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Mind Wandering and Reading Comprehension: Examining the Roles of Working Memory Capacity, Interest, Motivation, and Topic Experience

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Individual differences in mind wandering and reading comprehension were examined in the current study. In particular, individual differences in mind wandering, working memory capacity, interest in the current topic, motivation to do well on the task, and topic experience and their relations with reading comprehension were examined in the current study. Using confirmatory factor analysis and structural equation modeling it was found that variation in mind wandering while reading was influenced by working memory capacity, topic interest, and motivation. Furthermore, these same factors, along with topic experience, influenced individual differences in reading comprehension. Importantly, several factors had direct effects on reading comprehension (and mind wandering), while the relation between reading comprehension (and mind wandering) and other factors occurred via indirect effects. These results suggest that both domain-general and domain-specific factors contribute to mind wandering while reading and to reading comprehension.

Keywords: mind wandering, reading comprehension, individual differences

Reading comprehension is a critically important ability that is needed in a host of situations, including educational and professional settings. Given the importance of reading comprehension to many daily activities, researchers have long been interested in examining individual differences in reading comprehension and examining what potential factors might account for variation in reading comprehension (e.g., Baldwin, Peleg-Bruckner, & McClintock, 1985; Cromley & Azevedo, 2007; Daneman & Merikle, 1996; Palmer, McLeod, Hunt, & Davidson, 1985; Perfetti, 1985). In the current study we continue this tradition by examining how normal variation in a number of factors is related to variation in reading comprehension for an academic text. In particular, we examined how individual differences in mind wandering, working memory capacity, interest in the current topic, motivation to do well on the task, and topic experience all influence reading comprehension. As can be seen below, there are a number of reasons to suspect that these factors are important contributors to reading comprehension and that some factors actually mediate the relation between the other factors and reading comprehension.

Prior studies examining individual differences in reading comprehension have found that a number of processes are important (see Daneman, 1991, for a review). For example, Palmer et al. (1985; see also Baddeley, Logie, Nimmo-Smith, & Brereton, 1985) found small to moderate correlations between various information processes indices and reading including reading speed, listening comprehension, lexical decision, and semantic decision. These results led Palmer et al. to suggest that basic information processing abilities partially underlie individual differences in reading comprehension. Similar multivariate studies of individual differences in reading comprehension have suggested that a number of factors are responsible for variation in reading comprehension. For example, Cromley, Snyder-Hogan, and Luciw-Dubas (2010; see also Cromley & Azevedo, 2007) found that word reading, inferences, strategies, vocabulary, and background knowledge all correlated with reading comprehension scores and accounted for a large amount of variability in reading comprehension. Several factors, including vocabulary, inferences, and background knowledge, had direct influences on reading comprehension scores, while the other factors (strategies and word reading) had primarily indirect effect on reading comprehension scores. Like Cromley et al. (2010), prior research has consistently demonstrated moderate correlations between background knowledge (or experience with the topic of the text) and overall reading comprehension scores (e.g., Baldwin et al., 1985; Tobias, 1994). This relation suggests that the more prior knowledge a reader has, the better he or she is able to comprehend the text. In cognitive models of reading, such as Kintsch's (1998) theory of the constructive-integration, prior knowledge and the current text are combined to construct a situational model that is necessary for comprehension. Thus, the more prior knowledge a reader has, the better the overall model is and the better the text will be comprehended.

One important factor that has been examined extensively in terms of individual differences in reading comprehension is working memory capacity. Working memory capacity (WMC) refers to the ability to actively maintain task goals in the face of interference and distraction and to selectively retrieve goal relevant information from long-term memory (Engle & Kane, 2004; Unsworth & Engle, 2007). Early work by Daneman and Carpenter (1980) suggested moderate to strong relations between a WMC measure (reading span) and reading comprehension scores. Subsequent work has

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corroborated these results suggesting that a variety of WMC measures correlate quite well with specific and global measures of reading comprehension (Baddeley et al., 1985; Daneman & Merikle, 1996; Dixon, LeFevre, & Twilley, 1988; Turner & Engle, 1989). Specifically, a meta-analysis by Daneman and Merikle (1996) suggested correlations ranging from .20–.52 for a variety of WMC measures with reading comprehension scores. Likewise, Engle, Tuholski, Laughlin, and Conway (1999) found that a latent WMC factor predicted scores on the verbal SAT (VSAT) and McVay and Kane (2012b) recently demonstrated a moderate correlation between a latent WMC factor (composed of three WMC tasks) and a latent reading comprehension factor (composed of seven reading comprehension measures). Theoretically, WMC is needed to actively maintain text information while reading in order to integrate prior and current information (Daneman & Carpenter, 1980; Daneman & Hannon, 2001), to activate text relevant information and to filter out irrelevant information (Hasher & Zacks, 1988), and to maintain attentional focus on the task to prevent lapses of attention (McVay & Kane, 2012b). As suggested by a number of researchers, there are clearly a number of important cognitive components that are important for reading comprehension and for individual differences in reading comprehension.

In addition to these information processing correlates of reading comprehension, research has suggested that factors such as interest in the topic and overall motivation are also important. For example, a large body of research has consistently demonstrated that interest in the text that one is reading has a strong impact on what is read as well as overall comprehension scores (e.g., Baldwin et al., 1985; Hidi, 2001; Schiefele & Krapp, 1996; Tobias, 1994). Thus, the more interested one is in the topic of a particular text, the more likely one is to read the text deeply, leading to overall better comprehension scores. Overall levels of topic interest likely influence reading comprehension in a number of ways. In particular, several studies have suggested a moderate association between topic interest and prior knowledge, suggesting that overall interest in a topic leads to more engagement with the topic and, hence, more accumulation of knowledge (e.g., Tobias, 1994). It has also been suggested that topic interest and attentional allocation are related, such that the more interested one is in the current topic of the text the better their attention is focused on the text, leading to overall deeper processing of the text (Hidi, 2001). Additionally, topic interest has been linked with motivational factors, suggesting that the more interested one is in the topic of the text, the more motivated they are to read the text deeply and perform well on subsequent comprehension tests (e.g., Hidi & Harackiewicz, 2000). Thus, not only is overall interest in the text an important contributor to reading comprehension but so is the reader's overall motivation to read the text and perform well. Indeed, several studies have specifically examined the influence of motivation on reading comprehension and have consistently found that motivation (both intrinsic and extrinsic) is a strong predictor of reading comprehension scores and, in many cases, contributes unique variance to the prediction of reading comprehension scores (Anmarkrud & Braten, 2009; Guthrie et al., 2007; Guthrie, Wigfield, Metsala, & Cox, 1999). Overall, there are a number of both cognitive and noncognitive factors that influence individual differences in reading comprehension.

Recent research has begun to explore another important contributor to reading comprehension abilities: mind wandering. *Mind wandering* refers to the phenomenon in which attention is shifted away from external information to internal thoughts and feelings that are unrelated to the current task at hand (McVay & Kane, 2010; Smallwood & Schooler, 2006). Typically these shifts of attention inward and away from task-relevant information are known as *zone outs* or *task unrelated thoughts* (TUTs). A number of laboratory techniques have been developed to examine mind wandering, including thought probe techniques, in which periodically throughout a task participants are probed as to their current state (on task or off-task), and this is examined as a function of various experimental manipulations and individual differences correlates (see Smallwood & Schooler, 2006, for a review). This research has found that mind wandering (TUTs) varies as a function of task variables such as time on task, task complexity, and task difficulty (McVay & Kane, 2010; Smallwood & Schooler, 2006). Rates of mind wandering correlate with task performance, such that performance is lower when participants report mind wandering on the preceding trial compared with when participants report that they are focused on the current task (McVay & Kane, 2010; Smallwood & Schooler, 2006). Additionally, mind wandering rates are associated with very slow reaction times, which have long been seen as indicators of lapses of attention (McVay & Kane, 2012a). Furthermore, motivational factors also seem to play a role in mind wandering such that when motivation is high to perform well (based on financial incentives) mind wandering is reduced (Antrobus, Singer, & Greenberg, 1966). Conversely, increases in worry and distress for personal concerns have been shown to increase mind wandering (Antrobus et al., 1966). Mind wandering measured in the laboratory via TUTs has been shown to be related to indices of mind wandering in everyday life, as measured with experience sampling techniques (McVay, Kane, Kwapil, 2009). Furthermore, TUTs measured with real-time thought probes have been shown to be correlated with activity in the default mode network and to be correlated with a reduced P1 component (Gruberger, Ben-Simon, Levkovitz, Zangen, & Hendler, 2011; Stawarczyk, Majerus, Maquet, D'Argembeau, 2011), suggesting that mind wandering is associated with an increase in internal ruminations and a decrease in perceptual processing. In terms of individual differences, a number of recent studies have demonstrated that variation in mind wandering is related to a number of cognitive variables including WMC and attention control (Kane et al., 2007; McVay & Kane, 2012b). This is discussed in more detail later, but for now what is important is that the probe techniques for examining mind wandering have been shown to be both reliable and valid and have demonstrated the importance of examining mind wandering during a number of tasks.

Mind wandering while reading (or mindless reading), in particular, has become a recent focus of research (see McVay & Kane, 2012b; Smallwood, 2011, for reviews). For example, Giambra and Grodsky (1989) found a negative relation between interest and TUTs while reading, such that participants reported more TUTs for texts they found to be uninteresting compared with texts they found to be interesting. Similar results have been reported by Smallwood, Nind, and O'Connor (2009), who also found that task experience (prior knowledge) influenced TUTs while reading. Thus, domain-specific factors, such as interest, seem to be important in determining mind wandering while reading. Furthermore, Grodsky and Giambra (1990–1991) found that TUTs reported while reading were significantly correlated with TUTs during a

vigilance task, suggesting that overall propensity to mind wander is a stable individual trait. Likewise, in a recent study McVay and Kane (2012b) found that TUTs from various attention and reading tasks correlated and formed a single latent variable, and this general TUTs factor was strongly related to individual differences in WMC and attention control. Indeed, other recent research has found consistent correlations between WMC and TUTs, such that low-WMC individuals tend to mind wander more than high-WMC individuals in a number of different tasks and situations (Kane et al., 2007; McVay & Kane, 2009; Unsworth, Brewer, & Spillers, in press).

In addition to examining mind wandering while reading, recent research has examined how mind wandering while reading is related to performance on a subsequent comprehension test. For example, Schooler, Reichle, and Halpern (2004) found that TUT rates reported while reading *War and Peace* (Tolstoy, 1864–1869/1982) significantly correlated with overall accuracy on a subsequent comprehension test. Similar results have also been reported by Smallwood, McSpadden, and Schooler (2008) while examining inference critical episodes during reading. Recently, Unsworth, Brewer, and Spillers (in press) found that everyday instances of mind wandering (assessed with diaries) correlated with VSAT scores ($r = -.27$) suggesting that the overall propensity to mind wander is related to global measures of reading comprehension. Finally, McVay and Kane (2012b) found that a latent TUT variable (based on both attention and reading comprehension tasks) strongly correlated with an overall reading comprehension factor ($r = -.54$). Importantly, McVay and Kane found that TUTs in one task predicted reading comprehension performance in tasks where TUTs were not assessed. Thus, although mind wandering probes might be somewhat disruptive on the current task, thereby lessening comprehension of the text, these probes are valid to the extent that they predict reading comprehension on independent measures where thought probes were not utilized. Furthermore, these results speak to the reliability of measuring TUTs with thought probes by demonstrating that TUTs measured across a variety of tasks are correlated and predict performance. Additionally, McVay and Kane found that individual variation in TUTs partially mediated the relation between WMC, attention control, and reading comprehension. McVay and Kane suggested that these results indicate that part of the reason that WMC predicts reading comprehension so well is because high- and low-WMC individuals differ in their ability to control their attention, and thus, low-WMC individuals are more likely to mind wander and experience lapses of attention during tasks like reading, which hurts their performance on subsequent comprehension tests. These results are consistent with prior work suggesting the importance of attention control (Conners, 2009), effortful control (Deater-Deckard, Mullineaux, Petrill, & Thompson, 2009), and problems with inattention (Zumberge, Baker, & Manis, 2007) in accounting for variation in reading comprehension and further suggest that these relations may partially be due to differences in mind wandering whereby individuals low in attention and effortful control are more likely to mind wander while reading, leading to less comprehension. Collectively these results suggest that both domain-specific factors (such as interest in the topic of the text) and domain-general factors (such as WMC) likely influence mind wandering while reading, and these factors likely influence performance on subsequent comprehension tests.

The Present Study

The research reviewed previously suggests that there are a number of factors that are important for reading comprehension skills including prior knowledge of the topic of the text, WMC, topic interest, motivation to do well, as well as the propensity to mind wander while reading. Furthermore, prior research suggests that many of these factors are interrelated and account for similar variance in reading comprehension. Our goal in the present study was to better examine how these factors relate with one another and account for shared or unique variance in both mindless reading and reading comprehension. In particular, two main questions were examined. First, how do domain-general (WMC) and domain-specific (interest, motivation, topic experience) factors influence mind wandering while reading? Specifically, prior research has suggested a strong link between WMC and mind wandering, indicating that domain-general processes, such as attention control, are important determinants of mind wandering in a number of tasks (e.g., McVay & Kane, 2012b). At the same time, other research suggests that domain-specific factors, such as interest and experience with text and motivation to perform well on the current task, influence rates of mind wandering (Antrobus et al., 1966; Giambra & Grodsky, 1989; Smallwood et al., 2009). This suggests the possibility that both domain-general factors, such as WMC, and domain-specific factors contribute to individual variation in mind wandering (TUTs) while reading. To our knowledge no prior studies have examined how both general and specific factors influence TUTs while reading. Thus, novel to the current study is an examination of how multiple factors simultaneously influence TUTs while reading. Second, how do these domain-general and domain-specific factors influence reading comprehension and individual differences in reading comprehension? As noted previously, each of these factors has been shown to predict reading comprehension performance, but no study has examined how all of these factors jointly or uniquely account for variation in reading comprehension performance. It is possible that each factor will account for unique and shared variance with reading comprehension performance or that only a few factors will have direct effects on reading comprehension with the other factors influencing reading comprehension via indirect effects. For example, based on prior research reviewed previously, one might expect that both WMC and TUTs will contribute both shared and unique variance to reading comprehension. Likewise, topic experience (prior knowledge) should also contribute unique variance to reading comprehension performance. Both topic interest and motivation should have indirect effects through TUTs, such that individuals who are not interested in the current text or motivated to perform well (perhaps due to a lack of interest) should experience more mind wandering, leading to poorer reading comprehension performance. These factors might additionally have direct effects to the extent that interest and motivation influence performance independently of their relation with mind wandering.

To examine these issues we utilized confirmatory factor analysis and structural equation modeling to analyze the data. Participants performed several WMC measures, read a text, completed a reading comprehension test, and then answered questions about their interest in the topic, experience with the topic, and their overall motivation. Because we were interested in examining these issues in academic settings in which mind wandering is thought to be an

important factor for performance (Brown, 1927; Lindquist & McLean, 2011; Smallwood, Fishman, & Schooler, 2007), participants in the current study read the first half of the first chapter of a popular introductory political science text (Janda, Berry, & Goldman, 2009) and then completed a reading comprehension test of the material. While reading the text, participants were probed throughout to assess mind wandering rates while reading (McVay & Kane, 2012b; Smallwood & Schooler, 2006) Thus, rather than having participants read several different texts with separate reading comprehension tests, all participants read the same portion of an academic text while mind wandering was assessed and then completed a single reading comprehension test. This was done in order to examine how domain-specific factors related to the current text influence mind wandering while reading and performance on a subsequent reading comprehension test. As noted by Smallwood (2011) in a recent review of mind wandering while reading, examining individual differences in mindless reading and examining various situational factors (interest, motivation, and topic experience) that contribute to mind wandering while reading is an important endeavor for future research. The current study is a step in this direction.

Method

Participants

A total of 150 participants (63% female) were recruited from the subject pool at the University of Oregon. Participants were between the ages of 18 and 35 years ($M = 19.37$, $SD = 1.49$) and received course credit for their participation. Each participant was tested in a single laboratory session lasting approximately 2 hr.

Materials and Procedure

After signing informed consent forms, all participants completed operation span, symmetry span, and reading span, then read the text and completed the reading comprehension test, followed by a brief questionnaire assessing topic interest, topic experience, and motivation in relation to the text previously read.

Tasks

Working memory capacity (WMC) tasks.

Operation span (Ospan). Participants solved a series of math operations while trying to remember a set of unrelated letters (F, H, J, K, L, N, P, Q, R, S, T, Y). Participants were required to solve a math operation, and after solving the operation they were presented with a letter for 1 s. Immediately after the letter was presented the next operation was presented. Three trials of each list length (three to seven) were presented for a total possible of 75. The order of list length varied randomly. At recall, letters from the current set were recalled in the correct order by clicking on the appropriate letters (see Unsworth, Heitz, Schrock, & Engle, 2005, for more details). Participants received three sets (of list length two) of practice. For all of the span measures, items were scored if the item was correct and in the correct position. The score was the proportion of correct items in the correct position.

Symmetry span (Symspan). In this task participants were required to recall sequences of red squares within a matrix while performing a symmetry-judgment task. In the symmetry-judgment task participants were shown an 8×8 matrix with some squares filled in black. Participants decided whether the design was symmetrical about its vertical axis. The pattern was symmetrical half of the time. Immediately after determining whether the pattern was symmetrical, participants were presented with a 4×4 matrix with one of the cells filled in red for 650 ms. At recall, participants recalled the sequence of red-square locations in the preceding displays, in the order they appeared by clicking on the cells of an empty matrix. There were three trials of each list-length with list-length ranging from two to five for a total possible of 42 (see Unsworth, Redick, Heitz, Broadway, & Engle, 2009, for more details). The same scoring procedure as Ospan was used.

Reading span (Rspan). Participants were required to read sentences while trying to remember the same set of unrelated letters as Ospan. For this task, participants read a sentence and determined whether the sentence made sense or not (e.g., "The prosecutor's dish was lost because it was not based on fact."). Half of the sentences made sense, while the other half did not. Nonsense sentences were made by simply changing one word (e.g., "dish" from "case") from an otherwise normal sentence. Participants were required to read the sentence and to indicate whether it made sense or not. After participants gave their response they were presented with a letter for 1 s. At recall, letters from the current set were recalled in the correct order by clicking on the appropriate letters. There were three trials of each list length, with list length ranging from three to seven for a total possible of 75 (see Unsworth et al., 2009, for more details). The same scoring procedure as Ospan was used.

Academic Text

Participants read the first half of the first chapter (roughly five pages of text) from *The Challenge of Democracy* (Janda et al., 2009) discussing freedom, order, and equality. This is a popular introduction to political science text appropriate for college students, such as the current sample. Each paragraph was presented on screen, and when participants were done reading each paragraph they pressed the spacebar to advance the screen to the next paragraph. In all there were 17 separate paragraphs. Participants were allowed as much time as they needed to read the text.

Mind Wandering Probes

While reading the text, participants were periodically presented with thought probes asking them to classify their immediately preceding thoughts. Participants received six probes periodically throughout the reading task. We used the same thought probes as McVay and Kane (2012b), who asked participants to press one of six keys to indicate what they were thinking just prior to the appearance of the probe. Specifically, participants saw

What were you just thinking about?

1. The text

2. How well I'm understanding the text

3. A memory from the past

4. Something in the future

5. Current state of being

6. Other

During the instructions participants were given specific instructions regarding the different categories. Similar to McVay and Kane (2012b), Responses 3–6 were classified as TUTs.

Reading Comprehension Test

Immediately following the reading task, participants were given 10 multiple-choice questions regarding the material they had just read. These questions came from the online study guide that accompanies the textbook. For each problem, participants were given a question regarding the material (e.g., "*W*hat does the term National Sovereignty refer to?"), accompanied by five multiple-choice answers. Participants were instructed to select the option that best answered the question by pressing the corresponding key. Participants were allowed as much time as needed to the answer the questions.

Questionnaire

Immediately following the reading comprehension test, participants answered a series of questions regarding their interest in the text, their experience/prior knowledge of the topic of the text, and their motivation to perform well. Specifically, participants answered two questions regarding their interest in the topic of the text ("How interested were you in the topic of the text?" and "How interested are you in this topic in general?"), two questions regarding their motivation to perform the task ("How motivated were you to do well on the task?" and "How much did your overall motivation influence your performance on the test?"), and three questions regarding their experience/prior knowledge of the topic of the text ("How much background knowledge do you have on the topic of the text?" "How much did your prior knowledge influence your performance on the test?" and "How many Political Science or Government classes have you taken?"). For each question the anchor ratings were 1 (*not at all*) and 6 (*very much*), except for the question regarding the number of classes taken, for which participants simply typed the appropriate number. Brief descriptions of the ratings were provided, and participants were allowed as much time as needed to answer the questions.

Results

Descriptive Statistics

Descriptive statistics for all of the measures are shown in Table 1. As can be seen in Table 1, the measures had moderate levels of internal consistency and most of the measures were approximately normally distributed, with values of skewness and kurtosis under the generally accepted values (i.e., skewness < 2 and kurtosis < 4; see Kline, 1998). Correlations, shown in Table 2, were weak to moderate in magnitude with measures of the same construct generally correlating more strongly with one another than with measures of other constructs, indicating both convergent and discriminant validity within the data.

Table 1
Descriptive Statistics and Reliability Estimates for All Measures

Measure	*M*	*SD*	Range	Skew	Kurtosis	α
Read1	0.72	0.28	0–1	−0.71	−0.17	.60
Read2	0.66	0.28	0–1	−0.42	−0.46	.62
Read3	0.65	0.27	0–1	−0.43	−0.60	.61
Ospan	54.53	14.49	8–75	−1.15	1.17	.80
Symspan	28.85	7.24	2–42	−0.60	0.92	.79
Rspan	49.68	15.48	6–75	−0.75	0.08	.81
TUT1	0.44	0.30	0–1	0.16	−0.76	.56
TUT2	0.41	0.32	0–1	0.29	−0.91	.58
Interest1	2.45	1.35	1–6	0.71	−0.12	
Interest2	2.68	1.36	1–6	0.49	−0.61	
Motivate	3.20	1.25	1–6	0.11	−0.48	
Motivate2	3.87	1.31	1–6	−0.47	−0.42	
Experience1	3.30	1.30	1–6	0.26	−0.70	
Experience2	3.54	1.50	1–6	0.05	−0.93	
Expereince3	1.59	1.35	0–6	0.73	−0.02	

Note. Read = reading comprehension parcels; Ospan = operation span; Symspan = symmetry span; Rspan = reading span; TUT = task unrelated thoughts; Interest = self-report questions concerning topic interest; Motivate = self-report questions concerning motivation; Experience = self-report questions concerning topic experience.

Confirmatory Factor Analyses

Next, confirmatory factor analysis was used to test a measurement model to determine the structure of the data. Specifically, three separate reading comprehension parcels were created in which the first parcel (Read1) included the average of Questions 1–3, the second parcel (Read2) included the average of Questions 4–6, and the third parcel (Read3) included the average of Questions 7–10. A reading comprehension factor was then formed by having these three parcels load together on the same factor. Likewise, two TUT parcels were created, such that the first TUT parcel (TUT1) included the average of the first three probes, and the second TUT parcel (TUT2) included the last three probes. These two parcels were then used to create a TUT factor by having both TUT parcels load onto it. Separate factors were also created for WMC by having the three WMC tasks (Ospan, Symspan, and Rspan) load together on a factor, for interest by having the two interest questions load together on a factor, for motivation by having the two motivation questions load together, and for topic experience by having the three topic experience questions load together. All of these factors were allowed to correlate, and each measure was allowed to load only on the main factor of interest and not on any other factors.

Model fits were assessed via the combination of several fit statistics. These include chi-square, root-mean-square error of approximation, standardized root-mean-square residual, the nonnormed fit index, the comparative fit index, and the Akaike information criterion. The chi-square statistic reflects whether there is a significant difference between the observed and reproduced covariance matrices. Therefore, nonsignificant values are desirable. However, with large sample sizes even slight deviations can result in a significant value; therefore, the ratio of chi-square to the number of degrees of freedom is also reported. Ratios of two or less usually indicate acceptable fit. Test between nested models are examined via a chi-square difference test. Also reported are the root-mean-square error of approximation (RMSEA) and the stan-

Table 2
Correlations for All Measures

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Read1	—														
2. Read2	.23	—													
3. Read3	.36	.46	—												
4. Ospan	.33	.27	.21	—											
5. Symspan	.24	.11	.15	.48	—										
6. Rspan	.29	.19	.15	.57	.49	—									
7. TUT1	−.06	−.22	−.07	−.14	−.13	−.17	—								
8. TUT2	−.22	−.32	−.26	−.21	−.11	−.22	.27	—							
9. Interest1	.24	.19	.34	.11	.07	.01	−.13	−.18	—						
10. Interest2	.25	.16	.26	.12	.01	.04	−.13	−.21	.73	—					
11. Motivate1	.26	.18	.18	.01	.01	.03	−.18	−.34	.50	.37	—				
12. Motivate2	.21	.17	.15	.18	.14	.16	−.05	−.25	.11	.11	.24	—			
13. Experience1	.21	.11	.35	.01	−.08	−.01	.09	−.13	.46	.46	.26	.03	—		
14. Experience2	.12	.25	.35	.19	.09	.16	.06	−.09	.28	.31	.08	.08	.48	—	
15. Experience3	.01	.04	.16	.07	.03	.06	−.05	−.10	.39	.42	.22	.08	.38	.27	—

Note. Read = reading comprehension tests; Ospan = operation span; Symspan = symmetry span; Rspan = reading span; TUT = task unrelated thoughts; Interest = self-report questions concerning topic interest; Motivate = self-report questions concerning motivation; Experience = self-report questions concerning topic experience. Correlations $> .16$ are significant at the $p < .05$ level.

dardized root-mean-square residual (SRMR), both of which reflect the average squared deviation between the observed and reproduced covariances. In addition, the nonnormed fit index (NNFI) and the comparative fit index (CFI), which compare the fit of the specified model with a baseline null model, are reported. NNFI, and CFI values greater than .90 and RMSEA and SRMR values less than .08 are indicative of acceptable fit (Kline, 1998).

Results from the confirmatory factor analysis are shown in Table 3. The fit of the model was good, $\chi^2(75) = 92.00$, $p > .08$, $\chi^2/df = 1.23$, RMSEA = .04, SRMR = .06, NNFI = .96, CFI = .97. As can be seen each measure loaded significantly on its factor of interest. In terms of the interfactor correlations we see that, replicating much prior research (e.g., Daneman & Merikle, 1996; Engle et al., 1999), WMC and reading comprehension were correlated. Furthermore, consistent with prior research, reading comprehension was related to mind wandering (McVay & Kane, 2012b; Schooler et al., 2004; Smallwood et al., 2009; Unsworth, Brewer, & Spillers, in press), topic interest (e.g., Baldwin et al., 1985; Hidi, 2001; Schiefele & Krapp, 1996; Tobias, 1994), motivation (Anmarkrud & Braten, 2009; Guthrie et al., 1999, 2007), and topic experience (Baldwin et al., 1985; Cromley et al., 2010; Tobias, 1994). Thus, all factors examined in the current study were related to reading comprehension abilities. Examining the correlation between WMC and mind wandering suggests that these two factors were negatively correlated, consistent with prior research suggesting that higher levels of WMC are related to lower levels of self-reported mind wandering (McVay & Kane, 2012b). Furthermore, consistent with prior research, mind wandering was related to both topic interest (Giambra & Grodsky, 1989) and motivation (Antrobus et al., 1966). Finally, topic interest was strongly related to both motivation and topic experience, which were only moderately related with one another. Importantly these domain-specific factors were unrelated to WMC, suggesting the possibility that WMC contributes unique variance to mind wandering and reading comprehension independently of individual differences in topic interest, motivation, and topic experience. Thus, there seems to be a distinction between domain-general factors, such as WMC, and more domain-specific factors, such as interest, motivation, and topic experience, on rates of mind wandering while reading and overall comprehension scores.

Structural Equation Modeling

Next, structural equation modeling was used to test our primary questions of interest. Specifically, we examined how domain-general (WMC) and domain-specific (interest, motivation, topic experience) factors influence mind wandering while reading and how these factors influence reading comprehension and individual differences in reading comprehension. In order to examine the first question of how domain-general and domain-specific factors influence mind wandering while reading, we specified a model in which the WMC, Interest, and Motivation factors from the prior measurement model predicted the TUT factor. This model examines the extent to which variation in TUTs is explained by unique or shared variance from these factors. As shown in the previous confirmatory, factor analysis each of these factors was significantly related to TUTs, but it is not known whether these correlations represent unique relations or whether the correlations represent shared variance. Note that topic experience was not included in this model, given that the factor correlation between TUTs and topic experience was not significant. Shown in Figure 1a is the resulting model. The fit of the model was good, $\chi^2(21) = 19.30$, $p > .56$, $\chi^2/df = 0.92$, RMSEA = .00, SRMR = .05, NNFI = 1.0, CFI = 1.0. As can be seen, both WMC and Motivation accounted for unique variance in TUTs. Interest, however, did not account for unique variance in TUTs. Rather, although Interest was correlated with TUTs, this variability seemed to be shared with Motivation, as indicated by the strong correlation between Interest and Motivation. Furthermore, similar to the confirmatory factor analysis, WMC was not significantly related to either Interest or Motivation. Collectively, these three factors accounted for roughly 49% of the variance in TUTs while reading.

Because the relation between Interest and TUTs seemed to be mediated by Motivation, we next specified a model in which

Table 3
Confirmatory Factor Analysis for Reading Comprehension, Working Memory Capacity, Task Unrelated Thoughts, Interest, Motivation, and Topic Experience

	Latent factor					
Measure	Read	WMC	TUT	Interest	Motivation	Experience
Read1	.52*					
Read2	.58*					
Read3	.72*					
Ospan		.77*				
Symspan		.64*				
Rspan		.75*				
TUT1			.40*			
TUT1			.70*			
Interest1				.90*		
Interest2				.81*		
Motivate1					.84*	
Motivate2					.30*	
Experience1						.78*
Experience2						.58*
Experience3						.50*
	Interfactor correlations					
Read	—					
WMC	.45*	—				
TUT	−.58*	−.41*	—			
Interest	.48*	.10	−.33*	—		
Motivation	.40*	.05	−.61*	.62*	—	
Experience	.52*	.07	−.17	.69*	.36*	—

Note. Read = reading comprehension; Ospan = operation span; Symspan = symmetry span; Rspan = reading span; TUT = task unrelated thoughts; Interest = self-report questions concerning topic interest; Motivate = self-report questions concerning motivation; Experience = self-report questions concerning topic experience; WMC = working memory capacity.
* $p < .05$.

Interest predicted Motivation and both Motivation and WMC predicted TUTs, but there was not a direct effect from Interest to TUTs. Shown in Figure 1b is the resulting model. The fit of the model was good, $\chi^2(23) = 19.54$, $p > .66$, $\chi^2/df = 0.85$, RMSEA = .00, SRMR = .05, NNFI = 1.0, CFI = 1.0. As can be seen, Interest significantly predicted Motivation and both Motivation and WMC accounted for unique variance in TUTs. Furthermore, the indirect effect of Interest on TUTs was significant (indirect effect = –.28, $p < .05$). This suggests that both domain-general (WMC) and domain-specific (Interest and Motivation) factors influence mind wandering while reading. That is, the propensity to mind wander while reading is jointly influenced by one's WMC and by whether one is interested in the topic of the text, which influences their motivation to do well. When one is not interested in the topic of the text, one tends not to be motivated to do well leading to a greater propensity to mind wander while reading the text, and this occurs regardless of one's overall level of WMC.

For our final analysis we examined how the factors examined previously (along with topic experience) would influence reading comprehension. Specifically, we specified a structural model based on the prior model from Figure 1b, in which Interest predicted Motivation and both WMC and Motivation predicted TUTs. To this model we added the reading comprehension factor from the prior measurement model and allowed both WMC and TUTs to predict reading comprehension. Finally, we added topic experience to the model and allowed topic experience to correlate with both Interest and WMC (the two exogenous factors) and to predict reading comprehension. Thus, this model examines how these factors account for both shared and unique variance in reading comprehension scores. Shown in Figure 2 is the resulting model. The fit of the model was good, $\chi^2(81) = 93.31$, $p > .16$, $\chi^2/df = 1.15$, RMSEA = .03, SRMR = .07, NNFI = .97, CFI = .98. The major results can be summarized as follows. Interest significantly predicted Motivation, which in turn predicted TUTs with the indirect effect of Interest on TUTs being significant (indirect effect = –.31, $p < .05$). Variation in WMC also significantly predicted TUTs, and both WMC and TUTs significantly predicted reading comprehension scores. Note that the indirect effect of WMC on reading comprehension through TUTs was also significant (indirect effect = .15, $p < .05$). Fixing the path from WMC to reading comprehension to zero resulted in a significantly worse fit to the model, $\Delta\chi^2(1) = 5.75$, $p < .05$, suggesting that WMC accounted for unique variance in reading comprehension over and above that accounted for by its relation with TUTs. Furthermore, both the indirect effects from Interest (indirect effect = .13, $p < .05$) and Motivation (indirect effect = .20, $p < .05$) on reading comprehension were significant. Finally, topic experience accounted for significant unique variance in reading comprehension. Overall, these factors accounted for roughly 61% of the variance in reading comprehension scores. An additional model was examined to better determine the unique role of TUTs on reading comprehension. Specifically, the same model as shown in Figure 2 was specified, but the direct paths from Interest and Motivation to reading comprehension were freed to determine if these two factors accounted for unique variance in reading comprehension. Additionally, this model examines how TUTs predict reading comprehension when all the factors are allowed to simultaneously predict reading comprehension. The fit of the model was good, $\chi^2(79) = 93.22$, $p > .13$, $\chi^2/df = 1.18$, RMSEA = .04, SRMR = .07, NNFI = .97, CFI = .98. Importantly, the direct paths from Interest (direct effect = .09) and Motivation (direct effect = –.07) to reading comprehension were not significant (both ps $> .50$), but the direct path from TUTs to reading comprehension (direct effect = –.41) remained. Additionally, fixing the path from TUTs to reading comprehension to zero resulted in a significantly worse fit to the model, $\Delta\chi^2(1) = 4.52$, $p < .05$, suggesting that TUTs accounted for unique variance in reading comprehension.

Discussion

What accounts for individual differences in mind wandering while reading, and how do these factors influence reading comprehension scores? The results from the current study suggest that a number of factors are important in accounting for variation in mind wandering while reading and variation in subsequent comprehension scores. In particular, the current results suggest that both domain-general and domain-specific factors are important. In terms of individual differences in mind wandering while reading, the current results suggest that a strong predictor of mind wandering while reading is variation in WMC, which is consistent with prior research (McVay & Kane, 2012b). Individuals low in WMC tended to report more mind wandering while reading than individ-

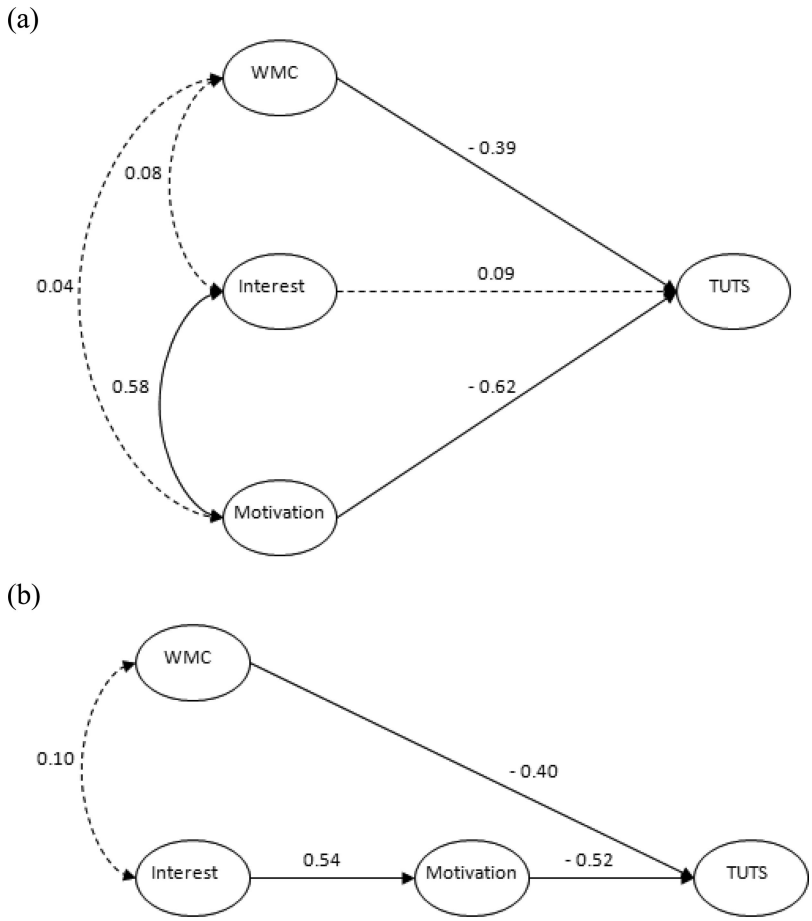

Figure 1. a. Structural equation model predicting task unrelated thoughts (TUTs) with working memory capacity (WMC), Interest, and Motivation. b. Structural equation model in which Interest predicts Motivation and Motivation and WMC predict TUTs. Single-headed arrows connecting latent variables (circles) to each other represent standardized path coefficients, indicating the unique contribution of the latent variable. Double-headed arrows connecting the latent factors represent the correlations among the factors. Solid lines are significant at the $p < .05$ level, and dotted lines are not significant at the $p < .05$ level.

uals high in WMC. Given prior research suggesting that individual differences in WMC are partially due to domain-general differences in attention control (Engle & Kane, 2004; Unsworth & Engle, 2007), the current results suggest that high-WMC individuals are better at controlling their attention while reading in order to maintain focus on the current task and to prevent lapses of attention and mind wandering compared with low-WMC individuals. These differences are needed not only during reading but also during a host of other activities where attention is needed to actively maintain task goals in the face of internal and external distraction, suggesting that this ability is domain-general in nature. Thus, consistent with prior research, individual differences in mind wandering while reading are partially due to domain-general differences in WMC and attention control.

At the same time, domain-specific factors are also important predictors of mind wandering while reading. In particular, the current results suggest that both topic interest and motivation are important contributors to mind wandering while reading. Specifically, participants who indicated that they were not interested in the topic of the text also reported more mind wandering than individuals who were interested in the topic of the text. Furthermore, individuals who indicated that they were more motivated to read the text and to perform well reported less mind wandering than individuals who indicated that they were not motivated. Thus, both interest and motivation were seen to influence mind wandering. Importantly, structural equation modeling suggested that motivation mediated the relation between topic interest and mind wandering rates, such that individuals who reported that they were not interested in the text also reported that they were not motivated to read the text deeply and to perform well resulting in overall higher rates of mind wandering. Thus, low levels of interest led to low levels of motivation, which, in turn, led to higher rates of mind wandering.

Furthermore, the structural equation models suggested that WMC was unrelated to both interest and motivation, and WMC and motivation accounted for unique variance in mind wandering. Thus, both domain-general and domain-specific factors influenced individual differences in mind wandering while reading. This

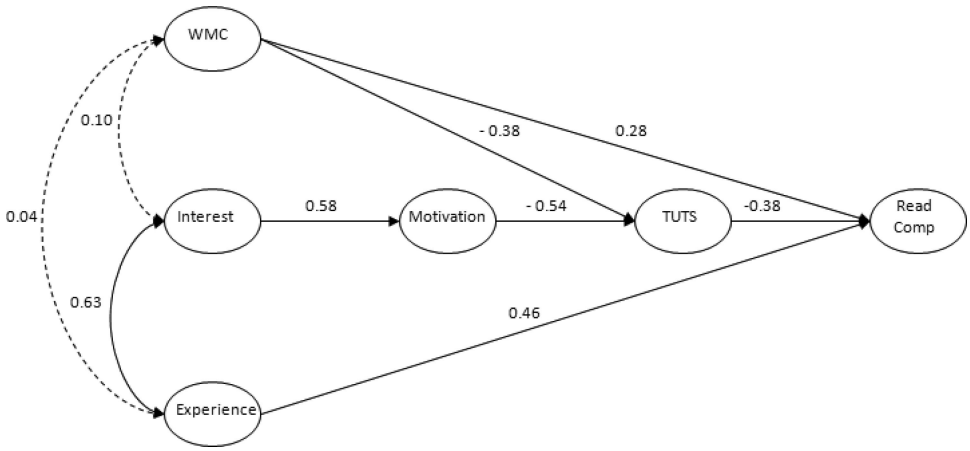

Figure 2. Structural equation model in which Interest predicts Motivation; Motivation and working memory capacity (WMC) predict task unrelated thoughts (TUTs); and TUTs, WMC, and Topic Experience predict Reading Comprehension. Single-headed arrows connecting latent variables (circles) to each other represent standardized path coefficients, indicating the unique contribution of the latent variable. Double-headed arrows connecting the latent factors represent the correlations among the factors. Solid lines are significant at the $p < .05$ level, and dotted lines are not significant at the $p < .05$ level.

suggests that when examining individual differences in mind wandering while reading, researchers need to take into account both domain-general and domain-specific factors, as each will provide predictive power in explaining variation in mind wandering. It should also be noted that the factors examined in the current study accounted for roughly 50% of the variance in mind wandering while reading. While this is impressive, it also suggests that other factors not examined in the current study are likely important in terms of explaining variation in mind wandering while reading. These other factors could include differences in more basic attention control processes not tapped by WMC measures (see, e.g., McVay & Kane, 2012b), as well as situational factors such as mood, fatigue, and personal concerns (McVay & Kane, 2010; Smallwood, 2011; Smallwood & Schooler, 2006), which could influence mind wandering while reading. Future work is needed to better examine the influence of additional factors in accounting for individual differences in mind wandering while reading and examining how these factors are interrelated and account for shared or unique variance in mind wandering.

In terms of individual differences in reading comprehension, the current results are consistent with the prior literature suggesting that topic experience (prior knowledge), interest, motivation, WMC, and mind wandering are all related to reading comprehension scores. Importantly the current results extend prior work by examining interrelations of all of these factors and by demonstrating that only some of these factors have direct effects on reading comprehension. Specifically, consistent with prior research, we found that topic interest and motivation were both related to reading comprehension scores (Anmarkrud & Braten, 2009; Baldwin et al., 1985; Guthrie et al., 1999, 2007; Hidi, 2001; Schiefele & Krapp, 1996; Tobias, 1994). However, the results of the current study suggest that these factors influence reading comprehension only indirectly via mind wandering. Thus, although topic interest and motivation are important predictors of reading comprehension, these effects seem to be due to the fact that interest and motivation influence mind wandering, which, in turn, influenced reading comprehension scores. Likewise, WMC also had an indirect effect on reading comprehension via mind wandering, suggesting that some of the relation between WMC and reading comprehension, which has been documented previously, is partially due to individual differences in the ability to control thoughts and prevent lapses of attention (McVay & Kane, 2012b). Furthermore, the current results suggested that mind wandering, WMC, and topic experience accounted for independent variance in reading comprehension. Thus, variation in mind wandering, due to variation in interest, motivation, and WMC, accounted for unique variance in reading comprehension, suggesting that mind wandering while reading results in the text not being read deeply and, thus, lower comprehension of the text. Likewise, WMC had both direct and indirect influences on reading comprehension (see also McVay & Kane, 2012b), suggesting that WMC differences in reading comprehension are multiply determined, with some variation being due to differences in attention control and mind wandering and other differences potentially being due to the ability to maintain text information while reading in order to integrate prior and current information (Daneman & Carpenter, 1980; Daneman & Hannon, 2001) as well as the ability to activate text relevant information and to filter out irrelevant information (Hasher & Zacks, 1988). Finally, consistent with much prior research, topic experience (prior knowledge) accounted for unique variance in reading comprehension, suggesting that individual differences in the ability to access prior knowledge and integrate it with the current text is important for variation in reading comprehension (Baldwin et al., 1985; Cromley et al., 2010; Kintsch, 1998; Tobias, 1994). Like prior multivariate studies of reading comprehension, these results suggest that reading comprehension is multiply determined and suggest that there are a number of important direct and indirect influences on reading comprehension. Given that roughly 60% of the variance in reading comprehension was accounted for in the current study, it is clear that other factors not measured in the

current study (such as inferences, vocabulary, strategies) are also important for individual variation in reading comprehension (e.g., Cromley et al., 2010). Examining these other factors in conjunction with factors examined in the current study should go a long way toward aiding our understanding of the nature of individual differences in reading comprehension abilities.

The current results not only have important implications for understanding the cognitive underpinnings of reading comprehension but also have important implications for understanding mindless reading in educational contexts (Smallwood et al., 2007). In particular, participants low in WMC and attention control will likely mind wander more while in class and while studying, leading to lower comprehension of the material. Consistent with this, we recently demonstrated that individuals low in WMC and attention control, as measured in the laboratory, were more likely to report that they mind wandered in class and while studying, and these mind wandering rates were significantly correlated with reading comprehension, as measured by verbal SAT scores (Unsworth, McMillan, Brewer, & Spillers, in press). Furthermore, the current results suggest that when students are not motivated or interested in the topic of the text, they will likely mind wander more, leading to lower comprehension and overall lower exam scores. As such the current results suggest the importance of integrating cognitive and educational perspectives in order to better understand reading comprehension.

In summary the results from the current study demonstrated that both domain-general (WMC) and domain-specific (topic interest, motivation) factors influence mind wandering while reading, and these factors, along with topic experience, are important influences on subsequent reading comprehension tests. Examining both domain-general processes, such as WMC and attention control, along with more domain-specific and situational specific factors, such as topic interest, topic experience, motivation, mood, and fatigue, should provide a better understanding of the factors that promote mind wandering while reading as well who is likely to mind wander frequently in a variety of situations. Future work is needed to expand our understanding of how the combination of these factors influences mindless reading and subsequent reading comprehension abilities.

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