The Impact of Modality on Mind Wandering during Comprehension

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Abstract

The executive resource hypothesis assumes a positive relationship between resource availability and mind wandering. Under the assumption that different modalities of information delivery differentially tax resources, we compared mind wandering across different modalities during the presentation of *The Red Headed League* (Experiment 1 and 2) and *Walden* (Experiment 3). An *Audio only* condition produced the most mind wandering. Two conditions that presumably consumed more executive resources than the Audio Only condition (i.e., *Audio + Text* and *Self-paced reading*) produced equivalent amounts of mind wandering during Experiments 1 and 2. In Experiment 3 the reading time of the Self-paced readers moderated the effect of mind wandering in that the fast readers mind wandered more than those in the Audio + Text condition. Results are discussed in the context of the demands of different modes of information delivery methods and mind wandering as well as the potential effects of material type.

*Keywords:* Mind Wandering, Attention, Reading, Information Delivery
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The way that information is delivered and consumed is constantly changing. For example, most books are now available in an electronic format and audio books are increasingly common. Some methods of information delivery may result in a higher propensity to engage in off-task thought than others. For the purposes of this project, we will refer to the action of engaging in task-unrelated thoughts as mind wandering. Mind wandering is defined here as an unintentional, attentional decoupling between the external stimuli and internal thought (Smallwood, Baracaia, Lowe, & Osbonawin, 2003; Smallwood & Schooler, 2006). Mind wandering has been studied in many contexts that have included tasks that require sustained attention (McVay and Kane, 2009, 2012; Smallwood, Riby, Heim, & Davis, 2006), tasks that tax working memory (Mrazek et al., 2012; Smallwood, Nind, & O’Conner, 2009; Smallwood et al., 2011), during reading (Feng, D’Mello, & Graesser., 2013; McVay & Kane; 2012b; Schooler, Reichle, & Halpern 2004; Smallwood, McSpadden, & Schooler, 2008), as well as during everyday activities (Killingsworth & Gilbert, 2010; McVay, Kane, Kwapi, 2009; Kane et al., 2007). One area that has been relatively underexplored is how mind wandering differs as a function of the modality with which information is presented, an issue that we take up in this paper.

Theoretical Perspective

There are various theoretical perspectives regarding how and why mind wandering occurs (Kane & McVay, 2012; Smallwood, 2013). A commonality between the differing perspectives is that executive control has an influence on attentional focus and thereby can facilitate or suppress mind wandering (McVay & Kane, 2010; Randall, Oswald, Beier, 2014; Smallwood & Schooler, 2006). Additionally, there are multiple theoretical perspectives
regarding the occurrence of mind wandering (i.e., Kane & McVay, 2012; McVay & Kane, 2011, Smallwood, 2013; Smallwood & Schooler, 2014). However, for the current study, we focus on the executive resource account of mind wandering (Thomson, Smilek, & Besner, 2014; Smallwood and Schooler, 2006) which assumes that internally generated and task-unrelated thoughts (i.e., mind wandering) compete with externally-influenced task-related thoughts for a limited pool of executive resources that direct attention (Levinson, Smallwood, & Davidson, 2012; Smallwood, 2013; Smallwood & Schooler, 2006; Teasdale et al., 1995). This perspective of mind wandering (hereafter referred to as the executive resource hypothesis) posits that tasks that consume lower amounts of executive resources are associated with a higher likelihood that attention will drift towards off-task thoughts compared to situations where there are fewer resources available (Smallwood, McSpadden, & Schooler, 2007; Smallwood & Schooler, 2006). Support for this perspective comes from studies, such as Smallwood, Nind, and O’Conner (2009), who found that there was less mind wandering during a working memory task compared to a choice reaction time task. These two tasks differ in the amount of exertion on working memory. The working memory task requires the constant encoding and storage of information where the choice reaction time task does not (Smallwood & Schooler, 2014).

Mind wandering has also been found to have a higher likelihood to occur during easy versus difficult tasks (Giambra, 1995; Smallwood, Obonsawin, & Heim, 2003; Smallwood, Obonsawin, & Reid, 2003), presumably because difficult tasks consume more resources than easy tasks\(^1\). Additionally, tasks that can be automated become easier to accomplish as the demands of a task decrease (i.e., consume less resources). In situations where automation is likely to occur, mind wandering has been shown to increase over the duration of the task.

\(^1\) One exception to this relationship between task difficulty and mind wandering was revealed by Feng, D’mello, and Graesser (2013) who found the opposite pattern: more mind wandering occurred when reading difficult text compared to easy texts.
(Smallwood et al., 2004). For example, Smallwood, Obansawin, & Reid (2003) found that tasks that afford automation (e.g., verbal encoding tasks) resulted in an increased amount of mind wandering in relation to an increased amount of time-on-task. However, tasks that required constant attention (i.e., a verbal fluency task) and could not be automated did not result in an increase in mind wandering over time. In support of the executive resource hypothesis, as tasks become easier, the availability of resources presumably results in attention being directed towards thoughts unrelated to the task.

Based on the assumption that different types of tasks consume resources differentially (i.e., automated tasks vs. tasks that require constant attention; Smallwood et al., 2003, 2004), we assume that that different modalities of information presentation also differentially consume executive resources. The processing demands of the task presumably vary depending on how the information is presented and therefore how the information is consumed. For example, it would stand to reason that, all things equal, the processing of information that is delivered in a single modality (i.e., auditory) would consume less resources than when information is presented via multiple modalities (i.e., audio and visual).

**Previous Research on Modality Effects on Mind Wandering**

Researchers have recently assessed differences in mind wandering as a result of how individuals interact with reading materials. Sousa, Carriere, and Smilek (2013) presented participants with materials from a text covering science topics in one of three conditions. Participants either read the text out loud, listened to the text being read to them, or engaged in silent reading. They assessed mind wandering using the probe-caught method where participants were periodically probed during the task and asked if they were currently thinking about the task or thinking about off-task thoughts. The results showed that reading out loud produced the least
amount of mind wandering followed by reading silently; listening to something being read resulted in the most mind wandering. They attribute their findings to the possibility that the more systems that are engaged during reading, the lower the likelihood to engage in off-task thought. That is, reading out loud not only involves the visual system but also the motor systems responsible for producing spoken language. Reading silently would tax fewer systems than reading out loud and listening to a presentation alone would consume the least amount of systems. Thus, a deeper level of overall involvement of multiple systems would suppress, or at least reduce the likelihood for attention to drift off task.

In contrast to the findings reported by Sousa et al. (2013), Franklin, Mooneyham, Baird, and Schooler (2013) found an opposite pattern. Participants in their study read an excerpt from a mystery novel and they either read it silently or read it out loud (there was no listening-only condition). Participants were probed to report their mind wandering similar to the method employed by Sousa et al. (2013). They found that participant who read out loud produced significantly more mind wandering reports than those who read silently, which is exactly the opposite of the pattern reported by Sousa et al. (2013). They offered many plausible explanations for their finding, such as the likelihood that reading out loud promotes self-conscious awareness and increases the propensity to direct attention to the self, thus increasing the propensity to direct attention towards internal off-task thought regarding the self.

Current Study

The two studies mentioned above (Franklin et al, 2013; Sousa et al., 2013) illustrate that mind wandering may differ depending on how the information is delivered, though the direction of the difference is unclear. To investigate this issue further, for the current study, we compared conditions that differed with regard to the modality with which information is delivered and
therefore consumed by an individual. We assessed the differences in mind wandering between participants who processed the same information in different modalities that theoretically require differential amounts of executive resource consumption with the goal of gaining a better understanding of mind wandering under conditions that are commonly used to consume information (e.g., audio books, online presentations, and normal or silent reading).

For the current study, three different information delivery methods (i.e., modalities) were used to present an excerpt from a text. Similar to the Sousa et al. (2013) and the Franklin et al. (2013) studies, we included a condition of normal reading. Participants were presented with the text and could read at their own pace (Self-paced Reading or SPR). A separate condition required participants to listen to an auditory presentation of the materials without any text (i.e., Audio Only or AO). A third condition presented the text and a concurrent presentation of a synchronized narration of the text akin to a close-caption format (i.e., Audio + Text or AT). We did not include a condition where participants read aloud because adults rarely engage in oral reading as most people transition into silent reading after fourth grade (Hiebert, Samuels, Rasinski, 2012; Juel & Holmes, 1981).

We assumed that these conditions would differ with regards to the demands of the executive resources. During normal reading (i.e., the SPR condition), the information to be processed enters the system and taxes the resources of the visual system (i.e., visio-spatio sketchpad). The auditory system (i.e., phonological loop) is then recruited to maintain an acoustic form of the information. The processes involved in processing language recruit the articulatory loop (within the phonological loop) to maintain this form until a match is made from the mental lexicon. The process described above is virtually identical when processing information presented exclusively in an auditory form (i.e., the AO condition) except that there is
no involvement of the visual system. Therefore, listening to something rather than reading it would require fewer resources for processing. In addition, the visual channel would be completely free of task related processing demands in the AO condition, so there could potentially be external visual distractions that would redirect attention. Conversely, if information was presented in a way in which systems involved with processing information aurally, as well as visually, were consumed (i.e., the AT condition), there would be an allocation of resources dedicated to processing the visual information as well as the audio information concurrently leaving fewer available resources.

Based on the aforementioned discussion, we hypothesize that the AO condition would produce the most amount of mind wandering because there are fewer systems involved in the processing of the information resulting in less resource consumption. The AT and the SPR conditions are similar in terms of the amount of resources dedicated to processing of information, however, the AT condition may be the most taxing of resources considering the redundant presentation of information (i.e., audio plus visual). Therefore, we predict that the AT condition will produce the least amount of mind wandering due to the processing demands of the redundant information. That is, as redundant information is presented, more resources need to be allocated to process the information coming from the multiple modalities resulting in fewer resources to direct towards off-task thought. Thus, the general predicted trend of mind wandering based on the executive resource hypothesis is: AT < SPR < AO.

We also considered one other difference between the conditions: control over pace of the presentation of materials. The readers in the SPR condition have the ability to read at their own pace. The timing of the presentation of the reading materials in the AT and AO condition is controlled. For this reason, the readers in the SPR condition may choose to skim or even skip
some portion of the text which would reflect poor engagement and faster reading times. This may also result in more mind wandering because the shallow processing that occurs during this type of reading consumes fewer resources. Alternatively, faster reading may reflect better reading ability and overall better comprehension skills. Faster reading may then be associated with less mind wandering. To test these possibilities, we considered the relationship between reading times and mind wandering in an exploratory attempt to identify differences in mind wandering between fast and slow readers of the SPR condition in comparison to the other conditions. However, we make no predictions regarding their outcomes.

We were also interested in exploring whether or not any findings would be consistent among different sets of materials. The conflicting findings between the Sousa et al. (2013) study and the Franklin et al. (2013) study may be due to the different materials that were used (i.e., science text vs. mystery novel). For the current study, we varied the reading materials among experiments. For Experiment 1 and 2, we presented an excerpt from *The Adventure of the Red Headed League* by Sir Arthur Conan Doyle (1975, 1891) as was used by Franklin et al. (2013). For Experiment 3, we presented an excerpt from *Walden* by Henry David Thoreau (1971, 1854). Although both excerpts were similar in terms of text complexity, as assessed by the Flesh Kincaid Grade Level (FKGL) assessment (Klare, 1974), (FKGL for The Red Headed League = 6.3; FKGL for Walden = 6.5), they are inherently two separate types of literature. Walden is an essay from the perspective of the author on civil disobedience and is considered by some to be a classic piece of American literature. It is written from the first person perspective of the author regarding his time spent in a cabin in the woods on Walden Pond. The mystery novel *The Red Headed League* is an intriguing mystery novel (see Appendix A and B for example excerpts from each text). Narratives, such as *The Adventures of the Red Headed League* are fundamentally

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2 In contrast to the Franklin et al. (2013) study, we used a shorter excerpt than what was used in their study.
distinct from the *Walden* in that they have a definitive story structure depicting main characters, goals, and outcomes (Trabasso, van den Broek, & Suh, 1989). Readers of narratives necessarily attend to elements of the story to create the mental representation to achieve a cohesive representation of the episodes that occur within the story (Graesser, Singer, & Trabbasso, 1994; Magliano, Taylor, & Kim, 2005; Zwaan & Radvansky, 1998).

**Experiment 1**

**Method**

**Participants.** Participants (*N* = 51) were recruited from Amazon Mechanical Turk (AMT). AMT allows voluntary workers to complete Human Intelligence Tasks (HITs) in return for monetary compensation. AMT has been suggested to be a reliable and valid data source to collect experimental data (Crump, McDonnell & Gureckis, 2013; Mason & Suri, 2012). We selected to recruit participants from AMT as it provides a population that is diverse along many dimensions compared to participants that would be recruited from a traditional university subject pool. All participants reported to be residing in the U.S. with a mean age of 28 years (range = 19 to 49).

**Materials.** Participants were presented with an excerpt from *The Adventure of the Red Headed League* (Doyle, 1975, 1891). The AT and AO excerpts were taken from a YouTube video (see Figure 1), which consisted of a text presentation of the book accompanied by a narrator reading the text. The text was presented in chunks (average 25 words at a time). All three conditions were presented with the exact same amount of content. The excerpt was divided into three sections, each corresponding to 8-minutes of content (see Design below). The total amount of words for all three SPR versions contained 3,658 words (first = 1163, second = 1245,
and third = 1250). There was a total of 96 chunks of information divided into the three sections (first = 30, second = 37, and third = 29) (see Appendix A for an example excerpt).

**Design and Procedure.** Participants were first exposed to the excerpt of the story followed by an assessment of comprehension. The experiment employed a within-subjects design. All of the participants were exposed to all three conditions of presentation to alleviate any concerns regarding differences in potential extraneous variables such as reading ability or interest that may influence results. All participants were exposed to the same excerpt of the story. However, the story was segmented into three sections presented in order to maintain the narrative flow of the story. Each section was presented in one of the three modalities with order of exposure to modality counterbalanced across participants with a Latin Square. For example, one participant may receive the ordering of the AT condition for the first segment, the AO condition for the second segment, and the SPR condition for the third segment.

The AT and AO conditions were presented with the material at the same pace and were presented with the same amount of information for the same period of time. For the AT condition, the text appeared on the screen in chunks corresponding to the information displayed on each screen (see Figure 1). For the Audio Only (AO) condition, the text was removed so the participant could only hear the auditory presentation; the title page was shown for the entire duration of the presentation (see Figure 1, Frame 1). Lastly, in the Self-paced reading condition (SPR) the amount of text that appeared on the screen was exactly the same as the AT condition, but the reader could read at their own pace and navigate forward through the text by pressing the space bar.

Mind wandering was assessed via the standard probe-caught method (Smallwood & Schooler, 2006) where participants were periodically asked to report instances on mind
wandering during the presentation of the material. Auditory probes occurred at 15 points during
the presentation (i.e., five probes per section or condition). The probe locations were pseudo-
randomly selected and care was taken to ensure that no two probes appeared within one minute
of each other in the AT and AO conditions. Upon hearing the auditory probe, participants were
to indicate whether their thoughts at that moment were on task (i.e., regarding the content of the
material) or off-task (i.e., mind wandering) (see Appendix C for Instructions). Probe placement
was equated across conditions based on the content of the materials as opposed to locations
determined by time into the task. This was done with the assumption that the SPR condition may
differ in terms of time-on-task thereby ensuring that all conditions would receive the same
number of probes. After participants were presented with the materials in all three conditions,
they were assessed on their comprehension of the materials at the very end of the session. An
experimenter generated posttest assessment consisted of 15 multiple choice items (see Appendix
D for an example test item). The test items referred to lexical or surface level information that
were directly contained in the story.

Results

Mean mind wandering reports per condition are shown in Table 1. An item-level (or
probe-level) mixed-effect logistic regression modeling approach was adopted to assess mind
wandering across conditions (Pinheiro & Bates, 2000). Mixed-effects models include a
combination of fixed and random effects and can be used to assess the influence of the fixed
effects on dependent variables after accounting for any extraneous random effects. The \textit{lme4}
package in R (Bates & Maechler, 2010) was used for the requisite analyses. The random effect
was \textit{participant}. This model contained two fixed effects. The first fixed effect was \textit{condition}.
We also added \textit{probe location} as a fixed effect covariate to alleviate any concern that there may
be more or less mind wandering reports during the beginning or end of the task. All participants were exposed to 15 mind wandering probes resulting in 555 items. A two-tailed alpha of .05 was adopted for all significance testing.

Fourteen participants were removed from the analysis using the mixed model approach due to failure of model convergence because these participants did not report any mind wandering for any of the conditions. As such, we also conducted an analysis using non-parametric techniques that included these participants because of the non-normal (zero-inflated) distributions attributed to the excess of participants who did not report mind wandering. We first report the mixed effects models followed by the results of the non-parametric analysis.

We initially assessed the overall effect of condition on mind wandering reports using the mixed-effect models approach \((N = 37)\) and found that there was a significant condition effect on mind wandering reports, \(F(2, 551) = 10.60, p < .01\). The overall pattern of mind wandering among condition was: \((AT = SPR) < AO\) (see Table 2 for regression coefficients). We then conducted the analysis containing all 51 participants using a Friedman’s test - the non-parametric equivalent to the repeated measures ANOVA. The dependent variable was the proportion of mind wandering reports in each condition. The results of the Friedman’s test were significant, \(\chi^2 = 14.68, df = 2, p < .01\). To conduct the non-parametric post hoc comparisons, we used the Wilcoxin matched pairs test which is analogous to the paired samples \(t\)-test. The results were: \(AT < AO, z = 2.99, p < .01; SPR < AO, z = 2.93, p < .01; AT = SPR, z = .50, p = .62\). Thus, the full and partial data sets yielded the same results as the nonparametric and mixed effects models produced identical patterns in the data.

We were also interested in exploring how the element of control over the pace of the presentation for those in the SPR condition would impact mind wandering during reading. To do
this, we first considered the relationship between the reading times of the SPR condition and mind wandering. The mean reading time for the SPR condition was 4.26 minutes compared to the AT and the AO condition where exposure to content was 8 minutes. The correlation between mind wandering and reading time for the SPR condition was slight (Spearman’s rho = -.06, p = .70). We then performed a median split of reading times (median = 4.11 minutes) of the participants in the SPR condition and separately compared the mind wandering of the fast and slow readers in the SPR condition to all participants in the AT and AO conditions and there were no differences beyond the pattern of result reported above. This was likely due to the lack of a correlation between mind wandering and SPR reading time.

We next considered the performance on the comprehension assessment. The comprehension assessment was scored and mean proportion scores were calculated for each condition. The results can be seen in Table 3. We first computed correlation coefficients to assess the relationships between mind wandering and comprehension within each condition. There was not a significant correlation between comprehension performance and mind wandering for either the AT condition (Spearman’s rho = -.22, p = .12) or the SPR condition (Spearman’s rho = -.15, p = .30), though the correlations were in the expected direction. The AO condition, however, did result in a significant relationship between mind wandering and performance on the comprehension assessment (Spearman’s rho = -.59, p < .01). A statistical comparison of the differences between conditions was assessed using the test of differences between dependent correlation coefficients with no variable in common (Lee & Preacher, 2013). The correlation coefficients were standardized using the Fisher’s Z transformation and then the asymptotic covariance of the estimates were computed (Steiger, 1980) and compared in an asymptotic Z-test. The statistical analysis revealed that the AT and SPR conditions were not
significantly different ($Z = -0.41, p > .05$). The correlations of the AO condition was significantly different from the correlations of the AT condition ($Z = -2.85, p < .01$), and the SPR condition ($Z = -3.04, p < .01$). A repeated measures ANOVA with condition as the within subject factor revealed that the three conditions did not, however, significantly differ in performance on the comprehension assessment ($p$’s > .05).

**Discussion**

We tested executive resource hypothesis by assessing differences in mind wandering between three conditions that varied with regard to how the information was delivered. Presumably these conditions also differ with regard to the amount of resources they consume. The executive resource hypothesis was supported in that the condition that consumed the least amount of resources (i.e., AO) resulted in the most amount of mind wandering when compared to the AT condition and the SPR condition. Contrary to our prediction, we found that there was no difference between the AT and the SPR condition. We also assessed comprehension and found no differences among conditions. We did find that there was a negative correlation between comprehension and mind wandering for all three conditions, but the correlation was strongest and only significant for the AO condition.

One concern is that the lack of any mind wandering differences between the SPR and the AT conditions may be due to the relatively short exposures to conditions and carry-over effects. To eliminate this possibility, for the second experiment, we used the same materials as Experiment 1, but with a between-subjects design that afforded longer exposures to condition and eliminated carry-over effects. Because we were interested in assessing the differences between the AT and SPR condition for the second experiment, we eliminated the AO condition and focused solely on the AT and the SPR conditions in Experiment 2.
Experiment 2

Method

Participants. Participants ($N = 90$) were again recruited from Amazon Mechanical Turk and monetarily compensated for participation. All participants reported to reside in the U.S. with the mean age of 32 years (range = 18 to 54).

Materials. Participants were presented with the same excerpt from *The Adventure of the Red Headed League* as was done in Experiment 1. The AT and the SPR conditions were presented with the exact same amount of content. The presentation length for the AT condition was 24 minutes. The text for SPR version contained 3,658 words, split into chunks corresponding to on-screen text in the AT condition.

Design and Procedure. The procedure was exactly the same as the first experiment: participants were first exposed to the presentation of materials followed by the assessment of comprehension. This experiment incorporated a between subject design where participants were randomly assigned to either the AT ($n = 41$) or SPR ($n = 49$) condition. Mind wandering was assessed via the probe method (Smallwood & Schooler, 2006) using the same instructions and 15 probe-locations as in Experiment 1. Participants were assessed on their comprehension of the reading materials using the same comprehension assessment as in Experiment 1.

Results

Mean proportion of mind wandering reports per condition are shown in Table 1. As was done in the previous experiment, an item-level mixed-effects logistic modeling approach was adopted (Pinheiro & Bates, 2000). The random effect was *participant*. The fixed effects were *condition* and *probe location*. All participants received 15 mind wandering probes, resulting in 1337 items.
There was not a significant difference of mind wandering reports between the AT and the SPR conditions, $F(2, 1334) = .011, p = .92, (B = -.06, SE = .57)$. As was done in the previous experiment, we explored how the element of control for those in the SPR condition would impact mind wandering during reading. The mean reading time of participants in the SPR condition was 14.1 minutes with a range of 4.8 to 28.5 minutes. Similar to Experiment 1, there was a small negative correlation between reading time in the SPR condition and mind wandering (Spearman’s $rho = -.04, p = .81$). We again performed a median split of reading times (median = 13.51 minutes) of the participants in the SPR condition. We then separately compared the mind wandering of the fast and slow readers in the SPR condition to the participants in the AT condition. Similar to Experiment 1 we found no differences beyond the pattern of result reported above, likely due to the lack of a correlation between mind wandering and SPR reading time.

We then examined comprehension performance (see Table 3). Similar to the Experiment 1, there was no significant difference between the AT and the SPR condition, $p > .05$. However, there was a significant negative correlation between comprehension performance and mind wandering for the AT condition (Spearman’s $rho = -.37, p = .02$) and for the SPR condition (Spearman’s $rho = -.34, p = .02$). A statistical comparison of the differences between conditions was assessed using the test of differences between correlation coefficients (Preacher, 2002). The correlation coefficients were standardized using the Fisher’s $Z$ transformation and then compared using the formula suggested by Cohen, Cohen, West, and Aiken (2013). The difference between these correlations was not statistically significant ($Z = -.54, p > .05$).

**Discussion**

The between subject design and longer exposure to content in Experiment 2 produced similar non-significant results between the AT and SPR conditions as Experiment 1, both with
respect to mind wandering and comprehension. In addition, similar to Experiment 1, there was no effect of the control of the pace of the presentation of the materials for those in the SPR condition as reading time was not correlated with mind wandering. We then considered whether the results found across the first two experiments would replicate when exposing participants to a different type of content as was the focus of Experiment 3.

**Experiment 3**

The goal of the third experiment was to assess whether a different set of materials would result in a different pattern of mind wandering results. The story excerpt that was used in Experiment 1 and 2, *The Adventure of the Red Headed League* (Doyle, 1975, 1891), was replaced with an excerpt from *Walden* (Thoreau, 1854). In an attempt to fully understand how mind wandering would be influenced by a different set of materials, we reintroduced the AO condition in addition to the AT and the SPR conditions in a between subject design. We also wanted to rule out the possibility that the non-significant differences between the AT and the SPR condition for Experiments 1 and 2 were simply due to the act of reading. Reading may inherently require more devotion of resources so simply exposing participants to text may have resulted in the lack of a significant difference between these two conditions. Furthermore, it is possible that the participants in the AT condition did not attend to the concurrent presentation of the audio and simply read the text presentation (i.e., similar to the SPR condition). To alleviate concerns regarding this possibility, we included an additional condition where participants were presented with the text-only and no audio, similar to the SPR condition of the previous experiments. However, the text was presented at the same rate as the AT and AO conditions. The participant did not have the control over the pace of the presentation, nor were they be presented with redundant information (i.e., AT condition). That is, the text was presented at an
equal pace as the AT and AO conditions and the probe placement was in the same exact temporal location. We refer to this condition as the Computer-paced Reading (CPR) condition. According to the executive resource hypothesis, this condition would consume an equivalent amount of resources as the SPR condition. The only difference between these two conditions is the element of control that the SPR condition has over the pace of the presentation of the materials.

**Method**

**Participants.** Participants ($N = 181$) were recruited from Amazon Mechanical Turk (AMT) and monetarily compensated for participation. All participants reported residing in the U.S. and had a mean age of 32 years (range = 18 to 62).

**Materials.** Participants were presented with an excerpt from *Walden* by Henry David Thoreau (1854). The AT, AO, and CPR excerpts were taken from YouTube. The YouTube video consisted of a text presentation of the book accompanied by a narrator reading the text. The text was presented in chunks (average 25 words at a time). The excerpt used for the current experiment was taken from the first chapter of the book and the presentation of the AT, AO, and CPR conditions were 20 minutes long. All three conditions were presented with the exact same amount of content. The SPR version contained 2,683 words across 94 chunks.

For the first two experiments we did not find an effect of condition on comprehension, although we did find that mind wandering and comprehension correlated in the expected direction. For the Experiment 3, we implemented a different type of assessment by asking an open-ended free recall question. After exposure to the materials in the respective conditions, participants were asked to answer the following question: “Please recall as much as you can remember from the presentation of Walden. Please try to be as complete as possible.” The question appeared above a blank text box on the computer screen where participants could type
their responses. There was not a time constraint and participants could take as long as they desired to answer the question.

**Design and Procedure.** The procedure was the same as the first two experiments; participants were presented with the materials followed by an assessment of comprehension. The experiment employed a between-subjects design where participants were randomly assigned to the AT, AO, SPR, and CPR conditions. Based on the assumption that the differences between the AT and SPR condition may be more subtle compared to the AO and CPR conditions (see Introduction and the previous two experiments), we collected more data with regard to the AT and SPR conditions to investigate our predictions. This resulted in unequal number of participants for each condition. (AT = 54, AO = 34, SPR = 55, CPR = 38).

Mind wandering was assessed via the standard probe-caught method (Smallwood & Schooler, 2006) using the same instructions as in Experiment 1 and Experiment 2. Auditory probes occurred at ten points during the presentation of the material. The probe locations were pseudo-randomly selected and care was taken to ensure that no two probes were appear within one minute of each other in the AT, AO, and CPR conditions.

**Results**

Mean mind wandering reports per condition are shown in Table 1. Data were analyzed at the item-level using a similar mixed-effects logistic modeling approach as Experiments 1 and 2 (Pinheiro & Bates, 2000). All 181 participants were exposed to ten mind wandering probes resulting in 1808 items.

We found that there was a significant condition difference on mind wandering reports, $F(3, 1803) = 6.92, p < .01$. Post-hoc tests confirmed that the AT condition resulted in significantly less mind wandering than the AO and the CPR conditions, $p$’s < .01. The difference
between the AT and the SPR condition was marginally significant ($p = .051$) as were the differences between the SPR and the AO condition ($p = .07$). The SPR condition was also significantly different than the CPR condition ($p = .02$). There was no difference between the AO and the CPR condition ($p = .72$). Thus, the general pattern was: $AT < SPR < (AO = CPR)$ (see Table 4 for regression coefficients).

We next considered the reading times of the SPR condition since we were also interested in exploring how the element of control for those in the SPR condition would impact mind wandering during reading. The AT, AO, and the CPR conditions were exposed to 20 minutes of content. The mean reading time for those in the SPR condition was 12.4 minutes with a range of 6.4 to 21.2 minutes. There was a negative correlation between reading time and mind wandering reports for those in the SPR condition (Spearman’s $rho = -.21$, $p = .13$); although not significant, the longer reading times (i.e., slower readers) were associated with less mind wandering. We performed a median split of reading times (median = 11.73 minutes) of the participants in the SPR condition. We then separately compared the mind wandering of the fast and slow readers in the SPR condition to all participants in the AT, AO, and CPR conditions (see Table 1). For the fast readers, posthoc tests revealed the following pattern in the results: $AT < (SPR = CPR = AO)$ (see Table 4 for regression coefficients). However, the analysis of the slow readers produced a different pattern of results: $(AT = SPR) < (CPR = AO)$.

For this third experiment, we implemented a different type of comprehension assessment by asking participants to recall as much as they could from the presentation of Walden. Due to experimenter error, the recall assessment was only administered to a subset of the participants ($N = 113$; AT = 41, AO = 21, CPR = 20, SPR = 31). The recall protocols were coded for idea units
from the text \(^3\) (See Table 2 for average idea units by condition). Idea units consisted of information regarding the content of the presentation (e.g., “The book was written in Concord Massachusetts”). Information that was not relevant to the content of the text was not coded as an idea unit (e.g., personal views on writing style: “The author is long winded”). There was no significant difference in the amount of idea units produced between conditions, \( p = .84 \). When considering only the amount of units in the SPR condition by reading times (fast vs. slow), the slow readers did produce more idea units than the fast readers (slow = 3.4, \( SD = 2.3 \); fast = 2.5, \( SD = 1.4 \)) although this difference was non-significant (\( p = .17 \)).

There was an overall significant negative correlation between the recall assessment and mind wandering (Spearman \( rho = -.21, p = .03 \)). All conditions did result in a negative correlations (Spearman \( rho \)) between the recall assessment and mind wandering (AT = -.30, AO = -.22, SPR = -.16, CPR = -.25). Although none were significant (all \( p \)'s > .05), the relationship between mind wandering and recall for the AT condition approached significance (\( p = .059 \)) and the trends for all the conditions were in the expected direction. There were no statistically significant differences of correlations among any of the conditions (all \( Z \)'s < .9, all \( p \)'s > .05).

**Discussion**

We tested the executive resource hypothesis by assessing mind wandering in a similar manner to Experiments 1 and 2 with a different set of materials. In addition, we included a computer-paced reading condition (CPR) and reintroduced the AO condition. The overall pattern of mind wandering results was: AT < SPR < (AO = CPR). Similar to Experiment 1, the executive resource hypothesis was supported in that the condition that consumed the least amount of resources due to only occupying a single processing channel (i.e., AO) resulted in the

\(^3\) Two independent coders were trained on a subset of data and then independently scored 20% of the responses, resulting in an inter-coder reliability of \( r = .92, p < .01 \). This was judged to be sufficiently high, so one coder independently scored the remaining data.
most amount of mind wandering when compared to the AT and SPR conditions. The executive resource hypothesis would assume that the SPR and the CPR conditions would have consumed an equal amount of resources resulting an equivalent amount of mind wandering. However, the CPR condition differed from the SPR condition and resulted in an equivalent amount of mind wandering as the AO condition.

At first glance, the AT condition produced significantly less mind wandering than the SPR condition, which is a different finding from the first two experiments. However, there was a different pattern of results when considering the fast vs. slow readers of the SPR condition. When considering the fast readers, the AT condition did indeed result in the least amount of mind wandering compared to the AO, SPR and the CPR conditions: \( \text{AT} < (\text{SPR} = \text{AO} = \text{CPR}) \). When considering the slow readers, the AO and the CPR conditions produced the greatest (and an equivalent) amount of mind wandering with no differences between the AT and SPR conditions: \( (\text{AT} = \text{SPR}) < (\text{AO} = \text{CPR}) \). These results suggest that the faster readers may have been less engaged in the text as evidenced by the increased amount of mind wandering. Those who read at a slower rate mind wandered less, presumably because they were more attentive to the reading than those who read fast.

There was a concern that participants in the AT condition did not attend to the concurrent presentation of the audio and read the text presentation, making the AT condition similar to the SPR condition. The CPR condition was included in Experiment 3 to alleviate this concern by allowing for an assessment of a condition that presented the text in a similar manner to the AT and SPR condition. The difference between the CPR and the SPR condition was that the SPR condition did include an element of control in that the participant had control over the pace of the presentation of the materials where the participants in the CPR condition were presented with the
content at the pace of the computer (similar to the AT and AO conditions). If participants in the AT condition were not attending to the audio, their mind wandering behaviors would have been expected to be the same as an identical condition with no audio (i.e., CPR). This was not the case, as we found that the CPR condition mind wandered more than the AT and SPR conditions. Overall, these findings suggest that the null results that emerged between the AT and SPR conditions from Experiment 1 and Experiment 2 may not simply be due to reading the text as the CPR condition resulted in an equivalent amount of mind wandering compared to the AO condition and significantly more than both the AT and SPR conditions when considering the slow readers. One caveat, however, is that those in the CPR condition may have read the information at a quick pace (similar to those in the SPR condition). A lack of control over the pace of the presentation may produce times of waiting for the next page of text to appear. It is reasonable to assume that this may have also contributed to an increased amount of mind wandering for those in the CPR condition.

**General Discussion**

Individuals today have the opportunity to consume information in many forms. Audio books and online learning environments have afforded new ways of information consumption leaving individuals with multiple options. The amount of studies examining mind wandering and information delivery is rather sparse and the results have been mixed (i.e., Franklin et al., 2013; Sousa et al., 2013). Thus, the goal of this study was to assess the impact of different modalities of information delivery on mind wandering. Across three experiments, we tested the executive resource hypothesis using various conditions that reflect how individuals consume information and with different types of material. What follows is a discussion of the major
findings, how they align with the executive resource hypothesis, and the applied implications of the findings.

**Main Findings.** Experiment 1 and 3 show a consistent pattern; when the materials is presented in the Audio Only format, there is a higher propensity to mind wander compared to a condition where multiple channels are occupied and/or available resources are limited (Audio + Text and Self-paced Reading). This finding supports the executive resource hypothesis in that mind wandering increases when resources are available to attract attention away from the task towards task-unrelated thoughts and ideas. We predicted that the AT condition would result in the least amount of mind wandering due to the redundant presentation of information resulting in more resource consumption. Counter to our prediction, we found no difference between the AT and SPR condition for Experiments 1 and 2 when participants were presented with *The Adventures of the Red Headed League.*

Our hypothesis that the AT condition would result in the least amount of mind wandering was only supported for Experiment 3 when participants were presented with *Walden.* These results highlight the fact that different types of materials likely result in different types of reading behaviors. Our materials differed in that one was a mystery that followed a traditional story line while the other was an essay on a topic that some may consider to be outdated by conventional standards. It could be assumed that the mystery story would likely be more interesting. It may be that when the material has the propensity to lose the interest of the individual, presenting in a way to consume multiple channels and presumably the most amount of resources (i.e., Audio + Text) would be the most beneficial to inhibit mind wandering. In fact, we found that when presenting Walden, those who read more slowly in the SPR condition did not differ from those in the AT condition. In Contrast, fast readers mind wandered more than those in the AT condition.
This finding differed from Experiment 1 and 2 and suggests that the type of content is important to consider when the goal is to minimize mind wandering.

One would assume that the condition that results in the most mind wandering would comprehend the least because of attention drifting away from the story. We found that there was no differences between conditions in Experiment 1 and 2 for comprehension of the story. We also found no differences between conditions when participants were asked to recall the story for Experiment 3. This is not unprecedented as Franklin et al. (2013) also found no comprehension differences between a read aloud and a silent reading condition although there were significant mind wandering differences. Furthermore, in accord with previous research (Schooler et al., 2004; Smallwood et al., 2008), we did find a negative relationship between comprehension and mind wandering for all conditions for Experiment 1, 2, and 3. However, considering the consistent lack of differences found among this and other studies that have investigated mind wandering as a function of modality, the investigation of the effects of mind wandering on comprehension should be further investigated, ostensibly, with materials that tap deeper rather than shallower levels of comprehension and on extended periods of engagement with the materials (i.e., reading Walden in its entirely rather than a single chapter).

**Limitations and Future Directions.** This work is not without limitations. First, there are no interest measures for this set of experiments. Interest has been known to be negatively associated with mind wandering (Smallwood et al., 2009). It would be useful for future studies to assess interest in the topic of study as a possible moderating factor between information modality and mind wandering. Third, the amount of information delivered was dictated by the formatting of the YouTube videos. Prior research of mind wandering during reading has varied the way that the information has been presented. For instance, text has been presented sentence
by sentence, word by word, and page by page. It would be worthy of future research to investigate whether the amount of information presented at a time has a differential influence on mind wandering. Next, this was a study conducted online. We consider this to be an advantage considering that one could argue that this would be similar to how normal information consumption occurs (i.e., in the home at your own pace). However, it would be worthwhile for future endeavors to also consider conditions such as these in other environments such as the classroom. Third, we acknowledge that the exposure to materials was relatively short. Generally, people engage with materials such as these for longer periods of time. It may be the case that longer sessions would result in a different pattern of results across conditions. It would be beneficial for future investigations to consider longer exposure to materials. Lastly, this study did not assess the types of thoughts that people experienced when reporting mind wandering. The content of mind wandering has been found to differ along many dimensions such as temporal (past, present, or future: Smallwood, Nind, & O’Conner, 2009) as well as with regard to thoughts associated with the current concerns of the individual (Klinger, 2013; Smallwood & Schooler, 2015). It would be beneficial for future research to consider the content of mind wandering that occurs when interacting with the materials that presumably differentially consume executive resources.

**Applied Implications.** The results of this study may be applicable to many situations where information is presented and mind wandering may be detrimental such as online tutorials. When the goal is to present material in a way that reduces the likelihood to mind wander, presenting in an audio only condition is the least optimal option, at least for the materials considered in our experiments. When considering the differences between presenting in a fashion of the SPR and the AT conditions, if the materials has the potential to be considered
uninteresting or there is a potential for disengagement, the optimal condition would be to present materials aurally in addition to textually (i.e., AT). It would be beneficial for future research to explore mind wandering under conditions presented here with different types of materials, such as filmed lectures or narrated power points, that are increasingly common in online learning forums (Szpunar, Kahn, & Schacter, 2013).

In summary, the way in which individuals consume information is constantly changing. Previous research has consistently shown that mind wandering occurs in many different situations. Our results suggest that less mind wandering occurs when the method of delivery is more taxing of resources that would otherwise be dedicated to processing information. For these materials, it is evident that the least optimal condition would be to present information in a similar fashion as an audio book (i.e., Audio Only). However, when considering alternative methods such as a redundant presentation of audio in addition to text (similar to an audio version with closed captions) or simply presenting text to read under a situation of normal reading, it may depend on the type of material that is being presented. That is, considering the type of content along with the methods of delivery may be the best consideration when the goal is to reduce mind wandering. These results may be applicable to any situation where the goal is to present information in a way to keep attention of an individual, reduce the propensity to mind wander, and increase engagement. However, future research is needed to investigate mind wandering in the different types of learning environments that are becoming commonplace.
References


Bates, D. M., & Maechler, M. (2010). *lme4: Linear mixed-effects models using S4 classes.* Retrieved from [http://CRAN.R-project.org/package=lme4](http://CRAN.R-project.org/package=lme4)


Retrieved from [https://www.youtube.com/watch?v=HuoMHA6XXqY](https://www.youtube.com/watch?v=HuoMHA6XXqY)

Table 1. Proportion of mind wandering by condition for each experiment (with standard deviations in parentheses).

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Audio + Text (AT)</td>
<td>.35 (.33)</td>
<td>.25 (.32)</td>
<td>.19 (.24)</td>
<td>.25 (.21)</td>
</tr>
<tr>
<td>Audio Only (AO)</td>
<td>.51 (.33)</td>
<td>.37 (.36)</td>
<td>.45 (.26)</td>
<td></td>
</tr>
<tr>
<td>Self-paced Reading (SPR)</td>
<td>.34 (.34)</td>
<td>.24 (.38)</td>
<td>.22 (.27)</td>
<td>.35 (.28)</td>
</tr>
<tr>
<td>SPR Fast Readers</td>
<td></td>
<td></td>
<td></td>
<td>.37 (.29)</td>
</tr>
<tr>
<td>SPR Slow Readers</td>
<td></td>
<td></td>
<td></td>
<td>.29 (.27)</td>
</tr>
<tr>
<td>Computer-paced Reading (CPR)</td>
<td></td>
<td></td>
<td></td>
<td>.46 (.29)</td>
</tr>
</tbody>
</table>

*Note.* Mind wandering reports were calculated for each participant and proportion scores were computed by dividing their number of “yes” response to probes by the number of probes (Exp 1 = 15, Exp 2 = 15, Exp 3 = 10)
Table 2. Experiment 1: $B$ coefficients for each comparison between conditions with standard errors in parentheses.

<table>
<thead>
<tr>
<th>Reference Condition</th>
<th>Audio + Text (AT)</th>
<th>Self-paced Reading (SPR)</th>
<th>Audio Only (AO)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Audio + Text (AT)</td>
<td></td>
<td>-.13 (.26)</td>
<td>.94 (.26)</td>
</tr>
<tr>
<td>Self-paced Reading (SPR)</td>
<td></td>
<td></td>
<td>1.06 (.26)</td>
</tr>
</tbody>
</table>
Table 3. Average comprehension scores (proportion correct) by condition for Experiment 1 and 2 (with standard deviations in parentheses) and average number of idea units produced by condition during free recall during Experiment 3.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Exp1 (Proportion Correct)</th>
<th>Exp2 (Proportion Correct)</th>
<th>Exp3 (Number of Idea Units)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Audio + Text (AT)</td>
<td>.64 (.26)</td>
<td>.68 (.20)</td>
<td>3.27 (3.06)</td>
</tr>
<tr>
<td>Audio Only (AO)</td>
<td>.60 (.33)</td>
<td></td>
<td>2.71 (1.71)</td>
</tr>
<tr>
<td>Self-paced Reading (SPR)</td>
<td>.57 (.28)</td>
<td>.65 (.20)</td>
<td>2.90 (2.02)</td>
</tr>
<tr>
<td>Computer-paced Reading (CPR)</td>
<td></td>
<td></td>
<td>2.97 (1.96)</td>
</tr>
</tbody>
</table>

*Note.* Comprehension scores for Experiments 1 and 2 were calculated for each participant and proportion scores were computed by dividing their correct number of responses by the total number questions (Exp1 = 15, Exp 2 = 15).
Table 4. Experiment 3: $B$ coefficients for each comparison between conditions with standard errors in parentheses.

<table>
<thead>
<tr>
<th>Reference Condition</th>
<th>Self-paced Reading (SPR)</th>
<th>SPR Fast Readers</th>
<th>SPR Slow Readers</th>
<th>Computer-paced Reading (CPR)</th>
<th>Audio Only (AO)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Audio + Text (AT)</td>
<td>.57 (.29)</td>
<td>.71 (.34)</td>
<td>.21 (.34)</td>
<td>1.28 (.31)</td>
<td>1.15 (.33)</td>
</tr>
<tr>
<td>Self-paced Reading (SPR)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SPR Fast Readers</td>
<td>.71 (.31)</td>
<td>.56 (.36)</td>
<td>.44 (.37)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SPR Slow Readers</td>
<td></td>
<td></td>
<td></td>
<td>1.04 (.36)</td>
<td>.92 (.37)</td>
</tr>
<tr>
<td>Computer-paced Reading(CPR)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-.13 (.34)</td>
</tr>
</tbody>
</table>
Appendix A

Sample Excerpt from The Red Headed League

I had called upon my friend, Mr. Sherlock Holmes, one day in the autumn of last year and found him in deep conversation with a very stout, florid faced, elderly gentleman with fiery red hair. With an apology for my intrusion, I was about to withdraw when Holmes pulled me abruptly into the room and closed the door behind me. "You could not possibly have come at a better time, my dear Watson," he said cordially. "I was afraid that you were engaged."

"So I am. Very much so." "Then I can wait in the next room." "Not at all.

This gentleman, Mr. Wilson, has been my partner and helper in many of my most successful cases, and I have no doubt that he will be of the utmost use to me in yours also." The stout gentleman half rose from his chair and gave a bob of greeting, with a quick little questioning glance from his small fat-encircled eyes. "Try the settee," said Holmes, relapsing into his armchair and putting his fingertips together, as was his custom when in judicial moods.

"I know, my dear Watson, that you share my love of all that is bizarre and outside the conventions and humdrum routine of everyday life. You have shown your relish for it by the enthusiasm which has prompted you to chronicle, and, if you will excuse my saying so, somewhat to embellish so many of my own little adventures."

"Your cases have indeed been of the greatest interest to me," I observed.

"You will remember that I remarked the other day, just before we went into the very simple problem presented by Miss Mary Sutherland, that for strange effects and extraordinary combinations we must go to life itself, which is always far more daring than any effort of the imagination." "A proposition which I took the liberty of doubting."
"You did, Doctor, but none the less you must come round to my view, for otherwise I shall keep on piling fact upon fact on you until your reason breaks down under them and acknowledges me to be right. Now, Mr. Jabez Wilson here has been good enough to call upon me this morning, and to begin a narrative which promises to be one of the most singular which I have listened to for some time. You have heard me remark that the strangest and most unique things are very often connected not with the larger but with the smaller crimes, and occasionally, indeed, where there is room for doubt whether any positive crime has been committed. As far as I have heard it is impossible for me to say whether the present case is an instance of crime or not, but the course of events is certainly among the most singular that I have ever listened to.

Perhaps, Mr. Wilson, you would have the great kindness to recommence your narrative. I ask you not merely because my friend Dr. Watson has not heard the opening part but also because the peculiar nature of the story makes me anxious to have every possible detail from your lips. As a rule, when I have heard some slight indication of the course of events, I am able to guide myself by the thousands of other similar cases which occur to my memory. In the present instance I am forced to admit that the facts are, to the best of my belief, unique."
Appendix B

Sample Excerpt from *Walden*

When I wrote the following pages, or rather the bulk of them, I lived alone, in the woods, a mile from any neighbor, in a house which I had built myself, on the shore of Walden Pond, in Concord, Massachusetts, and earned my living by the labor of my hands only. I lived there two years and two months. At present I am a sojourner in civilized life again. I should not obtrude my affairs so much on the notice of my readers if very particular inquiries had not been made by my townsmen concerning my mode of life, which some would call impertinent, though they do not appear to me at all impertinent, but, considering the circumstances, very natural and pertinent. Some have asked what I got to eat; if I did not feel lonesome; if I was not afraid; and the like. Others have been curious to learn what portion of my income I devoted to charitable purposes; and some, who have large families, how many poor children I maintained. I will therefore ask those of my readers who feel no particular interest in me to pardon me if I undertake to answer some of these questions in this book. In most books, the I, or first person, is omitted; in this it will be retained; that, in respect to egotism, is the main difference. We commonly do not remember that it is, after all, always the first person that is speaking. I should not talk so much about myself if there were anybody else whom I knew as well. Unfortunately, I am confined to this theme by the narrowness of my experience. Moreover, I, on my side, require of every writer, first or last, a simple and sincere account of his own life, and not merely what he has heard of other men's lives; some such account as he would send to his kindred from a distant land; for if he has lived sincerely, it must have been in a distant land to me. Perhaps these pages are more particularly addressed to poor students. As for the rest of my readers, they will accept such portions as apply to them. I trust that none will stretch the seams in putting on the coat, for it may
do good service to him whom it fits. I would fain say something, not so much concerning the Chinese and Sandwich Islanders as you who read these pages, who are said to live in New England; something about your condition, especially your outward condition or circumstances in this world, in this town, what it is, whether it is necessary that it be as bad as it is, whether it cannot be improved as well as not. I have travelled a good deal in Concord; and everywhere, in shops, and offices, and fields, the inhabitants have appeared to me to be doing penance in a thousand remarkable ways. What I have heard of Bramins sitting exposed to four fires and looking in the face of the sun; or hanging suspended, with their heads downward, over flames; or looking at the heavens over their shoulders "until it becomes impossible for them to resume their natural position, while from the twist of the neck nothing but liquids can pass into the stomach"; or dwelling, chained for life, at the foot of a tree; or measuring with their bodies, like caterpillars, the breadth of vast empires; or standing on one leg on the tops of pillars even these forms of conscious penance are hardly more incredible and astonishing than the scenes which I daily witness.
Appendix C

Mind Wandering Reporting Instructions

Sometimes when you are reading, you may suddenly realize that you are not thinking about what it is that you are reading. We call this "zoning out" or mind wandering about thoughts unrelated to the content of what it is that you are reading.

So, we would like you to tell us when you are zoning out. During the presentation, you will hear a "beep" and the story will stop. We would like to know if you are thinking about the story or if you are thinking about something else (e.g., what you did last night, what you will be eating for dinner).

When you hear the tone and you are zoning out, please indicate "Yes" by pressing the "Y" key on your keyboard. If you hear the tone and you are not zoning out, please indicate "No" by pressing the "N" key on your keyboard.
Appendix D

Example comprehension assessment item from Experiments 1 and 2

What was on the breast pin that Jabez Wilson wore?

a. a gold star

b. a pink scaled fish

c. an arc-and-compass

d. a Chinese coin
Figure 1. Example of the first three video frames of the Audio + Text condition for Experiment 1 presentation of *Walden*. The Audio Only condition consisted of Frame 1 for the duration of the presentation.