*

	Difficulty	Interest	Mind-wandering	Comprehension
Sentence				
Difficulty	-			
Interest	-.477**	-		
Mind-wandering	.241*	-.458**	-	
Comprehension	-.292*	.267*	-.122	-
Page				
Difficulty	-			
Interest	-.704**	-		
Mind-wandering	.387**	-.518**	-	
Comprehension	-.282*	.288*	-.233*	-

* $p < 0.05$, ** $p < 0.001$

Discussion

Replicating the results of Experiment 1 and 2, the effect of objective reading difficulty on mind-wandering was contingent on passage presentation mode in Experiment 3. When passages were presented one sentence at a time, MW rates were higher for hard passages than easy passages, and comprehension scores were lower. For page presentation, however, those effects were eliminated. It is therefore unlikely that objective difficulty has a sizeable influence on individuals' tendency to mind-wander while reading. If this were the case, then participants would have mind-wandered more while reading hard vs. easy passages regardless of the presentation mode. The nonsignificant effect of objective difficulty on MW in the page presentation mode suggests that the significant effect in the sentence presentation mode occurs because the hard passages are presented in longer sections of text.[11]

The subjective ratings of participants who received passages one sentence at a time were consistent with the possibility that participants perceived the relatively longer sections of text that comprised the hard passages as more difficult and less interesting than the shorter sections that comprised the easy passages. (As in the previous experiments, regression analyses suggested that the lower interest for hard vs. easy passages may have been related to higher mind-wandering rates.) Conversely, when passage section length was equated by full page presentation, differences in subjective difficulty and interest ratings were attenuated. Section length, not objective difficulty, would therefore seem to be the factor influencing subjective ratings of passages.

[11] Note, however, that these results also do not support the conclusion that longer sections of text generally increase mind-wandering. As shown in Table 2, MW rates for both easy and hard passages presented one page at a time were roughly equivalent to MW rates for easy passages presented one sentence at a time. Thus, it would appear that passage section length may only influence self-reported MW when it varies in a within-subject design. This issue is addressed in the General Discussion and investigated in Chapter 2.

Experiment 4

The results of Experiment 1-3 suggest that differences in section length underlie the effect of objective reading difficulty on mind-wandering. Hard passages had higher rates of MW when they had more text per screen than easy passages (sentence presentation), but this effect was eliminated when easy and hard passages had equivalent amounts of text per screen (page presentation). Although these results suggest that differences in passage section length between easy and hard passages were driving the difference in mind-wandering rates in the sentence presentation mode, it is also possible that another feature of the sentence presentation mode—one that was different from the page presentation mode—was driving this effect. For example, participants could not re-read previous sentences in the sentence presentation mode, but could in the page presentation mode. Thus, stronger evidence of a section length effect on mind-wandering would be obtained by demonstrating that the effect of objective reading difficulty on MW is eliminated in a presentation mode that not only equates the section length of easy and hard passages (as page presentation did), but is also identical to the sentence presentation mode in virtually all other respects.

In Experiment 4, hard passages were still presented one sentence at a time, identically to the previous sentence presentation experiments. However, the presentation of easy passages was now modified such that each section of text consisted of up to 6 short sentences that contained the same content as of each sentence of the corresponding hard passage. This was done to equate the average number of words per screen, which now was nearly identical for the easy (M = 30.40, SE = 0.60) and hard (M = 30.37, SE = 0.61) versions. Both the easy and hard versions were also equated in terms of number of screens per passage (M = 17.00, SE = 0.30, in both versions).

I had the following hypotheses in this experiment. First, equating section length (i.e., the amount of text per screen) between easy and hard passages should attenuate the effect of objective reading difficulty on MW rates relative to Experiment 3 (sentence presentation), in which section length was not equated. Second, equating section length should attenuate the effect of objective reading difficulty on reading comprehension relative to Experiment 3 (sentence presentation). And third, equating text length should reduce differences in subjective difficulty and interest ratings between easy and hard passages relative to Experiment 3 (sentence presentation).

As in the previous experiments, I also predicted that differences in MW rates across easy and hard passages would be significantly correlated with differences in subjective difficulty ratings across easy and hard passages and with differences in subjective interest ratings across easy and hard passages. Based on the results of Experiments 2 and 3, I also anticipated that differences in subjective interest ratings across easy and hard passages would be predictive of differences in MW rates across easy and hard passages.

Method

Participants.

One hundred students from the University of Waterloo participated in exchange for course credit.

Reading Materials

The same 12 passages and comprehension questions as in the preceding experiments were used, with the exception of a minor revision to one of the passages to better equate content.

Procedure

The procedure was identical to the previous sentence presentation condition used in Experiment 3. Participants read eight randomly selected passages, four easy versions and four hard versions. As mentioned above, the crucial change was implemented to the easy versions of the passages: Each screen of the easy version now matched the hard version in terms of section length and content.

Results

One participant missed 12 of 16 thought probes due to frequent rapid reading that outpaced thought probe onset. This participant was excluded for having insufficient mind-wandering data, leaving 99 participants whose data were analyzed.

Mind-wandering

On average, participants missed 2.84% of thought probes due to rapid responding. Mean MW rates are shown in Table 2. The difference in MW rates between easy and hard passages was nonsignificant, $t(98) = 1.22$, $p = 0.23$, $d = 0.11$ (though still in the direction of more MW for hard passages). Thus, consistent with my hypothesis, equating the amount of text per screen between the easy and hard versions of passages attenuated the effect of objective reading difficulty on MW.

To determine whether equating text length per screen significantly reduced the effects of objective reading difficulty on mind-wandering, I pooled the sentence presentation data from Experiment 3 (in which text length per screen was not equated between passage difficulty levels) and the present experiment (in which text length per screen was equated). A mixed-model ANOVA was conducted with Objective reading difficulty as a within-subject factor and Experiment (3 vs. 4) as a between-subjects factor. Of main interest, and consistent with my hypothesis, there was a significant Objective reading difficulty x Experiment interaction, *F*(1, 195) = 8.94, *MSE* = 0.03, $p = 0.003$, $\eta^2 = 0.04$. The effect of objective reading difficulty on mind-wandering, which was substantial in Experiment 3 (12.1%), was reduced to a nonsignificant 2.5% in Experiment 4. This effect was weakened largely due to an increase in self-reported MW in the easy passages, which now included more text per screen. Relative to the sentence presentation condition in Experiment 3, participants' average MW rates for easy passages increased by 7% (from 28% to 35%), a statistically significant difference, $t(195) = 2.04$, $p = 0.04$, $d = 0.29$. Participants' MW rates for the hard passages decreased by a statistically nonsignificant 2.5% from Experiment 3 to Experiment 4, $t(195) = 0.69$, $p = 0.49$, $d = 0.10$.

Unlike in the sentence presentation version of Experiment 3 (for which the preponderance of missed probes were for hard passages), the incidence of missed probes in Experiment 4 was equivalent for easy (*M* = 0.29, *SE* = 0.01) and hard (*M* = 0.28, *SE* = 0.01) passages. Indeed, participants missed significantly more thought probes due to rapid reading for easy passages in Experiment 4 than they did in Experiment 3 (*M* = 0.027, *SE* = 0.01), $t(195) = 2.68$, $p = 0.01$, d = 0.38. The increased amount of text per screen for easy passages in Experiment 4 may have decreased participants' motivation to read these texts, leading to more skim reading.

Reading comprehension

Mean comprehension scores are displayed in Table 3.[12] As anticipated, equating text length per screen for the easy vs. hard versions of passages attenuated the effect of objective reading difficulty on reading comprehension, $t(98) = 0.23$, $p = 0.82$, $d = 0.03$.

[12] A wording error in one of the passages made a comprehension question ambiguous (see SM). Responses to this question were not included in the analyses.

As with MW rates, a mixed-model ANOVA was conducted on the pooled Experiment 3 (sentence condition) and Experiment 4 reading comprehension data. The Objective reading difficulty x Experiment interaction was nonsignificant, $F(1, 195) = 3.07$, $MSE = 0.02$, $p = 0.09$, $\eta^2 = 0.02$, but trending in the expected direction. Consistent with my predictions, mean comprehension scores for easy passages were 4.2% lower in Experiment 4 than in the sentence presentation condition of Experiment 3, a marginally significant difference, $t(195) = 1.80$, $p = 0.07$, $d = 0.26$. Mean comprehension scores for hard passages, on the other hand, were quite similar across these two experiments, differing by less than 1%, $t < 1$.

Subjective ratings

Subjective ratings of passage writing difficulty were significantly higher for objectively hard passages than for objectively easy passages, $t(98) = 2.19$, $p = 0.03$, $d = 0.20$, a small effect. Subjective ratings of topic difficulty, writing interestingness, and topic interestingness were all nonsignificantly different between easy and hard passages (all *p*s > 0.10).

Mixed-model ANOVAs were conducted on the pooled Experiment 3 (sentence condition) and Experiment 4 subjective rating data for each measure. For writing difficulty and topic difficulty ratings, there were significant Objective reading difficulty x Experiment interactions $F(1, 195) = 6.31$, $MSE = 1.21$, $p = 0.01$, $\eta^2 = 0.03$, and $F(1, 195) = 5.22$, $MSE = 1.49$, $p = 0.02$, $\eta^2 = 0.03$, respectively. This signifies that differences in subjective difficulty ratings between easy and hard passages were smaller in Experiment 4 than in the sentence presentation condition of Experiment 3.

For writing interestingness and topic interestingness ratings, the Objective reading difficulty x Experiment interactions were both nonsignificant [$F(1, 195) = 0.38$, $MSE = 1.27$, $p = 0.54$, $\eta^2 = 0.002$, and $F(1, 195) = 1.86$, $MSE = 2.08$, $p = 0.20$, $\eta^2 = 0.01$, respectively].

Nevertheless, both effects were nonsignificant in Experiment 4 after having been significant in the sentence presentation condition of Experiment 3, as hypothesized.

Associations between subjective rating difference scores and MW difference scores

As in the previous experiments, I averaged each pair (writing, topic) of difficulty and interest measures to create composite scores, which were used in the analyses below. Table 9 shows the correlation coefficients between the mean difference scores (hard passage mean – easy passage mean) for subjective difficulty, subjective interest, mind-wandering, and comprehension scores. Mean differences in MW between hard and easy passages were once again significantly associated with mean differences in both subjective difficulty and subjective interest, which were themselves significantly correlated.

Table 9. *Correlation coefficients between the averaged difference scores (hard passage average - easy passage average) for the composite subjective measures (difficulty, interest), mind-wandering, and reading comprehension in Experiment 4.*

	Difficulty	Interest	Mind-wandering	Comprehension
Difficulty	-			
Interest	-.481**	-		
Mind-wandering	.395**	-.610**	-	
Comprehension	-.391**	.386**	-.255*	-

* $p < 0.05$, ** $p < 0.001$

I then conducted a multiple regression with participants' subjective difficulty mean difference scores and subjective interest mean difference scores as the predictors and their MW mean difference scores as the criterion. The regression model explained a significant proportion of the variance in the MW mean difference scores, $R^2 = 0.39$, $F(2, 96) = 30.06$, $p < 0.001$. The intercept was nonsignificant, $b = 0.01$, $t(98) = 0.25$, $p = 0.81$. Subjective interest mean difference scores significantly predicted MW mean difference scores, $b = -0.08$, $t(98) = -5.98$, $p < 0.001$, but subjective difficulty mean difference scores did not, $b = 0.02$, $t(98) = 1.46$, $p = 0.15$. Even though there was no overall mean difference in MW rates between objective difficulty conditions, individual differences in subjective interest ratings between these conditions were still predictive of individual differences in MW rates. This was not the case for subjective difficulty ratings.

Discussion

Equating the amount of text per screen between the objectively easy and objectively hard versions of passages mitigated the effects of objective reading difficulty on MW and reading comprehension, rendering them statistically nonsignificant. These results are consistent with the hypothesis that passage section-length is a key factor influencing MW and reading comprehension, with longer sections associated with more frequent MW and worse reading comprehension. Equating section length also reduced the difference between participants' subjective ratings of easy and hard passages. It would therefore appear that equating section length between objectively easy and hard passages eliminates the effect of objective difficulty on mind-wandering, regardless of whether passages are presented using the page presentation mode (Experiments 2 and 3) or the sentence presentation mode (the current experiment). What matters is that section length is equated.

As in the previous experiments, mind-wandering difference scores (across objectively easy and hard passages) were significantly correlated with both subjective difficulty difference scores and subjective interest difference scores. However, only subjective interest difference scores was a significant predictor of mind-wandering difference scores (as in Experiments 2 and 3). Across the first four experiments, then, evidence has mounted that differences in mind wandering across easy and hard passages were more strongly related to differences in interest across easy and hard passages than differences in subjective difficulty across easy and hard passages.

Experiment 5

In Experiments 2-4, the effect of objective difficulty on mind-wandering was eliminated when passage section-length was held constant. These results were consistent with the hypothesis that passage section length—as opposed to objective difficulty—is what influences mind-wandering. If passage section-length was indeed confounding the effect of objective difficulty on mind-wandering in the sentence presentation mode, then holding objective difficulty constant and only varying section length ought to yield an effect comparable in size to those obtained in Experiments 1 and 3 (sentence presentation), in which *both* objective difficulty and section length differed between easy and hard passages.

By holding objective difficulty constant and manipulating section length, Experiment 5 directly tested the hypothesis that passage section length influences mind-wandering. Participants only read the objectively easy passages from previous experiments. Half of the passages were presented across short, one sentence sections of text (M = 12.52 words, SD = 1.35), and the other half were presented across moderate-length sections with as many as 6 sentences (M = 30.40 words, SD = 2.09). These were the same two section lengths used for objectively easy and objectively hard versions of passages, respectively, that were presented one sentence at a time in Experiments 1 and 3.

Based on the results of the previous experiments, which supported the hypothesis that longer sections of text lead to increased mind-wandering, I predicted that MW rates would be higher for passages that were presented in moderate-length vs. short-length sections. Further, I anticipated that comprehension scores would be lower for passages presented in moderate vs. short sections, difficulty ratings would be higher, and interest ratings would be lower.

Last, I predicted that differences in interest ratings and difficulty ratings between moderate-section and short-section passages would be significantly correlated with differences in MW rates (as was found in the previous experiments, in which section length varied between easy and hard passages). Based on the results of Experiments 2-4, I anticipated that differences in subjective interest ratings (but not subjective difficulty ratings) would be predictive of differences in MW rates.

Method

Participants

Fifty students from the University of Waterloo participated in exchange for course credit.

Reading Materials

The same 12 objectively easy passages from the previous experiments, and the same comprehension questions, were used here.

Procedure

The passage presentation mode was identical to Experiment 3 (sentence condition) and Experiment 4. For each participant, eight randomly selected passages were presented. Four passages were presented in short sections (M = 12.52 words, SD = 1.35) and the other four passages were presented in moderate-length sections (M = 30.40 words, SD = 2.09).

Results

Mind-wandering

On average, participants missed 2.75% of thought probes due to rapid responding. Mean MW rates are shown in Table 10. MW rates were significantly higher for passages that were presented across moderate sections of text than passages that were presented across short sections, $t(49) = 4.22$, $p < 0.001$, $d = 0.52$.[13]

Table 10. *Mean mind-wandering rates (with SEs) for passages that were presented across short, moderate, and long sections in Experiments 5-6.*

Experiment	Short-section Passages	Moderate-section Passages	Long-section Passages
Exp. 5	.272 (.035)	.398 (.034)	
Exp. 6	.261 (.033)	.333 (.032)	.456 (.038)

Reading comprehension

Mean comprehension scores are displayed in Table 11. Participants had nominally better comprehension scores for passages presented across short sections than for passages presented across moderate sections, but this difference was not statistically significant, $t(49) = 0.68$, $p = 0.50$, $d = 0.12$. Given that the effect obtained in the previous sentence presentation experiments was quite small ($d = 0.23, 0.26$), it was perhaps unsurprising that the effect was nonsignificant in this experiment, given the smaller sample size and concomitant reduction in statistical power.

[13] Participants missed a significantly higher proportion of thought probes for passages presented in moderate sections ($M = 0.045$, $SE = 0.019$) than for those presented in short sections ($M = 0.010$, $SE = 0.006$), $t(49) = 2.14$, $p = 0.04$, $d = 0.35$, a result that was also observed in the sentence presentation condition of Experiment 3. This result was consistent with longer sections of text increasing participants' tendency to skim read, perhaps because longer sections of text decrease interest and task engagement. This possibility is explored in Chapter 3.

Table 11. *Mean proportion of comprehension questions answered correctly (with SEs) for passages that were presented across short, moderate, and long sections in Experiments 5-6.*

Experiment	Short-section Passages	Moderate-section Passages	Long-section Passages
Exp. 5	.526 (.022)	.507 (.025)	
Exp. 6	.549 (.022)	.522 (.026)	.489 (.029)

Subjective ratings

Mean subjective ratings are shown in Table 12.[14] Consistent with my predictions, participants' ratings of writing difficulty and topic difficulty were significantly higher for passages presented across moderate sections than for those presented across short sections [$t(49) = 3.18$, $p = 0.003$, $d = 0.35$, and $t(49) = 2.69$, $p = 0.01$, $d = 0.36$, respectively]. Ratings of writing interestingness and topic interestingness were significantly lower for passages presented across moderate sections vs. short sections [$t(49) = 3.65$, $p = 0.001$, $d = 0.45$, and $t(49) = 2.87$, $p = 0.01$, $d = 0.34$, respectively].

[14] A wording error in one of the passages made a comprehension question ambiguous (see SM). Responses to this question were not included in the analyses.

Table 12. *Mean subjective ratings (with SEs) of passages that were presented across short, moderate, and long sections in Experiments 5 and 6.*

Experiment	Short-section Passages	Moderate-section Passages	Long-section Passages
Experiment 5			
Writing difficulty	3.38 (.30)	4.09 (.27)	
Topic difficulty	4.03 (.26)	4.69 (.27)	
Writing interest	4.87 (.26)	4.02 (.27)	
Topic interest	4.03 (.23)	3.46 (.24)	
Experiment 6			
Writing difficulty	3.37 (.24)	3.81 (.21)	5.03 (.23)
Topic difficulty	4.42 (.21)	4.80 (.25)	5.32 (.22)
Writing interest	4.33 (.21)	3.98 (.22)	3.17 (.24)
Topic interest	4.83 (.24)	4.36 (.23)	3.52 (.25)

Associations between subjective rating difference scores and MW difference scores

As in the previous experiments, composite ratings were used for subjective difficulty and subjective interest. Table 13 shows the correlation coefficients between the mean difference scores (moderate-section passage mean – short-section passage mean) for subjective difficulty, subjective interest, mind-wandering, and comprehension scores. In contrast with the previous experiments that used the sentence presentation mode, MW mean difference scores were only marginally significantly correlated (p = 0.08) with subjective interest mean difference scores, and were nonsignificantly correlated with subjective difficulty mean difference scores. Subjective interest and subjective difficulty mean difference scores were once again significantly correlated with each other.

Table 13. *Correlation coefficients between the averaged difference scores (moderate-section passage average – short-section passage average) for the composite subjective measures (difficulty, interest), mind-wandering, and reading comprehension, in Experiment 5.*

	Difficulty	Interest	Mind-wandering	Comprehension
Difficulty	-			
Interest	-.378*	-		
Mind-wandering	.103	-.251†	-	
Comprehension	.009	.051	-.234	-

† $p < 0.10$, * $p < 0.05$, ** $p < 0.001$

Next, I regressed participants' mean MW difference scores on their mean subjective interest and mean subjective difficulty scores. The regression model explained a nonsignificant proportion of the variance in the mind-wandering difference scores, $R^2 = 0.06$, $F(2, 47) = 1.58$, $p = 0.22$. The intercept was significant, $b = 0.10$, $t(49) = 2.84$, $p = 0.01$. Subjective interest mean difference scores nonsignificantly predicted mind-wandering mean difference scores, $b = -0.04$, $t(49) = -1.62$, $p = 0.11$, although there was a trend in the expected direction of decreased interest predicting increased mind-wandering. Subjective difficulty mean difference scores were clearly a nonsignificant predictor of MW mean difference scores, $b = 0.001$, $t(49) = 0.06$, $p =$

0.95. Subjective interest mean difference scores may have been a nonsignificant predictor of MW mean difference scores in this experiment due to its lower statistical power (fewer participants) relative to Experiments 1-4, in which this effect was significant (see also Experiments 6 and 7).

Combined analyses with Experiment 3 (sentence presentation)

Last, I compared the results of the present experiment with the results of Experiment 3 (sentence presentation), to determine whether the section-length manipulation had a statistically equivalent effect on MW rates (and the other measures) as the objective difficulty manipulation. A null interaction between the MW rates in these two experiments would provide additional support for the hypothesis that the effect of objective difficulty on MW in the sentence presentation mode is entirely due to differences in sentence length.

I pooled the data from these two experiments and conducted a mixed-model ANOVA with Passage type (easy/short vs. hard/moderate) as a within-subject factor and Experiment as a between-subjects factor. The main effect of Passage type was robust, $F(1, 146) = 47.39$, $MSE = 0.02$, $p < 0.01$, $\eta^2 = 0.25$, whereas the main effect of Experiment was nonsignificant, as was the Passage type x Experiment interaction (Fs < 1). The difference in MW rates between passages presented in short- vs. medium-length sections of text in Experiment 5 (12.5%) was nearly identical to the difference in MW rates between objectively easy and hard passages in the sentence presentation condition of Experiment 3 (12.1%).

For comprehension scores, a mixed-model ANOVA revealed a marginally significant main effect of Passage type, $F(1, 146) = 3.40$, $MSE = 0.02$, $p = 0.07$, $\eta^2 = 0.02$, with comprehension tending to be slightly better for passages presented in short sections. The main effect of Experiment and the Passage type x Experiment interaction were both nonsignificant (Fs

< 1). For all four subjective ratings, a mixed-model ANOVA consistently revealed main effects of Passage type (all *p*s < 0.001). Importantly, all four Passage type x Experiment interactions were nonsignificant (writing difficulty: $p = 0.60$; topic difficulty: $p = 0.90$; writing interestingness: $p = 0.09$; topic interestingness: $p = 0.88$).

Overall, these combined analyses showed that the section-length manipulation used in Experiment 5 yielded results that were statistically indistinguishable from the objective difficulty manipulation used in Experiment 3. These results provide converging evidence that the effect of objective reading difficulty on MW obtained in the sentence presentation mode is largely attributable to objectively hard passages tending to have longer sentences than objectively easy passages.

Discussion

Experiment 5 provided converging evidence of a "section length" effect on mind-wandering. Participants mind-wandered more frequently when reading passages presented in moderately long sections than when reading passages presented in short sections. Given that these passage section lengths were identical to those used in easy and hard passages in the sentence presentation mode (Experiments 1 and 3), the fact that the effect of section length on mind-wandering was as large as the effect of objective difficulty on mind-wandering strongly suggests that the effect of objective difficulty was a consequence of hard passages having longer sections

Moreover, participants rated passages that were presented in moderately long sections as being more difficult and less interesting than passages presented in short sections. Unlike the previous experiments, difference scores between subjective interest ratings of passages with moderately-long section and passages with short sections were nonsignificantly related to mind-wandering differences scores between these two conditions (though this effect was trending in the expected direction), perhaps reflecting the fact that there was a smaller sample in this experiment.

Experiment 6

. Experiment 5 demonstrated that section length (i.e., amount of text per screen) influences the frequency of mind-wandering and subjective ratings of passage difficulty and interestingness. There was, however, no significant effect of section length on reading comprehension. Perhaps the difference in section lengths used in Experiment 5 was too subtle to consistently observe this effect, which was quite small in Experiments 1 and 3 (sentence presentation condition). This possibility was tested in Experiment 6 by adding a third section length condition—full pages—which I anticipated would yield significantly worse comprehension rates than passages presented in shorter sections. The short and moderate lengths were identical to those in Experiment 5, and the full page length was the same as used in Experiments 2 and 3. I hypothesized that MW would increase as section length increased and that reading comprehension would correspondingly decrease. Moreover, I expected that subjective ratings of difficulty would increase as section length increased, and that ratings of interest would decrease. In addition, I anticipated that differences in subjective interest ratings between passages with longer sections and passages with shorter sections would be significantly related to differences in MW rates between passages with longer sections and passages with shorter sections. Although this effect was only trending in Experiment 5, the accumulation of evidence across the previous experiments supports this idea.

Method

Participants

Fifty-three students from the University of Waterloo participated in exchange for course credit.

Reading Materials

Participants were exposed to the same 12 objectively easy passages from the previous experiments and to the same comprehension questions.

Procedure

Nine randomly selected passages were presented to each participant. Three passages were presented in short sections (*M* = 12.52 words, *SD* = 1.35), three in moderate sections (*M* = 30.40 words, *SD* = 2.09), and three in long sections (*M* = 257.25 words, *SD* = 4.49). Two methodological changes ensured identical thought probe presentation and timing across conditions. First, in all three section length conditions, probes always appeared at the *exact* moment that the random 10-30 s interval elapsed (as in the previous page presentation conditions) as opposed to waiting until the participant pressed the spacebar to advance to the next screen (the previous sentence presentation conditions). Second, participants could no longer outpace the thought probes by rapidly reading. If a participant reached the mid-point of the passage before the first thought probe appeared, then the first probe would appear at the mid-point (which corresponded to the end of the first page). If a participant reached the end of the passage before the second thought probe appeared, then the second probe would appear at the end of the passage.

Results

Mind-wandering

Mean MW rates are shown in Table 10. A repeated measures ANOVA revealed a significant effect of section length (short vs. moderate vs. long) on MW, $F(1, 104) = 14.23$, $MSE = 0.04$, $p < 0.001$, $\eta^2 = 0.21$. As hypothesized, MW rates were significantly higher for long-section passages than for moderate-section passages, $t(52) = 3.00$, $p = 0.004$, $d = 0.48$, or short-section passages, $t(52) = 5.36$, $p < 0.001$, $d = 0.76$. MW rates were also significantly higher for moderate-section vs. short-section passages, $t(52) = 2.18$, $p = 0.03$, $d = 0.31$.

Reading comprehension

Mean comprehension scores are displayed in Table 11. Comprehension scores followed the expected pattern of being highest for passages presented in short sections and lowest for passages presented in long sections. The repeated measures ANOVA, however, was only trending, $F(1, 104) = 2.36$, $MSE = 0.02$, $p = 0.10$, $\eta^2 = 0.04$. Comprehension of short-section passages was nonsignificantly different from comprehension of moderate-section passages, $t(52) = 1.03$, $p = 0.31$, which were nonsignificantly different from comprehension of long-section passages, $t(52) = 1.14$, $p = 0.26$. However, consistent with my hypothesis, comprehension rates of short-section passages were significantly higher than comprehension rates of long-section passages, $t(52) = 2.16$, $p = 0.04$, $d = 0.32$.

Subjective ratings

Mean subjective ratings are shown in Table 12. As hypothesized, subjective difficulty ratings increased and subjective interest ratings decreased as passage section-length increased. Repeated measures ANOVAs revealed that section length had a significant effect on ratings of writing difficulty, $F(1, 104) = 22.02$, $MSE = 1.96$, $p < 0.001$, $\eta^2 = 0.27$, topic difficulty, $F(1, 104) = 7.03$, $MSE = 1.90$, $p = 0.001$, $\eta^2 = 0.12$, writing interestingness, $F(1, 106) = 11.72$, $MSE = 1.67$, $p < 0.001$, $\eta^2 = 0.18$, and topic interestingness, $F(1, 106) = 11.04$, $MSE = 2.18$, $p < 0.001$, $\eta^2 = 0.18$.

Both writing difficulty ratings and topic difficulty ratings were significantly higher for long-section passages than moderate-section passages [$t(52) = 4.82$, $p < 0.001$, $d = 0.81$; $t(52) = 2.08$, $p = 0.04$, $d = 0.33$] or short-section passages [$t(52) = 5.69$, $p < 0.01$, $d = 1.01$; $t(52) = 4.25$, $p < 0.001$, $d = 0.65$]. Both writing interestingness and topic interestingness ratings were significantly lower for long-section passages than moderate-section passages [$t(52) = 3.92$, $p < 0.001$, $d = 0.51$; $t(52) = 3.17$, $p = 0.003$, $d = 0.49$] or short-section passages [$t(52) = 4.17$, $p < 0.001$, $d = 0.73$; $t(52) = 4.48$, $p < 0.001$, $d = 0.74$]. For all four measures, ratings of moderate-section passages were nonsignificantly different from ratings of short-section passages, although in each case there was a trend in the anticipated direction (writing difficulty: $p = 0.07$; topic difficulty: $p = 014$; writing interestingness: $p = 0.20$; topic interestingness: $p = 0.12$).

Associations between subjective rating difference scores and MW difference scores

As in the previous experiments, composite ratings were used for subjective difficulty and subjective interest. For the sake of brevity, only the difference scores between long-section passages and short-section passages are reported here. The statistical significance of the results is nearly identical for the difference scores between long-section passages and moderate-section passages, and also for the difference scores between moderate-section passages and short-section passages (a footnote indicates the lone exception).

Table 14 shows the correlation coefficients between the mean difference scores (long-section passages – short-section passages) for subjective difficulty, subjective interest, mind-wandering, and comprehension scores. Mean differences in mind-wandering were significantly correlated with mean differences in subjective interest, but not with mean differences in subjective difficulty.[15] Mean differences in subjective interest and difficulty were also significantly correlated with each other.

[15] For the mean differences between moderate-section passages and short-section passages, this correlation was statistically significant [$r(52) = .344$, $p = 0.01$].

Table 14. *Correlation coefficients between the averaged difference scores (long-section passage average – short-section passage average) for the composite subjective measures (difficulty, interest), mind-wandering, and reading comprehension, in Experiment 6.*

	Difficulty	Interest	Mind-wandering	Comprehension
Difficulty	-			
Interest	-.387*	-		
Mind-wandering	.189	-.518**	-	
Comprehension	-.246†	-.175	-.212	-

† $p < 0.10$, * $p < 0.05$, ** $p < 0.001$

I then conducted a multiple regression with participants' subjective difficulty mean difference scores and subjective interest mean difference scores as predictors of MW mean difference scores. As anticipated, the regression model explained a significant proportion of the variance in the MW difference scores, $R^2 = 0.27$, $F(2, 50) = 9.16$, $p < 0.001$. The intercept was significant, $b = 0.10$, $t(52) = 2.46$, $p = 0.02$. Subjective interest mean difference scores significantly predicted MW difference scores, $b = -0.07$, $t(52) = -3.99$, $p < 0.001$, but subjective difficulty mean difference scores did not, $b = -0.002$, $t(52) = -0.10$, $p = 0.92$. These results suggest that participants mind-wandered more while reading long-section passages that they perceived as less interesting, but not those that they perceived as more difficult, and mesh with the findings of Experiments 2-5.

Discussion

Experiment 6 replicated and extended the results of Experiment 5 by showing that mind-wandering increased as passage section-length increased over three section lengths (short, moderate, and long). As anticipated, comprehension scores also decreased as passage section-length increased. In terms of subjective ratings, as passage section-length increased, participants' ratings of passage difficulty increased and their ratings of passage interestingness decreased. Regression analyses revealed that subjective interest difference scores significantly predicted MW difference scores, but subjective difficulty difference scores did not. In sum, these results suggest that passages with longer sections were perceived as relatively uninteresting, which increased participants' tendency to mind-wander.

Appendix C shows that the presence of passages with relatively shorter sections in Experiment 6 increased mind-wandering rates for long-section (i.e., full page) passages relative to when participants read only full page passages in Experiment 2. Thus, it would appear that the presence of passages with shorter sections may impose a mind-wandering "cost" on passages with longer sections in a within-subject design. This possibility is examined in Chapter 2.

Chapter 1 General Discussion

In this chapter, I hypothesized that the previously observed effect of objective reading difficulty on mind-wandering (e.g., Feng et al., 2013; Mills et al., 2013) may have been a methodological artefact of the sentence presentation mode. This hypothesis was supported across six experiments. An effect of objective difficulty on mind-wandering only emerged when hard passages contained longer sections of text than easy passages—namely, when passages were presented one sentence at a time (Experiments 1 and 3). When easy and hard passages were presented across sections of equivalent length—whether in full pages (Experiments 2 and 3), or in relatively short sections akin to the sentence-presentation format (Experiment 4)—the effect of objective difficulty on mind-wandering was eliminated. There was no evidence of objective difficulty influencing mind-wandering; rather, section length appears to have been the driving factor. Indeed, when objective difficulty was controlled and passages only varied in terms of section length (Experiment 5), the effect on mind-wandering was equivalent to that of the objective difficulty manipulation in sentence presentation mode. Experiment 6 extended this pattern by showing a robust effect of passage section-length on mind-wandering across three different section lengths.

These results do not, however, rule out the possibility that objective difficulty may influence mind-wandering under certain circumstances. Objective difficulty manipulations targeting "deep" difficulty (Nelson et al., 2012) features such as narrative structure could potentially reveal differences in mind-wandering. Indeed, Mills et al.'s (2015) objective difficulty manipulation targeted both surface (e.g., sentence length) and deep difficulty features. They controlled section length (60 words per screen) and found that participants mind-wandered slightly but reliably more while reading hard passages (30.5%) than easy passages (27.8%).

Nonetheless, the results of Mills et al. and the present research suggest that controlling for section length greatly attenuates the effect of objective difficulty on mind-wandering.

Why might longer sections of text increase mind-wandering? Experiments 5 and 6 demonstrated that passages presented in longer sections are perceived as more difficult and less interesting than passages presented in shorter sections. In Experiment 6, subjective interest mean difference scores (between the passage section-length conditions) significantly predicted mind-wandering mean difference scores, but subjective difficulty mean difference scores were not a significant predictor. Similarly, in Experiments 1 and 3 (sentence presentation condition), the objectively hard passages (which had longer sections than the easy passages) were rated as more difficult and less interesting than the objectively easy passages. Subjective interest mean difference scores (across objective difficulty conditions) also significantly predicted mind-wandering mean difference scores in these two experiments, but subjective difficulty mean difference scores were only a significant predictor of mind-wandering mean difference scores in Experiment 1.

Overall, then, this package of results tentatively suggests that longer sections of text may lead to more mind-wandering because they are perceived as less interesting. The perception that longer sections of text are more difficult may also increase mind-wandering, although difficulty appears to have a smaller impact than subjective interest. Note, however, that these correlational data are also consistent with the possibility that increased mind-wandering leads to perceptions of increased difficulty and/or decreased interest. For example, another factor (aside from subjective impressions of passages) may lead participants to mind-wander more while reading passages with relatively long sections, and frequent mind-wandering may lead participants to infer that they found those passages difficult and/or uninteresting.

In the Introduction to this chapter, I raised the possibility that when passages are presented as full pages, the ability to re-read may help participants to construct a situation model (i.e., internal narrative) of the text, particularly in the case of objectively hard passages. Could re-reading account for the relatively smaller differences in participants' mind-wandering rates across objectively easy and hard passages in the page presentation mode vs. the sentence presentation mode? A number of results were inconsistent with this possibility. First, the difference in mind-wandering across easy and hard passages was attenuated not only for page presentation, but also when passage section length was equated in Experiment 4, which was akin to the sentence presentation mode and was therefore not conducive to re-reading. Second, reading times were equivalently long for objectively easy and hard passages in the page presentation experiments (see Appendix B), suggesting that participants did not take advantage of re-reading to help them build a situation model of objectively hard passages because re-reading would have taken additional time. And third, even assuming that some participants did re-read in the full page presentation mode, it would not appear to have helped them build a situation model. Comprehension scores for page presentation were lower in Experiment 6 relative to when passages were presented in smaller sections of text, and mind-wandering rates and subjective difficulty ratings were higher. Thus, it would appear that the possibility of re-reading was not responsible for the effect of objective difficulty on mind-wandering being eliminated in the page presentation mode; rather, this effect appears to have occurred because objectively easy and hard passages had equivalently long sections (and were therefore perceived as equivalently difficult and interesting).

The reading time data (see Appendix B) warrant further discussion. In particular, it is noteworthy that in the experiments in which passage section-length was equated—whether in the page presentation mode (Experiments 2 and 3) or the sentence presentation mode (Experiment 4), reading times for objectively hard passages were not significantly longer than reading times for objectively easy passages. This nonsignificant effect is surprising given that one generally expects increased difficulty to lead to longer reaction times for cognitive phenomena. In those experiments, however, a difference in objective difficulty of eight Flesch-Kincaid grade levels (FK grade 9 vs. FK grade 17) did not result in significantly different reading times.

What could account for this nonsignificant effect of objective difficulty on reading times when passage section-length was equated? One possible explanation is that participants did not perceive a sizeable difference in difficulty between objectively easy and hard passages—indeed, in each of these experiments, objective difficulty only had a modest effect on participants' subjective writing difficulty ratings. This effect may have been particularly muted in the present experiments because the passages covered a wide variety of topics of varying difficulty levels. Accordingly, participants' subjective writing difficulty ratings may have been influenced to a greater extent by topic difficulty than by the objective difficulty manipulation; indeed, the high correlations between participants' writing difficulty ratings and topic difficulty ratings are consistent with this claim.

Conversely, in experiments that used sentence presentation (Experiments 1 and 3), differences in section length between objectively easy and hard passages were salient, which may have strengthened the influence of the objective difficulty manipulation. The greater impact of the manipulation in those experiments was evident in terms of participants' subjective ratings (they rated objectively hard passages as more difficult and less interesting than objectively easy passages) and in terms of participants' mind-wandering (they mind-wandered more while reading objectively hard passages than objectively easy passages). This impact was also evident in terms of reading times, though perhaps not as one might expect: Participants had significantly *shorter* reading times for objectively hard passages versus objectively easy passages. These shorter reading times are suggestive of task disengagement and skim reading (see Phillips, Mills, D'Mello, & Risko, 2016 for evidence of an association between mind-wandering and skim reading). That is, passages with longer sections of text were perceived as more difficult and less interesting, which may, in turn, have led to task disengagement and skim reading. Chapter 3 investigates this possibility in greater detail by analyzing interest and reading time data over the course of the eight passages.

Before concluding this chapter, it is worth noting that the effect of section length on mind-wandering may be more robust in a within-subject design than in a between-subjects design, as is often the case with cognitive phenomena. In Experiment 3, participants who read easy passages one sentence at a time mind-wandered as frequently as participants who read easy passages one page at a time (a between-subjects comparison; see Table 2). And in the same experiment, participants who read hard passages one sentence at a time mind-wandered more than participants who read hard passages one page at a time, an effect that went in the opposite direction of the within-subject effect of section length on mind-wandering.[16] On the other hand, when the average section length of objectively easy passages was increased in Experiment 4 relative to Experiment 3 (sentence presentation condition), mind-wandering rates increased by 7%, a significant between-subjects difference (see Table 2), albeit one that was smaller than the typical within-subject differences observed in these experiments. Overall, then, this package of results tentatively suggests that the within-subject effect of section length on mind-wandering

[16] These results suggest that longer sections of text do not increase mind-wandering simply because they allow more time for mind-wandering or because they require fewer spacebar presses. If this were the case, then section length ought to have influenced mind-wandering equivalently both within-subject and between-subjects.

may be larger than the between-subjects effect. In Chapter 2, I explore this possibility and propose an explanation that is derived from the concept of distinctiveness (Hunt, 2006).

In summary, the six experiments in this chapter provided converging evidence that the effect of objective difficulty (manipulated by varying FK reading level) on mind-wandering in the sentence presentation mode is a function of objectively hard passages having longer sections of text than objectively easy passages in this type of presentation mode. These results are somewhat inconsistent with Feng et al.'s (2013) account that objective difficulty influences mind-wandering because participants are less successful in constructing a situation model for objectively hard passages, which may trigger cascading inattention (Smallwood et al., 2007) for those passages. Moreover, the regression analyses in Experiments 1-4 suggested that participants mind-wandered more while reading objectively hard passages when they found those passages to be less *interesting* (as opposed to more difficult). Thus, an important methodological implication of this research is that experimental manipulations targeted at task difficulty (such as the present objective difficulty manipulation) may also influence subjective interest—and it may be subject interest that subsequently impacts mind-wandering.

Chapter 2

Why does mind-wandering change as a function of passage section length? Exploring a distinctiveness explanation

Chapter 1 demonstrated a very clear effect of passage section length on mind-wandering while reading. As the section length of passages increased, so did participants' tendency to mind-wander. As noted in the General Discussion of Chapter 1 (see p. 49), the overall collection of results was consistent with the possibility that the effect of passage section length on mind-wandering may be larger and more reliable within-subject than between-subjects. For example, in Experiment 6, participants' mind-wandering rates were substantially higher (19.5%) for objectively easy passages that they read one page at a time compared to objectively easy passages that they read one sentence at a time (see Table 10). In contrast, in Experiment 3, the between-subjects difference in mind-wandering rates between participants who read objectively easy passages one page at a time and other participants who read objectively easy passages one sentence at a time was 0.3% (in the opposite direction). Although the results of Experiment 3 were consistent with a nonsignificant between-subjects effect, objective difficulty was also manipulated within-subject in that experiment. Thus, a "pure" between-subjects comparison could not be made given the influence of the within-subject manipulation.

In Experiment 7, I used a within-subject vs. between-subjects design (in which some participants completed a within-subject version of the experiment, and others completed a between-subjects version) to assess whether the within-subject passage section-length effect is attenuated in a comparable between-subjects design. I hypothesized that the effect of section length on mind-wandering would be significantly larger in a within-subject design than in a comparable between-subjects design due to the influence of distinctive processing (see Hunt, 2006, for an overview) in the within-subject design.[17] This distinctiveness explanation consists of three related claims. First, section length is distinctively processed when it is manipulated across passages in a within-subject design. Second, by virtue of distinctive processing, section length influences participants' subjective impressions of passage difficulty and interestingness. And third, these impressions have downstream consequences on mind-wandering and task engagement.

The first claim regarding distinctive processing is based on Hunt's distinctiveness research (Hunt, 2006, 2013; Hunt & Worthen, 2006). Hunt (2006, p. 12) defines distinctiveness as the "processing of difference in the context of similarity," and has demonstrated that distinctive encodings are memorable. A feature that is manipulated in a within-subject design (e.g., section length) typically constitutes a difference in the context of some similarity (e.g., reading passages), and should therefore be distinctively processed. The second claim—that distinctive features influence impressions—is supported by research on the *distinction bias.* Hsee and Zhang (2004) demonstrated that when options are directly compared (in "joint evaluation mode") quantifiable differences between them are salient (i.e., distinctive) and have a particularly strong impact on evaluations of the options. And the third claim—that impressions of tasks have downstream consequences on mind-wandering while performing them—is supported by separate lines of research showing that subjective impressions of difficulty (e.g., Mills et al., 2013, 2015) and interest (e.g., Giambra & Grodsky, 1989; Smallwood et al., 2009; Unsworth & McMillan, 2013) influence mind-wandering. Moreover, the results of Chapter 1

[17] Similarly, MacLeod and colleagues (2010) have argued that the production effect (the finding that reading aloud enhances the memorability of words) is larger in a within-subject design than in a between-subjects design due to the distinctive processing of speech information in a within-subject design (see also Forrin, Groot, & MacLeod, 2016). Here I focus on the influence of distinctiveness on evaluations, rather than on memorability (although MacLeod et al.'s distinctiveness explanation for the production effect inspired the present distinctiveness explanation).

were consistent with subjective interest having a particularly strong influence on mind-wandering.

To recap, based on the foregoing distinctiveness explanation, I propose that passage section length stands out as a distinct feature in a within-subject design. This distinct feature may strongly influence participants' impressions of passage difficulty and interest which, in turn, influence their tendency to mind-wander. Conversely, in a between-subjects design, section length does not stand out as a distinct feature (it is constant), and therefore, relative to a within-subject design, may have a weaker influence on subjective ratings and mind-wandering.

Experiment 7

Experiment 7 used a within-subject vs. between-subjects design to test the explanation that the effect of section length on mind-wandering is enhanced by the distinctive processing of section length information in a within-subject design. In the within-subject version of the experiment, participants read four passages than were presented one sentence at a time and four that were presented one page at a time (intermixed); in the between-subjects version, some participants read all eight passages one page at a time whereas others read all eight passages one sentence at a time.

I had three main predictions that were derived from this distinctiveness explanation. First, the effect of section length on mind-wandering would be significantly larger in the within-subject design than in the between-subjects design. Second, the effect of section length on reading comprehension would be significantly larger in the within-subject design than in the between-subjects design. And third, the effect of section length on subjective ratings (of passage difficulty and interestingness) would be significantly larger in the within-subject design than in the between-subjects design. Additionally, I expected to replicate the result in Experiment 6 that differences in subjective interest—but not in subjective difficulty—between long-section and short-section passages would be significantly related to differences in mind-wandering.

A secondary aim of this experiment was to explore whether the effect of section length on mind-wandering in a within-subject design reflected a "cost" (i.e., increased MW rates for passages presented over relatively long sections) or a "benefit" (i.e., decreased MW rates for passages presented over relatively short sections). In this experiment, the between-subjects conditions served as baselines against which within-subject conditions were compared to assess costs and benefits. In Chapter 1, cross-experiment comparisons were consistent with there being a cost (i.e., increased mind-wandering) associated with reading passages with long sections of text in a within-subject design versus a between-subjects design (see Appendix C). I therefore anticipated a cost of increased section length in the present experiment.

Method

Participants

One-hundred and ninety-two students from the University of Waterloo participated in exchange for course credit.

Reading Materials

The same 12 objectively easy passages from the previous experiments, and the same comprehension questions, were used in Experiment 7.

Procedure

Participants were randomly assigned to one of three experimental conditions. In the within-subject condition, four passages were presented one sentence at a time and four were presented one page at a time. These section lengths were identical to the "short" and "long" section lengths used in Experiment 6. In the between-subjects sentence condition, eight passages were presented one sentence at a time; in the between-subjects page condition, eight passages were presented one page at a time. All other aspects of the procedure were identical to Experiment 6, including thought probe placement and timing.

Results

Mind-wandering

Mean MW rates are shown in Table 15. The 7% difference in MW in the within-subject design was nullified in the between-subjects design. Consistent with my hypothesis, MW rates were significantly higher for passages presented in long sections vs. short sections when passage length was manipulated within-subject, $t(63) = 2.28$, $p = 0.03$, $d = 0.32$, but not between-subjects, $t(126) = 0.18$, $p = 0.86$, $d = 0.03$. However, Erlebacher's (1977) analytic method for comparing effects across design types revealed a nonsignificant (though trending) interaction, $F(1, 126) = 2.65$, $MSE = 0.04$, $p = 0.11$, $\eta^2 = 0.01$.

For passages that were presented in short sections, those presented in a within-subject design had significantly lower MW rates than did those presented in a between-subjects design of only short passages, $t(126) = 2.14$, $p = 0.03$, $d = 0.38$. Unexpectedly, this result is consistent with an attentional "benefit" of reading passages with short sections that are intermixed with passages with long sections. For passages that were presented in long sections, MW rates did not differ significantly between the two study designs ($t < 1$). Thus, there was no evidence of an attentional "cost" of reading passages with long sections when they are intermixed with passages with short sections.

Table 15. *Mean mind-wandering rates (with SEs) for passages that were presented across short and long sections in Experiment 7.*

	Short-section Passages	Long-section Passages
Exp. 7 (within)	.229 (.027)	.301 (.029)
Exp. 7 (between)	.308 (.025)	
Exp. 7 (between)		.301 (.026)

Reading comprehension

Mean comprehension scores are displayed in Table 16. In the within-subject design, participants had significantly higher comprehension scores for passages with short sections than for those with long sections, $t(63) = 3.86$, $p < 0.001$, $d = 0.51$. Unexpectedly, participants also had higher comprehension scores for passages with short sections in the between-subjects design, $t(126) = 2.72$, $p = 0.01$, $d = 0.48$. Neither comprehension scores for passages with short sections nor those for passages with long sections differed significantly depending on design type (*t*s < 1). Erlebacher's (1977) analysis revealed a nonsignificant interaction between design types ($F < 1$).

Table 16. *Mean proportion of comprehension questions answered correctly (with SEs) for passages that were presented across short and long sections in Experiment 7.*

	Short-section Passages	Long-section Passages
Exp. 7 (within)	.561 (.019)	.478 (.021)
Exp. 7 (between)	.545 (.018)	
Exp. 7 (between)		.481 (.015)

Subjective ratings

Mean subjective ratings are shown in Table 17. Writing difficulty ratings were significantly higher for passages with long sections compared to those with short sections in the within-subject design, $t(63) = 2.87$, $p = 0.01$, $d = 0.44$, but section length did not have a significant effect on writing difficulty ratings in the between-subjects design, $t < 1$. Consistent with my distinctiveness explanation, Erlebacher's (1977) analysis revealed a significant (though modest) interaction between design types, $F(1, 126) = 4.01$, $MSE = 2.56$, $p = 0.046$, $\eta^2 = 0.01$. Thus, the effect of section length on writing difficulty ratings was significantly larger in the within-subject design than in the between-subjects design.

Topic difficulty ratings also tended to be higher for passages with long sections compared to those with short sections in the within-subject design, $t(126) = 1.71$, $p = 0.09$, $d = 0.23$, whereas section length had a nonsignificant effect on topic difficulty ratings between-subjects, *t*s < 1. The interaction between design types, however, was nonsignificant ($F < 1$).

Writing interest ratings were significantly lower for passages with long sections compared to those with short sections in the within-subject design, $t(63) = 2.61$, $p = 0.01$, $d = 0.37$, and also in the between-subjects design, $t(126) = 2.05$, $p = 0.04$, $d = 0.36$. The interaction between design types was nonsignificant ($F < 1$).

Last, topic interest ratings were significantly lower for passages with long sections compared to those with short sections in the within-subject design, $t(63) = 2.69$, $p = 0.01$, $d = 0.37$, whereas section length did not have a significant effect on topic interest ratings between-subjects, $t(126) = 1.14$, $p = 0.26$, $d = 0.20$. The interaction between design types, however, was nonsignificant ($F < 1$).

To recap, the effect of section length on writing difficulty was significantly larger in the within-subject design than in the between-subjects design, consistent with my distinctiveness explanation for the effect of section length on mind-wandering. However, the effects of section length on the other three subjective measures did not differ significantly depending on the design type (though, in all cases, the within-subject effect was nominally larger than the between-subjects effect). Thus, these results provided only tentative support for my account that distinctive processing in a within-subject design leads to more polarized evaluations of passage based on the distinct dimension of passage length.

Table 17. *Mean subjective ratings (with SEs) of passages that were presented across short and long sections in Experiment 7.*

Condition	Short-section Passages	Long-section Passages
Within (short, long)		
Writing difficulty	3.69 (.22)	4.46 (.22)
Topic difficulty	4.51 (.21)	4.88 (.19)
Writing interest	4.33 (.22)	3.73 (.19)
Topic interest	4.73 (.23)	4.08 (.21)
Between (short)		
Writing difficulty	3.70 (.19)	
Topic difficulty	4.55 (.18)	
Writing interest	4.05 (.17)	
Topic interest	4.29 (.18)	
Between (long)		
Writing difficulty		3.69 (.21)
Topic difficulty		4.58 (.19)
Writing interest		3.54 (.18)
Topic interest		3.99 (.19)

Associations between subjective rating difference scores and MW difference scores

Here I examined the associations between mean difference scores (long-section passages – short-section passages) in the within-subject version of this experiment, to assess whether differences in subjective difficulty ratings and subjective interest ratings were related to differences in mind-wandering rates. As in the previous experiments, composite ratings were used for subjective difficulty and subjective interest. Table 18 shows the correlation coefficients between the mean difference scores (long-section passages – short-section passages) for subjective difficulty, subjective interest, mind-wandering, and comprehension scores. Mean differences in mind-wandering were significantly correlated with mean differences in subjective difficulty and subjective interest, which were significantly correlated with each other.

Table 18. *Correlation coefficients between the averaged difference scores (long-section passage average – short-section passage average) for the composite subjective measures (difficulty, interest), mind-wandering, and reading comprehension, in Experiment 7 (within-subject design).*

	Difficulty	Interest	Mind-wandering	Comprehension
Difficulty	-			
Interest	-.358*	-		
Mind-wandering	.334*	-.619**	-	
Comprehension	-.101	.377*	-.326*	-

† $p < 0.10$, * $p < 0.05$, ** $p < 0.001$

I then regressed participants MW mean difference scores on their subjective difficulty mean difference scores and subjective interest mean difference scores. As anticipated, the regression model explained a significant proportion of the variance in the MW difference scores, $R^2 = 0.40$, $F(2, 61) = 1633$, $p < 0.001$. The intercept was nonsignificant, $b = 0.01$, $t(163) = 0.53$, $p = 0.60$. Subjective interest mean difference scores significantly predicted MW mean difference scores, $b = -0.08$, $t(63) = -4.80$, $p < 0.001$, but subjective difficulty mean difference scores did not, $b = 0.01$, $t(63) = 0.07$, $p = 0.57$. Consistent with the results of the previous experiments, the present results suggested that participants mind-wandered more while reading long-section passages because they were perceived as less interesting, but not because they were perceived as more difficult.

Combined Experiment 6 and 7 analyses

A somewhat surprising result in Experiment 7 was that the difference in MW rates between short-section and long-section passages in the within-subject design was fairly small (7%) relative to the larger difference obtained in Experiment 6 (19.5%). Indeed, when these data were pooled, a mixed-model ANOVA with Experiment (6 vs. 7) as a between-subjects factor and Section length (short vs. long) as a within-subject factor revealed a significant interaction, $F(1, 115) = 5.71$, $MSE = 2.38$, $p = 0.02$, $\eta^2 = 0.05$, signifying that the effect of section length on MW was significantly larger in Experiment 6 than in Experiment 7.

Notably, MW rates were significantly higher for long-section passages in Experiment 6 ($M = .456$) than they were for long-section passages in the between-subjects version of Experiment 7 ($M = 0.301$), $t(115) = 3.31$, $p = 0.001$, $d = 0.62$. It appears that the presence of passages presented in moderate sections in Experiment 6 may have inflated MW rates for passages presented in long sections. Perhaps this occurred because passages with short sections and those with moderate sections both had relatively few words per section (*M*s = 12.52 words/section and 30.40 words/section respectively) compared to passages with long sections (*M* = 257.25 words/section). Thus, in Experiment 6, participants may have perceived the long sections as being *particularly* long—and thus particularly difficult and uninteresting. Consistent with this assumption, difficulty ratings tended to be higher for long-section passages in Experiment 6 vs. Experiment 7 [writing: $t(115) = 1.87$, $p = 0.06$, $d = 0.35$; topic: $t(115) = 1.69$, $p = 0.09$, $d = 0.31$] and interest ratings tended to be lower [writing: $t(115) = 2.06$, $p = 0.04$, $d = 0.38$; topic: $t(115) = 1.85$, $p = 0.07$, $d = 0.34$].

Comparing the within-subject effect of passage section-length on mind-wandering in Experiment 6 (the 19.5% difference across long-section passages and short-section passages) to the between-subjects effect in Experiment 7 (the -0.7% difference between long-section passages and short-section passages) highlights a pronounced difference in the size of within vs. between-subjects effects. Erlebacher's (1977) analysis revealed a nonsignificant interaction between the size of these two effects, $F(1, 104) = 18.16$, $MSE = 0.04$, $p < 0.001$, $\eta^2 = 0.05$.[18] Thus, although the evidence supporting a larger within- vs. between-subjects effect on passage section-length was inconclusive in Experiment 7, taking into account the data from Experiment 6 did provide stronger support, and suggests that this distinctiveness explanation warrants further investigation.

[18] Erlebacher's analysis requires an equal number of participants in the within-subject and between-subjects conditions of an experiment. To meet this requirement, only the first 53 participants from Experiment 6 were included in this analysis (to equal the 53 total participants run in each of the between-subjects versions of Experiment 7).

Chapter 2 Discussion

In this chapter, I examined whether the distinctive processing of section-length information underlies the effect of passage section-length on mind-wandering in a within-subject vs. between-subjects design. Although not definitive, this experiment yielded results that were informative with respect to achieving a better understanding of the effect of section length on mind-wandering. Consistent with my distinctiveness explanation, participants mind-wandered significantly more when reading passages that were presented one page at a time than one sentence at a time in a within-subject design, but not in a between-subjects design. However, the within-subject effect was not significantly larger than the between-subjects effect ($p = 0.11$), which only constitutes tentative support for my claim.

An essential claim of my distinctiveness account (inspired by Hsee & Zhang's, 2004, distinction bias) was that the distinctive processing conferred on the dimension of section-length in a within-subject design would result in this dimension having a stronger impact on subjective ratings of passages in the within-subject design relative to the between-subjects design. I therefore predicted that long-section passages would be perceived as significantly more difficult and less interesting than short-section passages. However, the results were again only suggestive. Although writing difficulty ratings were significantly larger in the within-subject design than in the between-subjects design, the size of the effects of the other three subjective ratings were only nonsignificantly larger in the within-subject design.

Unexpectedly, comprehension scores were significantly higher for short-section passages vs. long-section passages in the between-subjects design even though there was no difference in mind-wandering rates in this design. This pattern of results implies that additional factors (other than mind-wandering) strongly influenced reading comprehension.[19] One possibility is that, given that the multiple-choice comprehension test presented options in short sections of text, participants who also studied passages in short sections of text may have benefitted from a memory advantage due to transfer appropriate processing (Morris, Bransford, & Franks, 1977), in that the studied text and the tested text matched better when sections were short.

Another unexpected result in this experiment was that mind-wandering rates were significantly lower for short-section passages in the within-subject design compared to the between-subjects design, suggesting that the inclusion of long-section passages may reduce mind-wandering for short-section passages (a surprising "benefit"). There was no evidence of a congruent cost to reading long-section passages in a within-subject vs. a between-subjects design. Why might mind-wandering rates have been lower for passages with short sections in a within-subject vs. between-subjects design? One possibility is that passages presented over pages of text served as a baseline in the within-subject version of this experiment, against which participants anchored their evaluations of passages presented over sentences. Passages presented over pages may have constituted a baseline because, in an academic context, participants are accustomed to reading full pages of text. Thus, the passages presented over sentences may have been perceived as less difficult and more interesting relative to this baseline. Conversely, in Experiment 6, more passages were presented in relatively short sections of text (passages presented in moderate-length sections were more similar in section length to short-section passages than to long-section passages). Thus, in Experiment 6, the short- and moderate-section

[19] Correlational analyses showed a significant inverse relation between mind-wandering and comprehension in Experiments 1-6 (see Tables 6-9, 13, 14) and in the present experiment [within-subject design: $r(63) = -0.48$, $p < 0.001$; between-subject design: short-section passages: $r(63) = -0.46$, $p < 0.001$; long-section passages: $r(63) = -0.31$, $p = 0.01$].

passages may have constituted the baseline against which the long-section passages were perceived as more difficult and less interesting. Further research is needed to determine the factors that yield attentional costs vs. benefits.

In summary, the results of the present experiment provided only tentative support for my distinctiveness explanation. As predicted, the within-subject effect of section length on mind-wandering was larger than the between-subjects effect (which was nonsignificant), but the interaction did not reach significance. This nonsignificant interaction could be attributed to the fact that the within-subject effect of section length on mind-wandering was smaller than expected—especially given the robust effects obtained in Experiment 6. Indeed, the within-subject difference in mind-wandering across short-section and long-section passages in Experiment 6 was significantly larger than the difference across these same two conditions in Experiment 7.

The difference in the size of these within-subject effects could be attributed to the different contexts in which participants experienced short-section and long-section passages in these two experiments. The larger effect in Experiment 6 raises the intriguing possibility that the inclusion of the "middle" condition (i.e., moderate-section passages) may have amplified the size of the mind-wandering difference between short-section and long-section passages, perhaps because participants perceived the long-section passages as being particularly long—and therefore difficult and uninteresting—relative to the short-section and moderate-section passages (which were more comparable in length). Thus, an important implication of these results is that they demonstrate that the context of the experiment matters. Different experimental designs change the context of the experiment and may differentially impact mind-wandering. The context in which participants experience the conditions may not only lead to different mind-wandering rates in within-subject vs. between-subjects designs, but may also lead to different mind-wandering rates in a three level within-subject design (e.g., Experiment 6) vs. a two level within-subject design (e.g., Experiment 7).

If the context engendered by experimental design influences the effect of passage section-length on mind-wandering, then a potentially disconcerting implication would be that several other effects in the mind-wandering literature may be constrained to the within-subject design in which they have been typical observed. Consider, for example, the seminal finding that mind-wandering decreases as task demands increase. Researchers reporting this result have generally used within-subject (typically blocked) designs (e.g., Antrobus et al., 1966; Antrobus, 1968; Filler & Giambra, 1973; Forster & Lavie, 2009; Grodsky & Giambra, 1990; Giambra, 1995; Mason et al., 2007; McKiernan et al., 2006; Stuyven & Van der Goten, 1995; Smallwood et al., 2003; Teasdale et al., 1993; Thomson et al., 2013). If these effects do not replicate between-subjects, as the present distinctiveness theory suggests, then this would challenge Smallwood and Schooler's (2006) executive resource theory. I intend to investigate this possibility in future research.

Chapter 3

Evidence that increased mind-wandering over reading time is related to decreased interest

Intuition suggests that as a student's study time increases—whether listening to a lecture or reading a textbook—so too does his or her tendency to mind-wander. Consistent with this intuition, Risko et al. (2012) found that as participants' mind-wandering increased over the course of an online lecture, their memory for the lecture material decreased (cf. Wammes, Boucher, Seli, Cheyne, & Smilek, 2016). In this chapter, I first examined whether mind-wandering increases over time spent reading passages. Second, I explored the effect of objective difficulty on mind-wandering over time (at the group level), with the aim of shedding more light on the mechanisms underlying this effect in the sentence presentation mode. Third, at the individual level, I examined the relations between mind-wandering over passages and subjective difficulty/interest ratings over passages, to determine which of these subjective ratings was more strongly linked to participants' mind-wandering over time.

Pooling the data from Experiments 1 and 3 (sentence presentation) yielded a large dataset with higher statistical power to detect increases in mind-wandering over passages. My main hypothesis was that, overall (averaging across objectively easy and hard passages), participants' mind-wandering rates increased over passages in these experiments, and their subjective interest ratings, in contrast, decreased over passages. This pattern of results would suggest that decreasing interest over passages led to increasing mind-wandering over passages.

The possibility of a strong linkage between interest and mind-wandering over time is consistent with the strong relation observed between subjective interest ratings and mind-wandering in Experiments 1 and 3. In those experiments, differences in mind-wandering across objectively easy and hard passages were significantly related to differences in subjective interest across objectively easy and hard passages. Although this relation between subjective interest and mind-wandering was with respect to difference scores across objective difficulty conditions, I also expected that participants' subjective interest ratings were strongly related to their tendency to mind-wander on any given passage.

Given this ample evidence of a strong relation between subjective interest and mind-wandering (in the present research and in the mind-wandering literature more broadly; see, e.g., Jackson & Balota, 2012; Kane et al., 2007; Lindquist & McLean, 2011), I expected to find a pattern of results that would be consistent with the possibility that decreasing interest over passages led to increasing mind-wandering over passages. Relatedly, I also hypothesized that participants' reading times decreased over passages. Decreasing reading times would be suggestive of more frequent skim reading, a behaviour that would also be consistent with participants' interest (and perhaps motivation) decreasing over passages. Just as mind-wandering has been linked to rapid responding on the SART (a go/no-go task; Cheyne, Solman, Carriere, & Smilek, 2009), it may also be associated with skim reading.

I also hypothesized that participants' reading comprehension decreased over passages. This prediction was based on prior research showing a strong relation between mind-wandering and reading comprehension (e.g., Schooler et al., 2004), as well as research showing that performance decreases as mind-wandering increases over time-on-task (Cunningham et al., 2000; McVay & Kane, 2012a; Smallwood, 2004; Risko et al., 2012; Teasdale et al., 1993; Thomson et al., 2014; cf. Head & Helton, 2014).

To recap, in this chapter, I analyzed the data from Experiments 1 and 3 (sentence presentation condition) over passages at the group level. I had the following four predictions regarding the effects of the dependent measures over passages (i.e., averaging across objective difficulty conditions). First, Mind-wandering rates would increase over passages. Second, comprehension scores would decrease over passages. Third, interest ratings would decrease over passages. And fourth, reading times would decrease over passages. These hypothesized results would be consist with the possibility that mind-wandering increased (and comprehension correspondingly decreased) over passages because subjective interest decreased over passages (which may have also increased participants' tendency to skim read).

An alternate possibility worth exploring is that mind-wandering may have increased over passages because participants perceived successive passages as increasingly difficulty (perhaps stemming from fatigue). This possibility is consistent with McVay and Kane's (2009, 2010) *executive failure hypothesis.* They contend that a function of the central executive system is to stifle mind-wandering in service of sustaining attention on the primary task. However, when task demands are high, the central executive can be overburdened, reducing its effectiveness. If participants' mind-wandering rates and their subjective difficulty ratings increased over passages, then this result would be consistent with the executive failure hypothesis. Thus, assuming that mind-wandering rates increased over passages, it is plausible that this increase was related both to decreased subjective interest and to increased subjective difficulty over passages. Although these exploratory analyses did not test for these relations statistically, they were nonetheless informative insofar as they could reveal patterns that were either consistent or inconsistent with these possible relations.

My second goal in this chapter was to shed light on the mechanisms underlying the effect of objective difficulty on mind-wandering at the group level by exploring the "time course" of this effect (over passages). Although these results suggested that participants may have mind-wandered more while reading passages with longer (objectively hard) vs. shorter (objectively easy) sections because they found them less interesting, it is possible that differences in subjective interest between these two types of passages developed over time. Perhaps this effect increased in magnitude over the course of the experiment due to participants' interest in the hard passages decreasing more rapidly over time than their interest in the easy passages. When participants started the experiment, they may have been equivalently interested in both types of passages due to being fairly motivated to perform well at the reading task. However, assuming that participants' motivation waned over the course of the experiment, they may have been progressively less interested in objectively hard passages in particular, if we assume that longer sections of text stood out as an undesirable feature.

Following the group-level analyses, my third goal was to explore, at the level of the individual, the relations between mind-wandering over passages and subjective difficulty/interest ratings over passages. Recall that the individual difference analyses in Chapters 1 and 2 suggested that differences in subjective interest ratings across easy and hard passages were significantly related to differences in mind-wandering ratings across easy and hard passages, but differences in subjective difficulty ratings typically were nonsignificantly related to differences in mind-wandering ratings. Those results were consistent with the possibility that subjective interest ratings are more strongly related to mind-wandering ratings than are subjective difficulty ratings. Therefore, I expected that the "over passage" analyses in the present chapter would also reveal a stronger relation between subjective interest ratings and mind-wandering (compared to the relation between subjective difficulty ratings and mind-wandering).

Results

Analytic strategy (group-level analyses)

I pooled the sentence presentation data from Experiments 1 and 3 (N = 253) and grouped them in four successive blocks that each contained one easy passage and one hard passage. Tables 19-25 show the means for the following measures over blocks: MW rates (Table 19), comprehension scores (Table 20), writing interestingness (Table 21), topic interestingness (Table 22), writing difficulty (Table 23), topic difficulty (Table 24), and reading times (Table 25). These results are also displayed in Appendix D (Figures D1-D7). It can be seen that mean differences between hard and easy passages for each measure (except for writing difficulty) increased from block 1-4, with the largest increases typically occurring between blocks 1 and 2.

I conducted a series of mixed-model ANOVAs for each measure in which Experiment (1 vs. 3) was a between-subjects factor and Objective reading difficulty (easy vs. hard) and Block (1 vs. 2 vs. 3 vs. 4) were within-subject factors. The Experiment term only rarely interacted with these factors or had a significant main effect (see footnotes), reflecting the fact that the pattern of data was largely consistent across the two experiments.

Mind-wandering rates

There was a significant main effect of Objective reading difficulty, $F(1, 246) = 62.95$, $MSE = 0.90$, $p < 0.001$, $\eta^2 = 0.20$, with more overall MW reported for hard passages, and a main effect of Block, $F(3, 738) = 56.43$, $MSE = 0.08$, $p < 0.001$, $\eta^2 = 0.19$, indicative of MW rates increasing over blocks. More importantly, there was a significant Objective reading difficulty x Block interaction, $F(3, 738) = 6.25$, $MSE = 0.10$, $p < 0.001$, $\eta^2 = 0.02$. The linear contrast of this interaction term was also statistically significant, $F(1, 246) = 14.49$, $MSE = 0.10$, $p < 0.001$, $\eta^2 = 0.06$, suggesting that the difference in MW rates between easy and hard passages increased monotonically over blocks. Paired t-tests revealed that the difference in MW rates between the easy and hard passages was nonsignificant in the first block of the experiment ($p = 0.45$), but significant in blocks 2-4 (ps < 0.001).

Reading comprehension

There was a significant main effect of Objective reading difficulty, $F(1, 251) = 11.22$, $MSE = 0.08$, $p = 0.001$, $\eta^2 = 0.04$, with lower overall reading comprehension for hard passages, and a nonsignificant main effect of Block, $F(3, 753) = 1.15$, $MSE = 0.07$, $p = 033$, $\eta^2 = 0.004$. The Objective reading difficulty x Block interaction was trending, $F(3, 753) = 2.17$, $MSE = 0.07$, $p = 0.09$, $\eta^2 = 0.01$, and the linear contrast of this interaction term was statistically significant, $F(1, 251) = 6.06$, $MSE = 0.07$, $p = 0.01$, $\eta^2 = 0.02$, suggesting that the difference in comprehension scores between easy and hard passages increased linearly over blocks. The difference in comprehension scores between easy and hard passages was nonsignificant in the first block ($p = 0.93$), was trending in the second and third blocks ($p = 0.10$, $p = 0.06$), and was significant in the fourth block ($p = 0.001$).

Subjective interest ratings

For writing interest ratings, there was a significant main effect of Objective reading difficulty, $F(1, 231) = 13.66$, $MSE = 6.40$, $p < 0.001$, $\eta^2 = 0.06$, with hard passages tending to receive lower writing interest ratings, and a significant main effect of Block, $F(3, 693) = 2.71$, $MSE = 4.50$, $p = 0.04$, $\eta^2 = 0.01$, indicative of writing interest ratings decreasing over blocks. The Objective reading difficulty x Block interaction was significant, $F(3, 693) = 3.46$, $MSE = 4.60$, $p = 0.02$, $\eta^2 = 0.01$, as was the linear contrast of this term, $F(1, 231) = 8.49$, $MSE = 4.63$, $p = 0.004$, $\eta^2 = 0.04$, suggesting that difference in writing interest ratings between easy and hard passages increased linearly over blocks. The difference in writing interest ratings between easy and hard passages was nonsignificant in the first block (p = 0.55), but was significant in blocks 2-4 (ps < 0.05).

For topic interest ratings, there was a significant main effect of Objective reading difficulty, $F(1, 225) = 19.93$, $MSE = 9.12$, $p < 0.001$, $\eta^2 = 0.08$, with hard passages tending to receive lower topic interest ratings, and a significant main effect of Block, $F(3, 675) = 6.46$, $MSE = 5.96$, $p < 0.001$, $\eta^2 = 0.03$, indicative of topic interest ratings decreasing over blocks. The Objective reading difficulty x Block interaction was also significant, $F(3, 675) = 2.82$, $MSE = 7.23$, $p = 0.04$, $\eta^2 = 0.01$, as was the linear contrast of this term, $F(1, 225) = 7.06$, $MSE = 5.78$, $p = 0.01$, $\eta^2 = 0.03$, suggesting that difference in topic interest ratings between easy and hard passages increased linearly over blocks. The difference in topic interest ratings between easy and hard passages was nonsignificant in the first block (p = 0.49), but was significant in blocks 2-4 (ps < 0.05).

Subjective difficulty ratings

For writing difficulty ratings, there was a significant main effect of Objective reading difficulty, $F(1, 248) = 59.37$, $MSE = 5.81$, $p < 0.001$, $\eta^2 = 0.19$, with hard passages tending to receive higher writing difficulty ratings, and a marginally significant main effect of Block, $F(3, 744) = 2.55$, $MSE = 4.34$, $p = 0.054$, $\eta^2 = 0.01$, indicative of writing difficulty ratings tending to decrease over blocks. The Objective reading difficulty x Block interaction was nonsignificant, ($F < 1$). Across all four blocks, writing difficulty ratings were significantly higher for hard passages than for easy passages (ps < 0.001).

For topic difficulty ratings, there was a significant main effect of Objective reading difficulty, $F(1, 231) = 20.62$, $MSE = 6.40$, $p < 0.001$, $\eta^2 = 0.08$, with hard passages tending to receive higher topic difficulty ratings, and a significant main effect Block, $F(3, 693) = 3.25$, MSE

= 5.73, $p = 0.02$, $\eta^2 = 0.01$, indicative of topic difficulty ratings decreasing over blocks. Although the Objective reading difficulty x Block interaction was nonsignificant, $F(3, 693) = 1.40$, $MSE = 6.31$, $p = 0.24$, $\eta^2 = 0.01$[20], there was some evidence that this effect increased over blocks. The difference in topic difficulty ratings between easy and hard passages was nonsignificant in the first block ($p = 0.26$), but was significant in blocks 2-4 (ps < 0.05).

Reading times

There was a significant main effect of Objective reading difficulty, $F(1, 251) = 16.07$, $MSE = 2616.57$, $p < 0.001$, $\eta^2 = 0.06$, with hard passages tending to have shorter reading times, and a robust main effect of Block, $F(3, 753) = 127.82$, $MSE = 2559.20$, $p < 0.001$, $\eta^2 = 0.34$, indicative of reading times decreasing substantially over blocks.[21] The Objective reading difficulty x Block interaction was significant, $F(3, 753) = 3.20$, $MSE = 1413.99$, $p = 0.02$, $\eta^2 = 0.01$, as was the linear contrast of this term, $F(1, 251) = 7.00$, $MSE = 1691.10$, $p = 0.01$, $\eta^2 = 0.03$, suggesting that the difference in reading times between easy and hard passages increased linearly over blocks. The difference in reading times between easy and hard passages was nonsignificant in the first block ($p = 0.83$), marginally significant in the second block ($p = 0.06$), and significant in the third and fourth blocks (ps < 0.001).

[20] For topic difficulty ratings, there was a main effect of Experiment, $F(1, 231) = 4.06$, $MSE = 16.09$, $p = 0.045$, $\eta^2 = 0.02$, with topic difficulty ratings tending to be slightly higher in Experiment 3 than in Experiment 1, and a significant Experiment x Block interaction, $F(3, 693) = 5.10$, $MSE = 5.73$, $p = 0.002$, $\eta^2 = 0.02$, with topic difficulty ratings tending to decrease more substantially across blocks in Experiment 3.

[21] There was also a main effect of Experiment, $F(1, 251) = 4.87$, $MSE = 25347.36$, $p = 0.03$, $\eta^2 = 0.02$, signifying overall shorter reading times in Experiment 3.

Table 19. *Mean mind-wandering rates (with SEs) over four experimental blocks in Experiment 1, Experiment 3 (sentence presentation condition), and their combined data. Each block consisted of one objectively easy and one objectively hard passage.*

Experiment	Easy passage	Hard passage
Experiment 1		
Block 1	.236 (.020)	.260 (.023)
Block 2	.284 (.027)	.425 (.029)
Block 3	.359 (.027)	.466 (.029)
Block 4	.427 (.029)	.559 (.030)
Experiment 3 (sentences)		
Block 1	.219 (.029)	.225 (.033)
Block 2	.255 (.035)	.398 (.040)
Block 3	.316 (.038)	.454 (.043)
Block 4	.332 (.037)	.527 (.042)
Combined		
Block 1	.229 (.016)	.246 (.019)
Block 2	.273 (.021)	.415 (.023)
Block 3	.342 (.022)	.461 (.024)
Block 4	.390 (.023)	.547 (.025)

Table 20. *Mean proportion of comprehension questions answered correctly (with SEs) over four blocks in Experiment 1, Experiment 3 (sentence presentation condition), and their combined data. Each block consisted of one objectively easy and one objectively hard passage.*

Experiment	Easy passage	Hard passage
Experiment 1		
Block 1	.535 (.022)	.527 (.023)
Block 2	.535 (.024)	.506 (.022)
Block 3	.541 (.023)	.485 (.025)
Block 4	.519 (.022)	.448 (.023)
Experiment 3 (sentences)		
Block 1	.541 (.026)	.548 (.028)
Block 2	.541 (.029)	.484 (.029)
Block 3	.533 (.028)	.505 (.0290
Block 4	.587 (.028)	.482 (.030)
Combined		
Block 1	.537 (.017)	.535 (.018)
Block 2	.537 (.019)	.498 (.018)
Block 3	.538 (.018)	.493 (.019)
Block 4	.545 (.017)	.461 (.018)

Table 21. *Mean subjective writing interest ratings (with SEs) over four blocks in Experiment 1, Experiment 3 (sentence presentation condition), and their combined data. Each block consisted of one objectively easy and one objectively hard passage.*

Experiment	Easy passage	Hard passage
Experiment 1		
Block 1	3.82 (.20)	3.77 (.19)
Block 2	4.37 (.22)	3.92 (.21)
Block 3	4.01 (.21)	3.64 (.20)
Block 4	3.92 (.21)	3.11 (.20)
Experiment 3 (sentences)		
Block 1	3.68 (.25)	4.00 (.24)
Block 2	4.35 (.26)	3.81 (.24)
Block 3	4.22 (.23)	3.53 (.25)
Block 4	4.21 (.25)	3.64 (.26)
Combined		
Block 1	3.77 (.15)	3.86 (.15)
Block 2	4.36 (.17)	3.88 (.16)
Block 3	4.09 (.16)	3.60 (.15)
Block 4	4.03 (.16)	3.32 (.16)

Table 22. *Mean subjective topic interest ratings (with SEs) over four blocks in Experiment 1, Experiment 3 (sentence presentation condition), and their combined data. Each block consisted of one objectively easy and one objectively hard passage.*

Experiment	Easy passage	Hard passage
Experiment 1		
Block 1	4.51 (.22)	4.25 (.23)
Block 2	4.93 (.24)	4.08 (.24)
Block 3	4.29 (.24)	3.88 (.24)
Block 4	4.40 (.23)	3.12 (.23)
Experiment 3 (sentences)		
Block 1	4.13 (.30)	4.11 (.27)
Block 2	5.32 (.29)	4.35 (.30)
Block 3	4.48 (.29)	3.69 (.31)
Block 4	4.67 (.29)	3.89 (.30)
Combined		
Block 1	4.37 (.18)	4.19 (.17)
Block 2	5.08 (.19)	4.19 (.19)
Block 3	4.36 (.19)	3.81 (.19)
Block 4	4.50 (.18)	3.42 (.18)

Table 23. *Mean subjective writing difficulty ratings (with SEs) over four blocks in Experiment 1, Experiment 3 (sentence presentation condition), and their combined data. Each block consisted of one objectively easy and one objectively hard passage.*

Experiment	Easy passage	Hard passage
Experiment 1		
Block 1	3.40 (.21)	4.35 (.21)
Block 2	3.03 (.20)	4.11 (.21)
Block 3	3.08 (.20)	3.99 (.21)
Block 4	3.32 (.20)	3.86 (.21)
Experiment 3 (sentences)		
Block 1	3.44 (.25)	4.32 (.28)
Block 2	3.27 (.24)	3.99 (.24)
Block 3	3.27 (.22)	3.88 (.25)
Block 4	2.86 (.22)	4.15 (.26)
Combined		
Block 1	3.42 (.16)	4.34 (.17)
Block 2	3.12 (.15)	4.06 (.16)
Block 3	3.15 (.15)	3.95 (.16)
Block 4	3.14 (.15)	3.97 (.16)

Table 24. *Mean subjective topic difficulty ratings (with SEs) over four blocks in Experiment 1, Experiment 3 (sentence presentation condition), and their combined data. Each block consisted of one objectively easy and one objectively hard passage.*

Experiment	Easy passage	Hard passage
Experiment 1		
Block 1	4.94 (.23)	5.04 (.20)
Block 2	3.90 (.21)	4.51 (.23)
Block 3	3.84 (.22)	4.37 (.22)
Block 4	4.02 (.20)	4.51 (.21)
Experiment 3 (sentences)		
Block 1	4.57 (.28)	5.05 (.26)
Block 2	4.46 (.29)	4.73 (.27)
Block 3	4.54 (.28)	5.38 (.28)
Block 4	4.11 (.29)	5.10 (.27)
Combined		
Block 1	4.80 (.18)	5.05 (.16)
Block 2	4.15 (.17)	4.60 (.17)
Block 3	4.11 (.18)	4.76 (.18)
Block 4	4.06 (.18)	4.74 (.17)

Table 25. *Mean reading times in seconds (with SEs) over four blocks in Experiment 1, Experiment 3 (sentence presentation condition), and their combined data. Each block consisted of one objectively easy and one objectively hard passage.*

Experiment	Easy passage	Hard passage
Experiment 1		
Block 1	199.08 (6.30)	199.64 (6.42)
Block 2	171.93 (4.84)	165.30 (5.90)
Block 3	157.05 (4.94)	141.47 (5.74)
Block 4	137.82 (5.09)	123.50 (5.90)
Experiment 3 (sentences)		
Block 1	205.42 (7.21)	202.07 (8.05)
Block 2	193.25 (8.00)	184.57 (7.34)
Block 3	174.68 (5.93)	161.42 (6.34)
Block 4	158.09 (6.50)	144.51 (7.42)
Combined		
Block 1	201.54 (4.76)	200.58 (5.01)
Block 2	180.19 (4.33)	172.76 (4.63)
Block 3	163.88 (3.83)	149.20 (4.32)
Block 4	145.67 (4.05)	131.65 (4.65)

Summary of group-level analyses

As predicted, overall MW rates tended to increase over passages, and reading comprehension and reading times decreased over passages. Subjective interest ratings also decreased over passages, but only for objectively hard passages, suggesting that participants' motivation may have declined more sharply for these passages.

Strikingly, the objective reading difficulty manipulation was increasingly impactful over the course of the experiment for every measure but subjective writing difficulty. There was a nonsignificant difference in MW rates after participants read one easy and one hard passage (i.e., block 1), as well as nonsignificant differences for every other measure except for writing difficulty. Thus, the objective difficulty manipulation initially only had the intended effect of influencing participants' perceptions of writing difficulty, but this difference did not have an immediate impact on MW rates. Perhaps as participants became increasingly bored over time, their motivation to read the hard passages decreased. This possibility is supported by the steep decline in interest ratings and reading times over blocks for hard passages.

Individual-level analyses

These analyses explored, at the individual level, the relation between subjective interest over passages and mind-wandering over passages and the relation between subjective difficulty ratings and mind-wandering over passages. I expected that, for both objectively easy and objectively hard passages, mind-wandering over passage blocks would be more strongly related to subjective interest over blocks than to subjective difficulty over blocks. In order to avoid multicollinearity issues in the analyses below, composite subjective difficulty scores were computed (as in Chapters 1 and 2) by averaging each participant's two difficulty ratings (writing and topic) for each passage, and composite subjective interest scores were computed in the same manner.

To assess the strength of these relations between these measures over blocks, simple slopes were calculated for each participant that represented: a) changes in mind-wandering as a function of passage block, b) changes in subjective difficulty ratings as a function of passage block, and c) changes in subjective interest ratings as a function of passage block. Slopes were calculated separately for the objectively easy passages and for the objectively hard passages. Table 26 shows the Pearson correlations between participants' slopes over blocks for mind-wandering, subjective difficulty ratings, and subjective interest ratings. For both objectively easy and objectively hard passages, there was a significant positive relation between subjective difficulty slopes and mind-wandering slopes and a significant negative relation between subjective interest slopes and mind-wandering slopes.

Next, I conducted a regression analyses to determine whether participants' slopes for difficulty and slopes for interest were significant predictors of their slopes for mind-wandering. Again, separate regressions were conducted for objectively easy and objectively hard passages. For objectively easy passages, the regression model explained a significant proportion of the variance in the slopes for mind-wandering, $R^2 = 0.23$, $F(2, 252) = 37.31$, $p < 0.001$. The intercept was also significant, $b = 0.06$, $t(252) = 7.76$, $p < 0.001$. More importantly, subjective interest slopes significantly predicted mind-wandering slopes, $b = -0.06$, $t(252) = -7.91$, $p < 0.001$, but subjective difficulty slopes did not, $b = 0.005$, $t(252) = 0.55$, $p = 0.58$.

For objectively hard passages, the regression revealed the same pattern of results. The regression model again explained a significant proportion of the variance in the slopes for mind-wandering, $R^2 = 0.10$, $F(2, 252) = 13.98$, $p < 0.001$. The intercept was significant, $b = 0.09$, *t*(252) = 9.15, $p < 0.001$. More importantly, subjective interest slopes significantly predicted mind-wandering slopes, $b = -0.05$, $t(252) = -4.85$, $p < 0.001$, but subjective difficulty slopes did not, $b = 0.003$, $t(252) = 0.26$, $p = 0.80$.[22]

Table 26. *Correlation coefficients between the simple slopes for the composite subjective measures (difficulty, interest) as a function of passage block and mind-wandering as a function of passage block for the combined Experiments 1 and 3 (sentence presentation) data.*

	Difficulty	Interest	Mind-wandering
Objectively easy passages			
Difficulty	-		
Interest	-.342**	-	
Mind-wandering	.192*	-.478**	-
Objectively hard passages			
Difficulty	-		
Interest	-.352**	-	
Mind-wandering	.126*	-.317**	-

* $p < 0.05$, ** $p < 0.001$

[22] When the data were collapsed across objective difficulty conditions and the same analyses were performed across all 8 passages (rather than across 4 blocks), the pattern of results was identical. The same results were significant/nonsignificant as when each objective difficulty level was analyzed separately.

In summary, at the individual level, mind-wandering simple slopes (over passages) were significantly related to both subjective difficulty simple slopes and subjective interest simple slopes. However, only subjective interest ratings slopes significantly predicted mind-wandering slopes in a regression analysis. This pattern of results tentatively suggests that decreasing interest over passages leads to increasing mind-wandering over passages. However, a causal relation cannot be demonstrated using the present data. It is also possible that increasing mind-wandering over passages leads to decreasing subjective interest ratings over passages.

Chapter 3 Discussion

These exploratory analyses revealed several notable results. First, at the group level, as participants' mind-wandering increased over successive passages, their comprehension tended to decrease. This result suggests that the relation between mind-wandering and reading comprehension (e.g., Schooler et al., 2004), may extend over time spent reading, which is consistent with prior research showing a coherence between mind-wandering and performance over time on a variety of cognitive tasks (Cunningham et al., 2000; McVay & Kane, 2012a; Smallwood, 2004; Risko et al., 2012; Teasdale et al., 1995; Thomson et al., 2014). Appendix E provides further analytic evidence of a relation between mind-wandering and reading comprehension over time.

As predicted, participants' subjective interest ratings tended to decrease over passages (averaging across easy and hard passages). This result suggests that waning motivation over time may lead to increased mind-wandering, in line with intuition. Consistent with this explanation, low motivation has been linked to increased mind-wandering during lectures (Seli, Wammes, Risko, & Smilek, 2015) and while performing the SART (Seli, Cheyne, Xu, Purdon, & Smilek, 2015; see also Antrobus et al., Experiment 2), and while reading (Unsworth & McMillan, 2013). Indeed, Unsworth and McMillan found that motivation mediated the relation between topic interest and mind-wandering.

Another result from the present analyses that was consistent with the possibility that participants were becoming less motivated over time is that participants' reading times decreased precipitously over passages (especially for objectively hard passages). It would appear that as participants mind-wandered more frequently they also tended to decrease the amount of effort they put into the reading task (perhaps opting to skim-read). This result is consistent with research showing that re-reading—which may also increase individuals' tendency to skim-read—is related to increased mind-wandering (Phillips et al., 2016), presumably because skim-reading frees up resources for mind-wandering. In short, decreasing interest over passages appears to be related to increasing mind-wandering and decreasing reading times. Motivation may have mediated the relation between interest and reading times and may also have mediated the relation between interest and mind-wandering (see Unsworth & McMillan, 2013). Future experiments ought to investigate this possibility by measuring participants' motivation to read each passage.

Surprisingly, subjective difficulty ratings did not increase over passages; in fact, they even decreased slightly. Declining subjective difficulty suggests that participants may have exerted less effort as they progressively withdrew from the reading task. Thus, decreasing subjective difficulty may have arisen due to decreased motivation and task disengagement as opposed to executive resource failure (McVay & Kane, 2009, 2010). The fact that subjective difficulty ratings were only moderate (i.e., at around the mid-point of the 11-point scale) and decreased over passages suggests that executive failure did not lead to increased mind-wandering over passages. The more likely possibility appears to be that decreased interest/motivation led to increased mind-wandering.

These exploratory analyses provided further insight into the underpinnings of the effect of objective difficulty on mind-wandering. It is particularly noteworthy that this effect was small (1.7%) and nonsignificant in block 1 and then became sizeable (14.2%) and significant in block 2 (despite the fact that, in block 1, participants had rated the hard passage that they read as having more difficult writing than the easy passage). This result suggests that, although participants detected a difference in writing difficulty between easy and hard passages after only having read two passages, this difference seemingly did not impact their tendency to mind-wander. Rather, it would appear that another factor—one that became increasing influential as the experiment progressed—resulted in the size of the effect of objective difficulty on mind-wandering becoming increasingly large over time. I contend that this factor was interest. Participants' subjective interest ratings declined precipitously over the course of the experiment (for hard passages in particular). Although mind-wandering ratings over passages were equally highly correlated with interest ratings for both easy and hard passages, the steeper decline in interest ratings over hard passages does appear to have contributed to the steeper ascent in mind-wandering.

Note that this pattern of results over passages is inconsistent with Feng et al.'s (2013) explanation that participants mind-wander more for objectively hard vs. easy passages because greater reading difficulty causes participants to be less successful in building a situation model for objectively difficult passages, leading to increased mind-wandering (in line with Smallwood et al.'s, 2007, cascade model of inattention). Had this been the case, one would expect higher mind-wandering rates for objectively hard vs. easy passages in the first passage block of the dataset, given that participants perceived their first objectively hard passage to have higher writing difficulty than their first objectively easy passage. Moreover, cascading inattention seemingly would not lead to increasing mind-wandering *over* passages because the failure to build an internal representation/narrative of one passage ought not to increase mind-wandering for a subsequent passage, given that each passage has its own unique topic.

Assuming that participants' struggle to build a situation model for objectively hard passages led them to mind-wander more for these passages, then one would expect to find that mind-wandering rates increased across thought probes for objectively hard passages (due to cascading inattention; Smallwood et al., 2007) but not for the objectively easy passages. I investigated this possibility in Appendix F and found that mind-wandering increased across thought probes for both objectively easy and hard passages. Surprisingly, this increase in mind-wandering across thought probes actually tended to be larger for objectively easy passages than for objectively hard passages. Those results therefore suggest that cascading attention was unlikely to be responsible for the effect of objective difficulty on mind-wandering. Instead of cascading inattention, the results of these "over passage" analyses appear to be more consistent with the explanation that the effect of objective difficulty on mind-wandering occurs in the sentence presentation mode because the objectively hard passages are perceived as progressively less interesting over the course of the experiment—perhaps because their relatively longer sections of text become progressively more unappealing as participants' motivation declines.

Last, individual difference analyses revealed that changes in participants' mind-wandering over passages (in terms of simple slopes) were negatively related to their subjective interest ratings over passages and positively related to their subjective difficulty ratings over passages. But only subjective interest ratings over passages were a significant predictor of mind-wandering over passages. It cannot be determined from these correlational data whether decreasing subjective interest over passages leads to increasing mind-wandering, or whether increased mind-wandering over passages leads participants to infer that are becoming less interested. However, along with the regression analyses from Chapters 1 and 2, the present results provided converging evidence that subjective interest is more strongly related to participants' tendency to mind-wander than is subjective difficulty.

Concluding Remarks

Main findings

This work contributed to the literature on mind-wandering while reading by revealing three key results:

1) The effect of objective reading difficulty on mind-wandering is confounded by passage section length when passages are presented one sentence at a time (Chapter 1).

In the sentence presentation mode, objectively hard passages have longer sections of text than objectively easy passages. Section length was found to be positively associated with subjective difficulty and strongly negatively associated with subjective interest, and subjective interest was consistently a significant predictor of mind-wandering A methodological implication of this finding is that researchers examining the effect of objective difficulty on mind-wandering should use full pages of text (or at least equivalently long sections; e.g., Mills et al., 2015) to preclude section length from confounding their results.

2) Individuals mind-wander more when reading passages presented over long vs. short sections of text in a within-subject design but not in a between-subjects design (Chapter 2).

Although the within-subject effect of section length on mind-wandering had been robust and reliable across several experiments, it was nullified in a between-subjects design. These contrasting results were consistent with the possibility that distinctive processing (Hunt, 2006) plays an influential part in influencing individuals' tendency to mind-wander (although the interaction between design types was only trending, $p = 0.11$, so more research is needed to test this explanation). These results suggest that the context in which participants experience tasks in a mind-wandering experiment—as determined, to some extent, by the experimental design—influences their mind-wandering. Another result that was consistent with this interpretation was that the effect of passage section-length on mind-wandering was significantly larger in the three-level design from Experiment 6 (that had short-section, moderate-section, and long-section passages) vs. the two-level design from Experiment 7 (that had only short-section and long-section passages). Even though participants experienced both short-section and long-section passages in these two experiments, the inclusion of the moderate-section passages in Experiment 6 represented a contextual factor that may have influenced participants' perception of the other types of passages.

3) **The effect of objective difficulty on mind-wandering increases over the course of reading multiple passages (Chapter 3).**

In experiments that presented passages one sentence at a time, there was no effect of objective reading difficulty on mind-wandering at the first passage block (i.e., one easy vs. one hard passage). This result provides converging support for the claim that objective difficulty solely cannot explain differences in mind-wandering. Over the course of the experiment, however, as interest declined, significant effects on mind-wandering emerged. Moreover, at the individual level, subjective interest ratings over passages were negatively related to mind-wandering rates over passages (i.e., when interest decreased over passages, mind-wandering tended to increase). An important implication of this pattern of results is that time on task can drastically influence the results of mind-wandering research due to decreasing interest. Researchers studying mind-wandering should therefore be cognizant that decreasing interest/motivation over time may have a similarly strong impact on the effect they are studying.

Future directions

A central theme that emerged in this work is that interest is a theoretically important factor in mind-wandering research. Subjective interest ought to be measured routinely in research that focuses on the impact of task difficulty on mind-wandering. As demonstrated in Chapter 1, experiments that manipulate task difficulty are likely to also influence subjective interest, and it may be the effect on subjective interest that influences mind-wandering. Future research should investigate the possibility that subjective difficulty mediates the relation between task difficulty and mind-wandering.

A second main theoretical implication is that the experimental design influences the context in which participants experience a given task, and may thereby influence mind-wandering rates. In the context of a within-subject design, participants are typically able to directly compare multiple versions of a task across blocks, which may make certain features stand out as distinctive (Hunt, 2006). Such comparisons may influence perceptions of task difficulty and interestingness. For example, a feature may stand out as relatively uninteresting when participants directly compare tasks across blocks, and may therefore exert a strong influence on mind-wandering. Conversely, in a between-subjects design, the same feature is not distinctively processed and may consequently have a relatively weak effect on mind-wandering.

Of particular theoretical import, if the executive resource hypothesis (Smallwood & Schooler, 2006) is valid, then increased task difficulty ought to engender more frequent mind-wandering regardless of the experimental design (e.g., within-subject vs. between-subjects). Yet, prior research that was consistent with this hypothesis has generally used a within-subject design (e.g., Antrobus et al., 1966; Antrobus, 1968; Filler & Giambra, 1973; Forster & Lavie, 2009; Grodsky & Giambra, 1990; Giambra, 1995; Mason et al., 2007; McKiernan et al., 2006; Stuyven & Van der Goten, 1995; Smallwood et al., 2003; Teasdale et al., 1993; Thomson et al., 2013). Future research should investigate whether the effect of task difficulty on mind-wandering extends to a between-subjects design.

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Appendix A

Easy and hard versions of the galaxy passage, followed by comprehension questions

Objectively easy version (FK grade 9.0)

A galaxy is a massive system bound by gravity.

It consists of stars, stellar remnants, an interstellar medium of gas and dust, and dark matter.

Dark matter is an important but poorly understood component.

The word galaxy is derived from the Greek galaxias (γαλαξίας).

It literally means "milky", a reference to the Milky Way.

Examples of galaxies range from dwarfs with as few as ten million stars to giants with one hundred trillion stars.

Each orbits their galaxy's own center of mass.

Galaxies contain varying numbers of planets, star systems, star clusters and types of interstellar clouds. In between these objects is a sparse interstellar medium of gas, dust, and cosmic rays.

Supermassive black holes reside at the center of most galaxies.

They are thought to be the primary driver of active galactic nuclei found at the core of some galaxies.

The Milky Way galaxy is known to harbor at least one such object.

The first attempt to describe the shape of the Milky Way and the position of the Sun in it was carried out by William Herschel.

Herschel carefully counted the number of stars in different regions of the sky.

He made a diagram of the shape of the galaxy.

The solar system was close to the center of his diagram.

There are probably more than 170 billion galaxies in the observable universe.

Most are 1,000 to 100,000 parsecs in diameter.

They are usually separated by distances on the order of millions of parsecs (or megaparsecs).

Intergalactic space is the space between galaxies.

It is filled with a tenuous gas of an average density less than one atom per cubic meter.

Most galaxies are arranged into a family of associations known as galaxy groups and clusters.

These, in turn, tend to form larger superclusters.

At the largest scale, these groups and clusters are arranged into sheets and filaments, around which are large voids.

Galaxies have been historically group based on their shape.

Their shape is usually referred to as their visual morphology.

A common form is the elliptical galaxy.

It has an ellipse-shaped light profile.

Spiral galaxies are disk-shaped with dusty, curving arms.

Those with unusual shapes are known as irregular galaxies.

They tend to originate from disruption by the gravitational pull of neighboring galaxies.

Such interactions between nearby galaxies may finally result in a merger.

This can induce much increased incidents of star formation leading to starburst galaxies.

Smaller galaxies lacking a clear structure are called irregular galaxies.

In October 2013, z8 GND 5296 was confirmed to be the most distant galaxy yet found.

It is around 13.1 billion light-years from Earth.

The galaxy appears to astronomers as it was just 700 million years after the Big Bang.

At that time, the universe was only about 5 percent of its current age of 13.8 billion years.

z8 GND 5296 produces stars at a rate of about 300 suns per year in mass.

Tens of thousands of these galaxies have now been catalogued.

Only a few have been given a well-known name.

These include the Andromeda Galaxy, the Magellanic clouds, the Whirlpool Galaxy and the Sombrero Galaxy.

Objectively hard version (FK grade 17.0)

A galaxy is a massive, gravitationally bound system consisting of stars, stellar remnants, an interstellar medium of gas and dust, and dark matter, an important but poorly understood component.

The word galaxy is derived from the Greek galaxias (γαλαξίας), literally "milky", which is a reference to the Milky Way.

Examples of galaxies range from dwarfs with as few as ten million stars to giants with one hundred trillion stars, each orbiting their galaxy's particular center of mass.

Galaxies contain varying numbers of planets, star systems, star clusters and types of interstellar clouds, and in between these objects is a sparse interstellar medium of gas, dust, and cosmic rays.

Supermassive black holes reside at the center of most galaxies, and black holes are thought to be the primary driver of active galactic nuclei found at the core of some galaxies (the Milky Way galaxy has been identified as harboring a minimum of one such object).

The first attempt to describe the shape of the Milky Way and the position of the Sun in it was carried out by William Herschel in 1785 by carefully counting the number of stars in different regions of the sky and producing a diagram of the shape of the galaxy with the solar system close to the center.

There are undoubtedly more than 170 billion galaxies in the observable universe, the majority of which are 1,000 to 100,000 parsecs in diameter and usually separated by distances on the order of millions of parsecs (or megaparsecs).

Intergalactic space (the space between galaxies) is occupied with a tenuous gas of an average density less than one atom per cubic meter.

The majority of galaxies are organized into a hierarchy of associations known as galaxy groups and clusters, which, in turn usually form larger superclusters.

At the largest scale, these associations are generally arranged into sheets and filaments, which are surrounded by immense voids.

Galaxies have been historically categorized according to their apparent shape, usually referred to as their visual morphology.

A typical form is the elliptical galaxy, having an ellipse-shaped light profile.

Spiral galaxies are disk-shaped with dusty, curving arms, and those with irregular or unusual shapes are known as irregular galaxies and typically originate from disruption by the gravitational pull of neighboring galaxies.

Such interactions between nearby galaxies, which may ultimately result in a merger, sometimes induce significantly increased incidents of star formation leading to starburst galaxies.

Smaller galaxies lacking a coherent structure are referred to as irregular galaxies.

In October 2013, z8 GND 5296 was confirmed to be the most distant galaxy yet discovered, at a distance of approximately 13.1 billion light-years from Earth.

The galaxy appears to astronomers as it was "just 700 million years after the Big Bang, when the universe was only about 5 percent of its current age of 13.8 billion years," and it produces stars at a phenomenal rate of about 300 suns per year in mass.

Tens of thousands of these galaxies have now been catalogued, although only a few galaxies have been given a well-established name, such as the Andromeda Galaxy, the Magellanic clouds, the Whirlpool Galaxy and the Sombrero Galaxy.

Comprehension Questions (note: correct answers bolded).

Between planets, star systems, star clusters, and intersellar clouds there is a sparse interstellar medium of:
a) gas, dust, and cosmic rays
b) supermassive black holes
c) stars, stellar remnants, gas, and dust
d) gas, dust, and dark matter

What is thought to be the primary driver of active galactic nuclei found at the core of some galaxies?
a) cosmic rays
b) stellar remnants
c) black holes
d) dark matter

What have galaxies been historically grouped based on?
a) sheets
b) shape
c) clusters
d) filaments

How far is galaxy z8 GND 5296 from earth?
a) 700 million light-years
b) 13.8 billion light-years
c) 300 million light-years
d) 13.1 billion light years

Appendix B

Passage reading time analyses

Experiment 1

Reading times (not including response times to thought probes) were significantly longer for easy passages (M = 166.47 s, SD = 56.81 s) than for hard passages (M = 157.48, SD = 62.31), $t(154) = 3.07$, $p = 0.002$, $d = 0.15$. This modest difference may have occurred because participants perceived the objectively hard passages as less interesting than the objectively easy passages (see the Results section of Experiment 1), so they were more likely to skim read the objectively hard passages (perhaps due to low motivation). Another possibility is that passages with short sections were presented across more screens, which required more presses of the spacebar and gaze re-orientation.

Experiment 2

Reading times before the first thought probe were not recorded for each participant due to a programming error. After the first probe, reading times for easy passages (M = 134.69 s, SD = 49.40 s) and hard passages (M = 134.40 s, SD = 50.78), were nonsignificantly different, $t(162)$ = 0.18, $p = 0.86$. Given that the first probe appeared at a random 10-30 s time for each participant in this large sample, the mean passage reading time would have been approximately 20 s longer in each condition. Thus, even though precise reading times were not obtained, the available data indicate that there was not a meaningful difference between conditions.

Experiment 3

In the sentence presentation condition, reading times were significantly longer for easy passages (M = 182.86 s, SD = 56.02 s) than for hard passages (M = 173.14, SD = 60.52), $t(97)$ = 2.69, $p = 0.01$, $d = 0.17$, replicating this result in Experiment 1. Once again, this result may have reflected the fact that participants perceived the objectively hard passages as less interesting and may therefore have been more inclined to skim read them. As in Experiment 2, reading times before the first thought probe were not recorded in the page presentation condition. After the first probe, reading times across easy passages (*M* = 147.93 s, *SD* = 52.36 s) and hard passages (*M* = 145.60, *SD* = 54.67), were nonsignificantly different, $t(98) = 0.92$, $p = 0.36$, suggesting that there was not a reliable difference in passage reading times between conditions.

Experiment 4

Reading times for easy passages (*M* = 165.54 s, *SD* = 48.62 s) and hard passages (*M* = 165.81, *SD* = 48.71), were nonsignificantly different, $t(98) = 0.11$, $p = 0.91$. Overall, reading time data from Experiments 1-4 suggested that objective reading difficulty did not significantly influence passage reading times. Mean reading times for easy and hard passages were equivalent when they were presented over an equal number of screens. These results were contrary to the notion that objectively easy passages ought to take less time to read than hard passages. Perhaps that did not occur because easy passages contained more sentences, which would have resulted in more brief pauses in reading.

Experiment 5

Consistent with the reading time results of the prior experiments, reading times were significantly longer for passages with short sections (*M* = 171.03 s, *SD* = 59.75 s) than for passages with moderate-length sections (*M* = 160.17, *SD* = 65.67), $t(49) = 3.09$, $p = 0.003$, $d = 0.17$.

Experiment 6

A repeated measures ANOVA revealed a significant difference in reading times between passages that were presented across short (*M* = 179.12 s, *SD* = 55.85 s), moderate (*M* = 175.30 s, *SD* = 65.60 s), and long (*M* = 162.85 s, *SD* = 59.75 s) sections, *F*(1, 81.01) = 4.47, *MSE* = 1102.62, *p* = 0.02, η^2 = 0.08 (with a Greenhouse-Geisser correction for a violation of sphericity). Only the difference between short-section passages and long-section passages was significant, *t*(52) = 2.32, *p* = 0.02, d = 0.25. This pattern was consistent with those from the previous experiments in which participants took less time to read passages that were presented in relatively longer vs. shorter sections.

Experiment 7

In the within-subject version of the experiment, reading times were significantly longer for passages with short sections (*M* = 186.08 s, *SD* = 55.01 s) than for passages with long sections (*M* = 171.75, *SD* = 60.06), *t*(63) = 3.12, *p* = 0.003, *d* = 0.25, consistent with the results of the previous experiments. In the between-subjects version, reading times of passages with short sections (*M* = 175.10, *SD* = 53.02) and passages with long sections (*M* = 164.11, *SD* = 56.23) were nonsignificantly different, *t*(126) = 1.14, *p* = 0.26, *d* = 0.20.

Appendix C

Combined analyses Experiment 2 and Experiment 6 (long-section passages)

Here I examined whether MW rates for passages that were presented in full pages of text were higher in Experiment 6 (in which passage section-length varied within-subject) compared to Experiment 2 (in which all passages were presented in full pages). This result would suggest that there is a cost in terms of increased mind-wandering imposed on passages with long sections when they are intermixed with passages with short sections compared to when only long-section passages are presented. Given that passages in Experiment 6 were all objectively easy, I compared them to the objectively easy passages in Experiment 2.

MW rates for passages presented in full pages were significantly higher in Experiment 6 ($M = 0.456$) than in Experiment 2 ($M = 0.294$), $t(214) = 4.19$, p < 0.001, $d = 0.64$. Further, participants' subjective ratings were consistent with this pattern: Writing difficulty and topic difficulty ratings were both significantly higher in Experiment 6, and writing interestingness and topic interestingness ratings were significantly lower in Experiment 6 (all *p*s < 0.05).[23] Reading comprehension scores, however, were nonsignificantly different between the two experiments ($t < 1$), which was somewhat surprising given the substantial differences in MW rates and subjective ratings.

When passages were only presented in full pages (Experiment 2), full pages of text may not have seemed particularly long (and therefore not particularly difficult and/or uninteresting). However, in Experiment 6, full pages stood out as being particularly long (a "wall of text")

[23] A statistical comparison of the full page data from Experiment 6 to those from Experiment 3 (easy passages in the page presentation condition) revealed a comparable pattern of results. MW rates were significantly higher in Experiment 6, $t(150) = 4.22$, $p < 0.001$, $d = 0.70$. Subjective writing difficulty and topic difficulty ratings were higher in Experiment 6 ($p = 0.01$ and $p = 0.06$ respectively) and there was a trend of subjective writing interestingness and topic interestingness being lower in Experiment 6 ($p = 0.12$ and $p = 0.08$). There was no difference in reading comprehension between these two experiments ($t < 1$).

relative to the shorter sections of text. This potentially unfavourable comparison may have adversely impacted participants' perceptions of these texts (as reflected in the high difficulty ratings and low interest ratings) and increased their mind-wandering rates. This possibility is investigated in Chapter 2.

Appendix D

Figures in Chapter 3

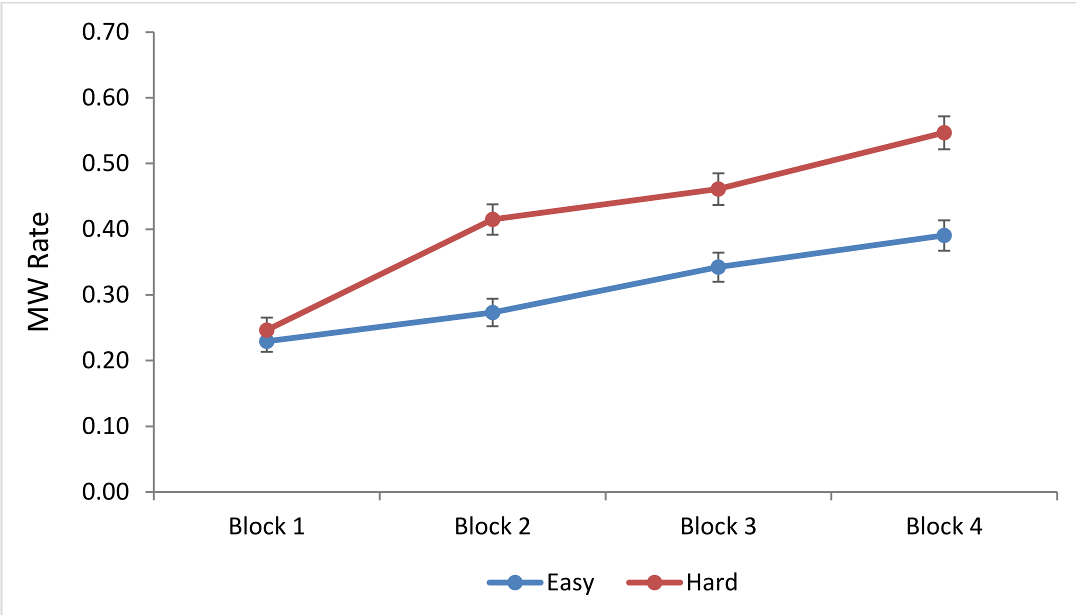

Figure D1. Mean mind-wandering rates over passage block for the pooled sentence presentation data (Experiments 1 and 3).

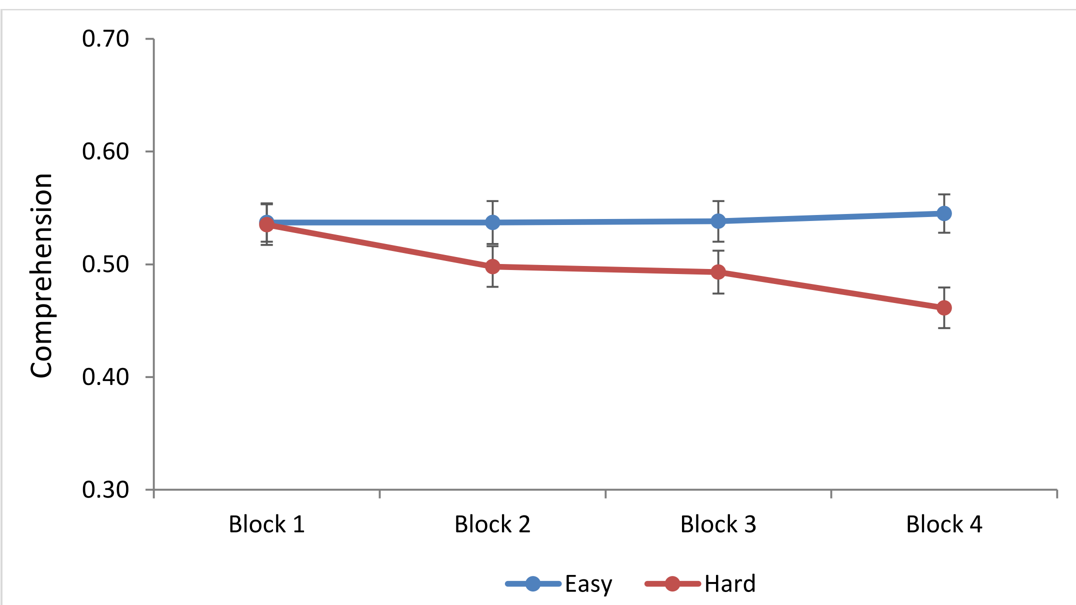

Figure D2. Mean proportion of correctly answered comprehension questions over passage block for the pooled sentence presentation data (Experiments 1 and 3).

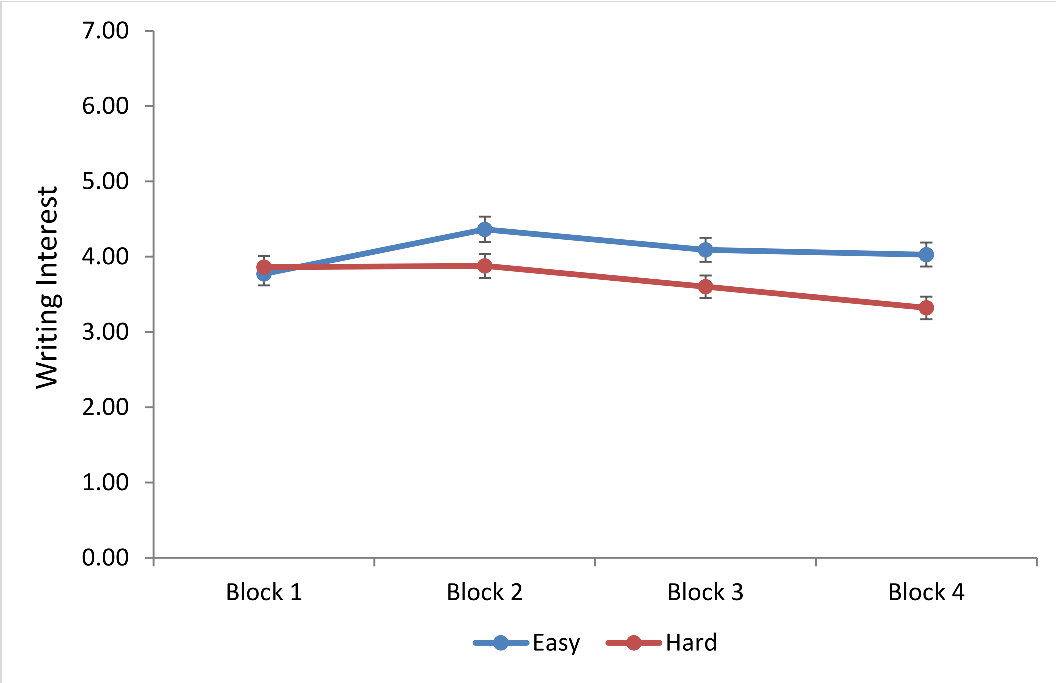

Figure D3. Mean writing interest ratings over passage block for the pooled sentence presentation data (Experiments 1 and 3).

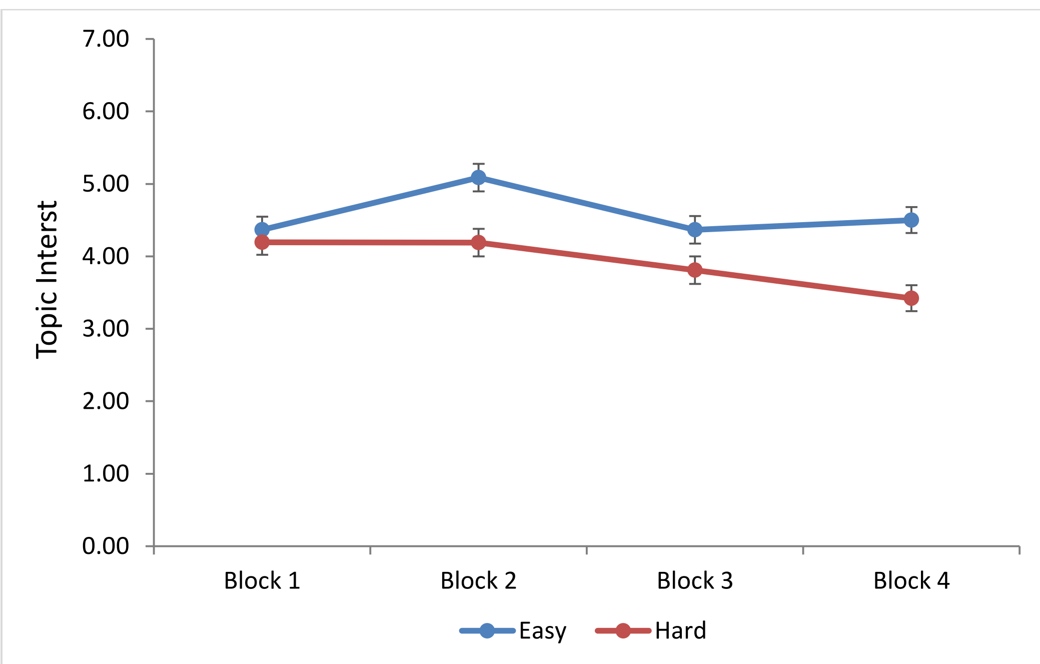

Figure D4. Mean topic interest ratings over passage block for the pooled sentence presentation data (Experiments 1 and 3).

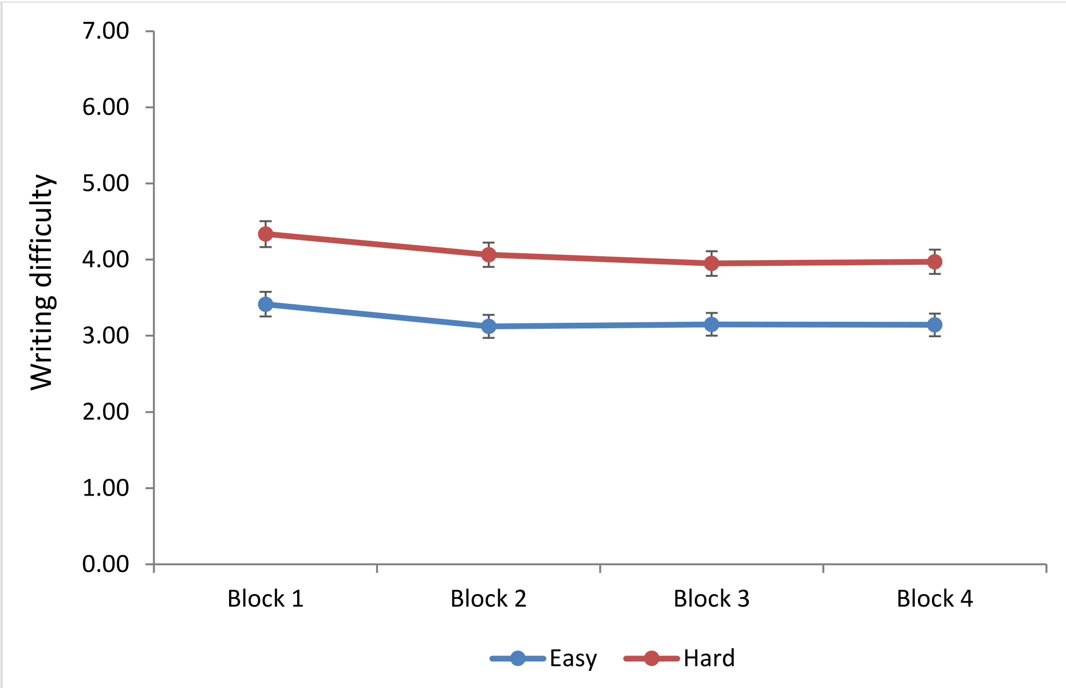

Figure D5. Mean writing difficulty ratings over passage block for the pooled sentence presentation data (Experiments 1 and 3).

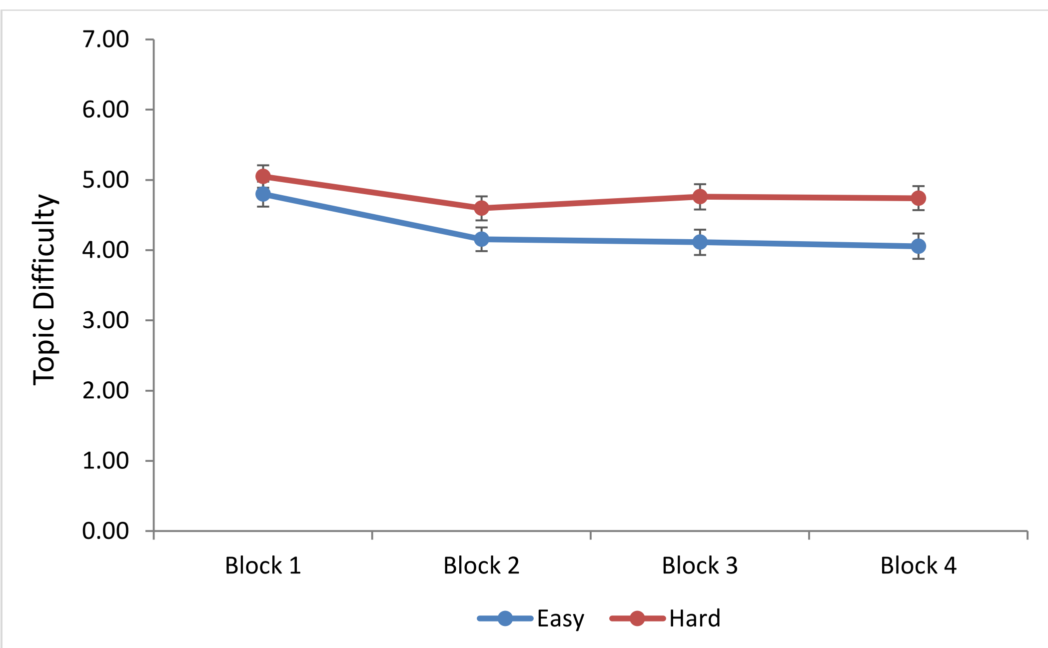

Figure D6. Mean topic difficulty ratings over passage block for the pooled sentence presentation data (Experiments 1 and 3).

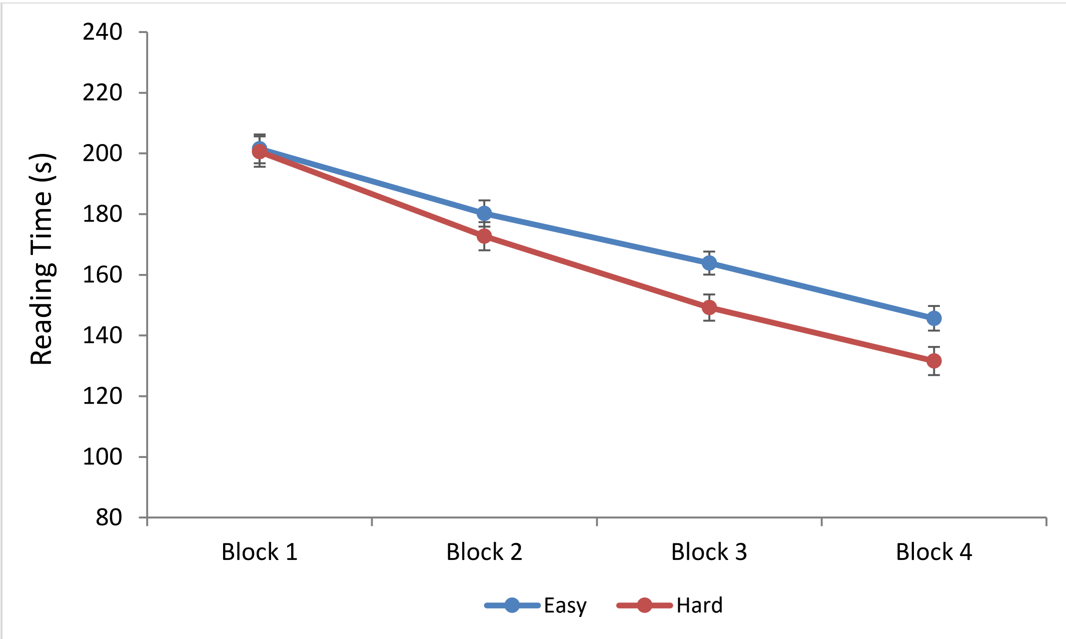

Figure D7. Mean reading times over passage block for the pooled sentence presentation data (Experiments 1 and 3).

Appendix E

Further evidence for a relation between mind-wandering and comprehension over passages

For each participant (of the pooled data analyzed in Chapter 3), I obtained Pearson correlation coefficients between MW rates over blocks and comprehension over blocks. (A given coefficient could not be calculated when at least one of the measures had identical values over blocks.) Separate correlation coefficients were computed for objectively easy and objectively hard passages. I then averaged these correlations across participants. One-sample *t*-tests revealed that the mean correlation coefficients for easy passages (M = -0.15, SD = 0.46) and for hard passages (M = -0.25, SD = 0.55) were both significantly greater than 0 ($ps < 0.001$). And a paired sample *t*-test indicated that these mean correlation coefficients were nonsignificantly different from each other, $t(205) = 1.64$, $p = 0.10$. The negative correlation between MW over blocks and comprehension over blocks demonstrates that the association between MW over time and performance over time (see Thomson et al., 2014) extends to the domain of reading.

Appendix F

Mind-wandering rates over thought probes

Here I assessed Feng et al.'s (2013) claim that objectively hard passages lead to more mind-wandering than objectively easy passages because participants are less successful in building a situation model for objectively hard passages, which leads to cascading inattention (Smallwood et al., 2007) while reading those passages. If cascading inattention was more likely to occur for objectively hard passages than for objectively easy passages, then one would expect to find a larger increase in mind-wandering over probes for objectively hard passages than for objectively easy passages. I tested this hypothesis using the data from Experiments 1 and 3 (sentence presentation condition) due to the robust effect of objective reading difficulty on mind-wandering in these conditions. MW rates for easy and hard passages were compared in each half of passages by analyzing the thought probe(s) that appeared in each half. These mean MW rates are shown in Table F1.

Results

An Objective reading difficulty (easy vs. hard) x Passage half (first vs. second) repeated measures ANOVA was conducted for each experiment. In Experiment 1, there were significant main effects of Objective reading difficulty, $F(1, 154) = 29.87$, $MSE = 0.05$, $p < 0.001$, $\eta^2 = 0.16$, and Passage half, $F(1, 154) = 19.93$, $MSE = 0.02$, $p < 0.001$, $\eta^2 = 0.28$, signifying that hard passages had higher MW rates than easy passages overall and that the second half of passages had higher MW rates than the first half. Unexpectedly, there was also a significant interaction between these terms, $F(1, 154) = 8.55$, $MSE = 0.02$, $p = 0.004$, $\eta^2 = 0.05$. The difference in MW rates in Experiment 1 was larger for the first half of the passage than for the second half.[24] First-

[24] Analyzing MW rates across four probes rather than across two halves did not impact the statistical significance of these results.

half MW rates were significantly higher for hard vs. easy passages, $t(154) = 6.35$, $p < 0.001$, $d = 0.54$, as were second-half MW rates, $t(154) = 2.98$, $p = 0.003$, $d = 0.24$.

For Experiment 3 (sentence presentation condition), there were significant main effects of Objective reading difficulty, $F(1, 97) = 34.61$, $MSE = 0.04$, $p < 0.001$, $\eta^2 = 0.26$, and Passage half, $F(1, 97) = 28.92$, $MSE = 0.05$, $p < 0.001$, $\eta^2 = 0.23$, signifying that hard passages had higher MW rates than easy passages overall and that the second half of passages had higher MW rates than the first half. The interaction was nonsignificant, $F(1, 97) = 2.40$, $MSE = 0.03$, $p = 0.12$, $\eta^2 = 0.02$. First-half MW rates were significantly higher for hard vs. easy passages, $t(97) = 5.56$, $p < 0.001$, $d = 0.60$, as were second-half MW rates, $t(97) = 3.34$, $p = 0.001$, $d = 0.33$

To recap, objective difficulty significantly influenced mind-wandering rates in both halves of passages that were presented one sentence at a time. These results suggest that surface features of a text—in this case, section length—may influence attention and engagement early in the process of reading. More importantly, these results were inconsistent with Feng et al.'s (2013) explanation that the effect of objective difficulty on mind-wandering reflects cascading inattention (Smallwood et al., 2007) when participants read objectively hard passages (due to their struggle to build a situation model).

Table F1. *Mean mind-wandering rates (with SEs) for the first and second halves of objectively easy and objectively hard passages in Experiments 1 and 3 (sentence presentation condition).*

	Easy Passages		Hard Passages	
	First Half	Second Half	First Half	Second Half
Experiment 1	.261 (.017)	.391 (.022)	.394 (.022)	.457 (.022)
Experiment 3 (sentence)	.208 (.024)	.351 (.027)	.358 (.027)	.445 (.031)