

**RE-ENGAGING WITH READING MATERIAL AFTER A MIND WANDERING
EPISODE**

by

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Abstract

Despite active growth in the field of mind wandering over the past decade, there is currently a lack of understanding of what happens when mind wandering ends and individuals' focus returns to their original task. The present thesis proposes and explores the idea that following a mind wandering occurrence during a reading task, individuals will re-engage with the text by re-reading. In Experiment 1 participants were asked to indicate where in the passage they mind wandered and note any re-reading that occurred. Experiment 2 extended this investigation to address whether re-reading as a compensatory behaviour extends to non-plot based texts, if it differs as a function of mind wandering methodology (self-caught versus probe-caught) and explored the subjective decision to complete re-engagement behaviours. Results from both studies revealed that participants re-read following mind wandering occurrences, with rates up to 45%. Furthermore, participants typically re-read 1-2 lines of text, or less, and were equally likely to re-read following probe-caught and self-caught reports of mind wandering. Experiment 2 also established that individuals were most likely to engage in compensatory acts when they felt that further clarification was needed. This thesis provides a framework that could extend to other settings, both those that easily allow for re-engagement via reviewing missed information (e.g., listening to an audiobook) and those that do not (e.g., attending live lectures, driving). Understanding how individuals re-engage in various settings where mind wandering is likely to occur can provide insight into the fluctuation of attentional focus and the immediate impact of a mind wandering episode.

Preface

All of the work in the present document was conducted in the Brain and Attention Research lab at the University of British Columbia where Alan Kingstone is the Principal Investigator. I conducted and/or supervised all data collection, analyzed the data and wrote the manuscript. My supervisor, Alan Kingstone, assisted with project conceptualization and suggested edits to the manuscript. The experiments reported were approved by the University of British Columbia's Behavioural Research Ethics Board [project file H10-00527].

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Chapter 1: Introduction

In recent years, there has been a surge of interest in understanding what happens when attention lapses and people lose their focus on a particular task. This task disengagement is often called "mind wandering". For the present thesis, mind wandering will be defined as a shift of attention from the primary task to any unrelated, internal stream of thought. The purpose of this thesis is to investigate an as-of-yet unexamined aspect of attention and mind wandering research: attentional re-engagement.

1.1 Review of Relevant Literature

1.1.1 Measuring mind wandering

One of the most prototypical settings where mind wandering is measured and described is while reading. Reading paradigms have frequently been used to understand mind wandering behaviour in experimental settings as these are able to reliably illicit mind wandering behaviour and can easily be tested in a laboratory setting. Due to the frequency that this setting is used, the present thesis will discuss mind wandering and reading paradigms exclusively, and use reading tasks for both Experiment 1 and 2.

Typically, researchers have measured mind wandering using one of two methods: probe-caught and self-caught sampling. Probe-caught sampling, the most frequently used method, requires participants to report mind wandering during the task when prompted by a tone or visual cue. With this method, probes can be spaced throughout the task to measure changes in mind wandering reports over time and provide a proportional measure of mind wandering frequency. Self-caught sampling, on the other hand, requires the participant to notice that their thoughts are wandering and report this during the task. Realizing and reporting mind wandering has been linked to meta-awareness, the ability to notice that one's mind has shifted to unrelated thoughts,

without an external cue (Schooler et al., 2011; Smallwood, McSpadden, & Schooler, 2007; Smallwood & Schooler, 2006). Self-caught measures have no upper bound on frequency of reports, allowing the researcher to capture all mind wandering noticed by the participant throughout the task; however this method relies on the individual's meta-awareness ability.

Using probe caught measures, mind wandering is reported upwards of 50% of the time during reading tasks (Giambra, 1995; Killingsworth & Gilbert, 2010; Schooler, Reichle, & Halpern, 2004; Smilek, Carriere, & Cheyne, 2010; Varao Sousa, Carriere, & Smilek, 2013). Self-caught reports vary greatly, with average reports ranging between 1 to 10 reports in 30 minute reading tasks (Jackson & Balota, 2012; Reichle, Reineberg, & Schooler, 2010; Sayette, Reichle, & Schooler, 2009; Schooler et al., 2004). Interestingly, research has found that in tasks where both methods are used simultaneously, participants are sometimes "caught" mind wandering by a probe before they self-catch (Jackson & Balota, 2012; Reichle et al., 2010; Sayette et al., 2009; Smallwood, Fishman, & Schooler, 2007). In a classic investigation, Schooler et al. (2004) had participants read *War and Peace* for 45 minutes, while both self-catching and receiving intermittent mind wandering probes. This study found that participants self-caught mind wandering 5.4 times across the task, on average, but were also caught mind wandering by the probe 13% of the time. This finding indicates that one is not always aware that one's mind has drifted, and that an external probe can capture mind wandering before one catches one's self. This finding suggests that self-caught measures may be impacted by individuals' meta-awareness ability and that self-caught measures alone may not capture all mind wandering cases. However, only using probe caught methodology misses mind wandering episodes that occur between probes, and additionally fails to provide information on individuals' natural attention to their wandering mind.

In conjunction with self-reports, researchers have used objective measures to understand mind wandering behaviour. By using techniques such as eye tracking or neuroimaging, researchers have investigated physiological activity before and during mind wandering reports. Eye tracking has frequently been used to understand the complex eye movements made during reading (Blanchard & Iran-Nejad, 1987; Reichle, Rayner, & Pollatsek, 2004; Reichle et al., 2010). In turn, comparisons of these “normal” eye movements can be made against those that occur in the moments preceding a report of mind wandering. Results from these studies have found that, compared to on task reading, mind wandering involves more blinks, slower reading, longer fixations, and fewer within word regressions (Foulsham, Farley, & Kingstone, 2013; Reichle et al., 2010; Smilek et al., 2010; Uzzaman & Joordens, 2011). Although research has not investigated changes in brain activity while mind wandering during reading tasks, research has demonstrated changes in activation while mind wandering in other tasks. By investigating event-related potentials (ERPs) during a breath-monitoring task, a study by Braboszcz and Delorme (2011) found that when mind wandering, individuals show decreased alertness and sensory processing, compared to their on task state. Similar results have been found in visual oddball tasks, sustained attention tasks, motor tracking and time-estimation tasks (Barron, Riby, Greer, & Smallwood, 2011; Kam et al., 2012; Smallwood, Beach, Schooler, & Handy, 2008). Combining these different methods for measuring mind wandering has allowed for a better understanding of how information is being processed in the moments leading up to, as well as during, a mind wandering episode.

1.1.2 Consequences of a wandering mind

Given that a great deal of time is spent immersed in wandering thoughts, it is important to consider whether there is a consequence to this behaviour. It may come as no surprise that when

attention is not focused on the task at hand, performance suffers in comparison to when attention is task-focused. To test the consequences of mind wandering while reading, numerous studies have included post-experimental memory tests (Schooler et al., 2004; Sayette et al., 2009; Smallwood, McSpadden, & Schooler, 2008; Varao Sousa et al., 2013). Research using probe-caught methodology, but not self-caught methods, has found that mind wandering reports are negatively correlated with memory test performance, indicating that test performance declines as mind wandering reports increase (Franklin, Smallwood, & Schooler, 2011; Schooler et al., 2004; Smallwood et al., 2008b; Varao Sousa et al., 2013). Since this correlation only appears reliably in probe-caught mind wandering designs, researchers have suggested that it is due to the nature of probe-caught paradigms capturing “unaware” cases of mind wandering, where individuals have not been perceptive to the lapse.

Researchers have investigated why this detriment occurs in reading tasks, concluding that mind wandering prevents integration of ideas, encoding of information, and importantly narrative model-building, which allows for inferential processing (Smallwood et al., 2007a). To investigate the impact of mind wandering on inferential narrative model-building, Smallwood and colleagues (2008b) used a popular mystery novel. The results suggested that readers who were caught mind wandering when a key piece of information was revealed about the story's villain were later impaired in their ability to answer questions about the villain's identity. Additionally, the results suggested that mind wandering had the biggest impact when it was reported earlier in the narrative, indicating that the initial building of a narrative model is crucial to a coherent understanding of the text. In sum, a reduction in attentional allocation due to mind wandering can greatly compromise task performance.

1.2 The Present Investigation

Despite the diversity of mind wandering research one question has been, as of yet, left uninvestigated. What happens *after* one catches oneself mind wandering? No investigation has yet examined this shift of attention back to the task and whether compensatory behaviour occurs following a mind wandering episode. The present thesis focuses on the shift from mind wandering back to task focused attention to examine the behavioral aftermath of mind wandering during a silent reading task. By studying this shift from a mind wandering episode to the task, mind wandering researchers can begin to more fully understand the process and impact of mind wandering.

1.2.1 Attentional re-engagement

To the extent that mind wandering is considered a lapse in attention, research in other domains can be used to inform mind wandering researchers about the corrective or compensatory behaviours that may occur. For example, Boomer and Laver (1973) noted that when an individual experiences a slip of the tongue, a neural monitoring system is in place which first detects the slip and then corrects it. This suggests that awareness of a slip in attention can trigger a corrective behaviour. Additionally, in the Sustained Attention to Response Task (SART), researchers have shown that errors, which are viewed as a result of lapses in attention, are generally followed by a slowed reaction time to subsequent stimuli, this has been labelled the “Oops phenomenon” (Manly, Robertson, Galloway, & Hawkins, 1999; Robertson, Manly, Andrade, Baddeley, & Yiend, 1997). This change in behaviour is indicative of a cautious, corrective reaction to help prevent future errors and is considered an index of the re-engagement to the task-at-hand (Cheyne, Solman, Carriere, & Smilek, 2009; Malkovsky, Merrifield, Goldberg, & Danckert, 2012; Rabbitt, 1979; Robertson et al., 1997).

In spite of the evidence provided above, no research has investigated if or how participants execute re-engagement behaviour following mind wandering. One obvious reason for this is that the designs of mind wandering experiments have normally precluded the opportunity for a participant to initiate compensatory behaviour once realization of a mind wandering episode occurs. For instance, experimental paradigms investigating mind wandering during silent reading often present material on a computer screen in a number of ways such as word-by-word, line-by-line, or in single paragraphs, and exclude the opportunity to move backwards through the text (Foulsham et al., 2013; Franklin et al., 2011; Jackson & Balota, 2012; Smallwood, Nind, & O'Connor, 2009; Varao Sousa et al., 2013). In other words, re-engagement and compensatory behaviours simply have not been the focus of prior studies. The present thesis takes a different tack by using a setting that allows for natural reading behaviours in order to build an understanding of the transition from mind wandering back to attentional focus. It is interesting to note that the use of a silent reading task is not only perhaps the most classic of all examples used by researchers when they introduce the idea of mind wandering but it is one that readily lends itself to the natural investigation of re-engagement behaviour following a mind wandering event. By using full pages of text and allowing participants to move backwards and forwards freely through the text, natural behaviour that might not occur in a contrived experimental paradigm can be examined.

If it is the case that people do not adjust their behavior to try and offset the loss of information from mind wandering, then past studies that have precluded re-reading have not overlooked anything significant and have captured an accurate representation of real-world mind wandering behaviour. However, the possibility that individuals routinely and systematically adjust their behaviour after noticing that they have mind wandered, for example by re-reading

when provided the opportunity to do so, has implications for the external validity of the findings in the field so far. For instance, if one catches oneself mind wandering while performing a word-by-word reading task and cannot go back to review material there is no choice but to continue reading without determining what was missed. This may cause deterioration in task performance compared to when the opportunity for re-reading is present. Another possibility is that without the opportunity to re-read participants may struggle to build narrative-models and perhaps confuse the internal process of building a narrative with mind wandering, thereby over-reporting mind wandering in a given task. In short, answering whether people do or do not routinely re-read following a mind wandering event holds theoretical importance for the field, as it is unclear from past studies how re-engagement responses will occur following a mind wandering episode. However, to the extent that mind wandering is perceived as an attentional slip where information has been missed it is reasonable to predict a compensatory act.

1.2.2 Experimental design and research questions

The present thesis is comprised of two experiments that investigate the compensatory behaviour of re-reading following mind wandering. Experiment 1 was designed to establish whether re-reading behaviour occurs at all, using a narrative text and a self-caught mind wandering methodology to detail descriptive information about the behaviour. Building on these findings, Experiment 2 investigated re-reading behaviours with a non-plot based text and compared directly self-caught and probe-caught methodologies.

Experiment 1 involved an investigation of if, and how, compensatory behaviour occurs during a silent reading task. Participants were provided with a hardcopy of the introductory chapters of *War and Peace* (Tolstoy, 1982), and asked to document where they were in the text when they noticed that they were mind wandering, and to also indicate if and where they went

back to re-read the text after they caught themselves mind wandering. Under the assumption that re-reading would occur, a number of follow up questions were planned: (i) how often does re-reading occur? (ii) how far back do individuals re-read and does this align with a spatial break in the text (e.g., paragraph breaks)? (iii) does re-reading behaviour change over the course of the task? By simply asking participants to document any re-reading that occurs following a self-caught mind wandering episode, this experiment allowed for the characterization of previously undocumented re-engagement behaviour.

Experiment 2 built on the preliminary findings of re-engagement behaviour in Experiment 1. In a within-subjects design, participants were provided with two chapters from *A Short History of Nearly Everything* (Bryson, 2003), and as in Experiment 1, asked to document their location in the text when self-reporting mind wandering, and also to indicate the location where they went back to re-read, if they chose to do so. Differing from Experiment 1, this study had participants read a non-narrative text. While narrative model building is important when the storyline is linear, in a case where material is non-narrative or non-plot based, inferential model building does not occur. This difference between text styles may in turn impact how one re-engages and compensates following a mind wandering report. A second investigation of Experiment 2 was to determine if re-reading behaviour differs between probe-caught and self-caught methods. Given that probe-caught methodology is the norm in experimental designs, it is important to determine if any fundamental difference between these two reporting methods impacts re-reading behaviour. Although rates of mind wandering may differ across the sessions, participants were only asked to report re-reading after a mind wandering event. As such, I expected that the likelihood of reporting re-reading and the amount re-read would be equivalent across report methods. Finally, at the completion of the experiment participants were asked why

they went back to re-read (if they did) and, in cases where they did not re-read, why they opted not to. These subjective reports provided insight on the perceived purpose or motive for re-reading.

Chapter 2: Experiment 1

Experiment 1 used a novel lab-based paradigm to determine whether re-reading is a measurable behaviour. This simple pen-and-paper task asked participants to note their mind wandering and any re-reading that followed a self-report of mind wandering. This study was designed to determine (i) whether or not re-reading occurs, and (ii) document any consistent characteristics in participant reports.

2.1 Method

2.1.1 Participants

A total of 32 students from the University of British Columbia participated in return for course credit. Three participants were excluded from further discussion and analyses: one for reporting to have previously read the passage, and two individuals who failed to report any mind wandering episodes while reading the text (as per Foulsham et al., 2013; Franklin, Broadway, Mrazek, Smallwood, & Schooler, 2013; Smilek et al., 2010). This resulted in the inclusion of 29 participants (22 female) for the following analyses. Student ages ranged from 17–27 years ($M_{age} = 20$, $SD = 2.20$).

2.1.2 Group assignment

Psychology studies in general are often vulnerable to the concern that by measuring a particular behaviour (e.g., as it relates to perception, memory, or attention) one may change that behaviour from how it would naturally occur (Parsons, 1974; Zwane et al., 2011). Mind wandering studies are no exception and therefore to determine if the experimental instructions in this study affected re-reading behaviour the participants were randomly assigned to two separate groups that differed in their instructions. Specifically, one group was provided an example that involved re-reading 20 words back (Group 1: 14 participants) and the other was provided an example that

involved going back 40 words (Group 2: 15 participants). If these examples shaped re-reading behaviour, participants in Group 1 were expected to report re-reading less text than Group 2.

2.1.3 Reading materials

Double-sided, printed packages of the first six chapters of *War and Peace* (Tolstoy, 1982) were provided to each participant. This text has been used previously for mind wandering and reading experiments (Jackson & Balota, 2012; McVay & Kane, 2012; Schooler et al., 2004; Uzzaman & Joordens, 2011). Pages were printed in Times New Roman size 12 font, and the average number of lines per page was 34.4. Participants were provided 30 minutes to read as much as they could of the 6 chapters provided. Reading was self-paced and allowed for participants to move forward and backwards through the pages.

2.1.4 Memory test

To assess material comprehension, a 14 item True-False memory test was administered once the allocated reading time was completed. Questions were adapted from Jackson and Balota (2012, with permission). Questions that participants were unable to answer, based on the text completed within the 30 minute block, were removed from their individual analyses.

2.1.5 Interest and difficulty ratings

Upon completion of the reading task, participants were asked to report their interest in the text and its difficulty using a 5-point scale (adapted from Giambra & Grodsky, 1989). These measures were collected to establish rating norms for these materials and were not used for any further analyses. The median Interest Rating was 2, indicating a below midpoint interest in the passage. Median Difficulty Rating was 3, indicating that the passage was found to be midpoint difficult.

2.2 Procedure

Participants were brought into a study room and completed the study in two groups: group differences were defined by the re-reading example. Informed consent was obtained before the study began. The requirements of the experiment were explained, such that participants were told to make note of any mind wandering occurrence by circling the word at which they realized they were mind wandering. A definition of mind wandering was provided as: “Any thoughts that are experienced that are not related to the material being presented” (see Lindquist & McLean, 2011; Varao Sousa et al., 2013). Examples were provided (e.g., thoughts about lunch, thoughts about past weekend events, concerns about coursework, etc.). To explain the act of re-reading, participants were told: “If, after you catch yourself mind wandering, you go back to read an earlier point in the text, please draw a line back to that point and circle the word you start re-reading from. Do not mark re-reading if you go back any other time, such as to check a name or review a piece of information. If you do not go back after mind wandering, you do not need to make any further notation, just continue reading. Remember to only mark re-reading following a mind wandering occurrence”. Participants were next provided an example of re-reading (20 words back for Group 1 and 40 words back for Group 2). Participants were advised that they would complete a post-study survey, which included a memory test. After 30 minutes of reading participants were asked to stop, to note their position (end point), and were then provided the post-reading survey. The post-reading survey asked participants to provide basic demographic information, answer whether they had previously read *War and Peace*, report their interest and difficulty ratings, and answer the memory test questions.

2.3 Results

There were no significant differences between the two re-reading example groups on any of the measures¹ (all $ps > .29$), and as such the data reported were collapsed across groups. Table 2.1 includes a summary of all descriptive statistics.

2.3.1 Mind wandering reports

The average number of self-caught reports was 14.62 ($SD = 9.28$) or roughly one self-caught mind wandering episode for every two minutes of reading. This rate is consistent with previous self-caught mind wandering investigations (Ward & Wegner, 2013; Jackson & Balota, 2012; but see Schooler et al., 2004 for lower rates).

2.3.2 Memory test

Mean memory test performance was 75%, this was significantly better than chance (50%), $t(28) = 8.20$, $p < .001$. Mind wandering reports rarely overlapped with the information tested (29% of reports). Consistent with this, no correlation between mind wandering reports and memory was found, $r(29) = -.15$, $p = .43$. There was also no correlation between memory and re-reading frequency, $r(29) = -.20$, $p = .31$. As such, memory performance is not discussed further.

2.3.3 Re-reading reports

Of the 29 participants, 28 (97%) reported at least one instance of re-reading after mind wandering. On average, re-reading occurred after 45% of mind wandering reports. The number of words re-read was not normally distributed, but rather best characterized by a power law distribution ($R^2 = .54$). Re-read lengths ranged from as few as 3 words, to as many as 347 words.

¹A Shapiro-Wilk test of normality indicated that number of words re-read was non-normally distributed for both the 20 and 40 word example groups, $ps < .001$. A Kolmogorov-Smirnov test confirmed that the distributions of the 20- and 40-word groups did not differ significantly, $Z = .98$, $p = .29$.

Notably, no meaningful measure of central tendency exists for distributions of this kind. As such, the median was used to characterize the mid-point of this distribution – i.e., the point below which 50% of the data occurs. The median number of words re-read was 24.

To investigate whether the structural conventions of the text played a significant role in re-reading behaviour the start location of re-reading was coded based on whether it occurred (i) within the same paragraph, (ii) within a prior paragraph, or (iii) to the start of a prior paragraph. These locations were selected as they represent narrative blocks created by the author to provide informational flow, and as such can be thought of as "idea units". The most common re-reading location was within the same paragraph as a mind wandering episode ($M = 74\%$), followed by the start of a prior paragraph (16%), and least commonly, within a prior paragraph (10%).

Lastly, I examined whether re-reading changed between the first half and the second half of the text that was read over the 30 minute interval. There was no significant difference between mind wandering in the first half ($M = 45\%$) compared to second half ($M = 55\%$), $t(28) = -1.33$, $p = .19$, 95% CI [-25.57, 5.43]. There was a significant effect of passage half on re-reading², such that participants were more likely to re-read following a mind wandering occurrence in the first half ($M = 53\%$) than the second half ($M = 36\%$), $t(27) = 2.55$, $p = .017$, 95% CI [3.19, 31.09], $d = .52$. Figure 2.1 displays the percentages for each half of the task.

² Amount re-read in both the first and second half of the passage was non-normally distributed, as per a Shapiro-Wilk test of normality $ps < .001$, however results were equivalent for a Wilcoxon Signed Ranks test ($Z = 2.25$, $p = .021$) and a t-test, as reported.

<u>Measure</u>	
Self-caught mind wandering reports - Mean	14.62 (9.28)
Self-caught mind wandering reports - Range	1-39
Re-reading reports as a percentage of mind wandering reports - Mean	45% (29%)
Number of words re-read - Median	24
Memory test performance - Mean	75% (15%)

Table 2.1. Summary of task statistics for Experiment 1. Standard deviations appear in parentheses.

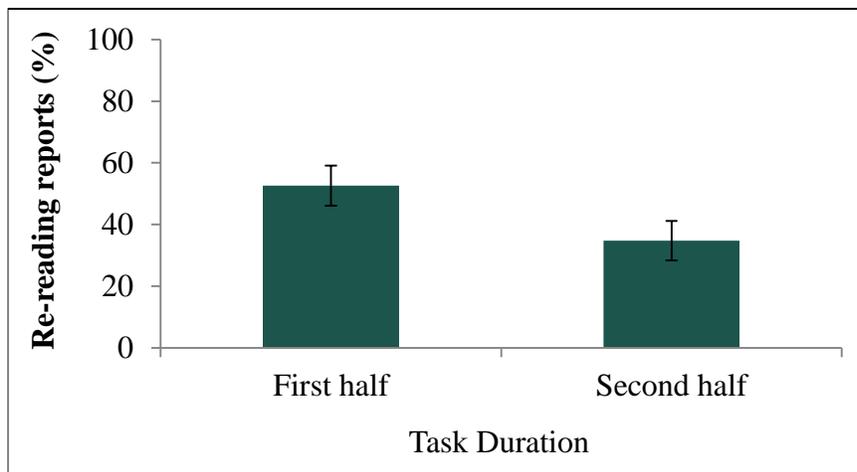


Figure 2.1. Re-reading as a percentage of overall mind wandering split by task duration. Error bars represent one standard error of the mean.

2.4 Discussion

The results of this study show that in a simple real-world setting individuals who are reading silently routinely respond to mind wandering by re-reading text, on average 45% of the time. This experiment also provides documentation of re-reading behaviour characteristics. First, the total number of words re-read (and in turn, time spent re-reading) is characterized by a power law. This indicates that individuals are increasingly less likely to re-read large amounts of text, with half of the re-read occurrences constituting 24 words or fewer (this is the equivalent of 1-2

lines of text in *War and Peace*). Next, and in line with the first characterization, 74% of the re-readings occur in the same paragraph as the mind wandering report. As paragraphs are, by definition, self-contained units dealing with a particular idea, the implication is that participants are re-reading to clarify the main point of the paragraph that was missed while mind wandering. Lastly, re-reading declines as one moves further into the story although mind wandering itself does not. Taken together, this simple paradigm captures the systematic behaviour of re-reading which seems to be a reliable response to a wandering mind.

With regard to previous mind wandering research, it is of interest to re-plot the distribution of the number of words re-read as a distribution of time spent re-reading, on the basis of each individual's reading speed. If individuals are re-reading to capture information that was missing during mind wandering, the median 24 words re-read translates into a mind wandering interval of 9 seconds. Although no studies have documented the time span of a mind wandering episode, it is noteworthy and encouraging that this 9 second interval is convergent with the 5-15 second window that studies have used when investigating the behavioural and physiological differences in the moments prior to individuals reporting mind wandering (Christoff et al., 2009; Franklin et al., 2013; Kam et al., 2012; Smilek et al., 2010; Uzzaman & Joordens, 2011). While these 9 seconds relate only to the time spent re-reading and not necessarily how long individuals spent mind wandering, it is a promising start for research characterizing mind wandering events.

Participants were more likely to re-read in the first half of the passage compared to the second, despite no decline in mind wandering reports. While the present study is unable to address exactly why individuals chose to re-read, one reasonable explanation is that re-reading allows for missed material or information to be consolidated in their working model of the

narrative. With this, it is possible that as the narrative of the text develops and the sequence of events become increasingly connected, the overall need to re-read to recover lost information diminishes (i.e., missed ideas and intentions may be recovered by moving forward within the narrative). Experiment 2 builds on this result to investigate if the text type influences this pattern of results.

While the present study sought only to test for and document the occurrence of re-reading behaviour following a self-caught mind wandering report, the fact remains that 55% of the time no re-reading occurred after a mind wandering event. If one assumes for a moment that re-reading occurs when the main point of the text has been missed, as suggested when participants re-read within a paragraph, then it follows that choosing *not* to re-read a particular passage of text may indicate that the main point of the text was acquired or that the reader anticipates that it can be gained by continued reading, consistent with the decline in re-reading as participants moved further into the narrative.

Chapter 3: Experiment 2

Experiment 2 was comparable in design to Experiment 1, with three exceptions: (i) mind wandering report methodology, (ii) text style, and (iii) the inclusion of a post-study questionnaire. The current experiment used a within-subjects design to investigate any differences in re-reading behaviour between probe-caught and self-caught mind wandering measures, two distinct but commonly used methodologies. Participants reported self-caught mind wandering during one passage and probe-caught mind wandering in the other, with methodology counterbalanced across participants. I also investigated whether reading a non-plot based text impacts re-reading reports. This allows for re-reading behaviour, as a function of text style, to be assessed. Additionally, at the end of the experiment participants were asked to report both why they chose to re-read, and why they chose not to re-read, following a mind wandering report. This direct approach could shed light on the interpretations placed on the data collected.

3.1 Method

3.1.1 Participants

A total of 36 students from the University of British Columbia participated in return for course credit. Six participants were excluded from analysis for failing to report any mind wandering episodes (as per Foulsham et al., 2013; Franklin et al., 2013; Smilek et al., 2010; Uzzaman & Joordens, 2011). In the end, 30 participants (21 female) were included in the analyses. Student ages ranged from 18 – 37 years ($M_{age} = 21.03$, $SD = 3.59$). One participant was excluded from the memory test due to a technical error.

3.1.2 Reading materials

Two chapters from *A Short History of Nearly Everything* (Bryson, 2003) were provided for each participant. This text has been used in mind wandering and reading experiments previously

(Smallwood et al., 2009; Smilek et al., 2010; Varao Sousa et al., 2013). Full pages of text were provided. The average number of lines per page was 39, and pages were printed in Times New Roman, size 12 font. Participants were given 20 minutes to read each passage. There was no time limit per page and participants were allowed to move freely through the text, both backwards and forwards.

3.1.3 Probes

In the probe-caught condition, participants were presented with twelve audio probes, with a sample provided at the beginning of the session. The spacing of the probes was determined with a random number generator, set to vary between 30 to 180 seconds, yielding an average spacing between probes of 97 seconds. This probe spacing is consistent with previous probe-caught mind wandering and reading literature (Foulsham et al., 2013; McVay & Kane, 2012; Smilek et al., 2010; Uzzaman & Joordens, 2011; Varao Sousa et al., 2013).

3.1.4 Memory test

To assess memory for material, 16 True-False questions were designed for each chapter (adapted from Varao Sousa et al., 2013). Memory was tested at the end of each block. Questions that participants were unable to answer, based on the text completed within the designated time, were removed from their individual analyses.

3.1.5 Ratings

Interest, Difficulty and Motivation ratings were collected via a 5-point scale (1-5) upon finishing each 20 minute session. These ratings were collected to establish a baseline of subjective task experience with the materials. A rating of 5 indicated high motivation, high interest, or extreme difficulty, respectively.

3.1.6 Follow-up questionnaire

To better characterize re-reading reports and gain an insight into why participants do or do not display re-reading behaviour, two questions were asked verbally at the end of the experimental session. These questions were: “If you went back and re-read following any of the times you reported mind wandering, why did you do so?” and “If you did not go back following a mind wandering report, why not?”.

3.2 Procedure

The study was completed in a private testing room. Informed consent and basic demographic information were obtained at the start of the session. Mind wandering and re-reading definitions were identical to those used in Experiment 1, and were provided at the start of each session. Experiment 1 indicated that re-reading example (20 words versus 40 words) did not impact results, as such only a 20 word example was provided. For self-caught reporting, participants were advised to circle their location in the text when they noticed that their mind had wandered. For probe-caught reporting, participants were told to circle the word that they were at, only at times when they heard the tone. To indicate whether or not they were mind wandering at that moment, participants wrote “Y” (for Yes) or “N” (for No) under the circled word. Participants were informed they would complete a memory test following each passage. After 20 minutes of reading, a research assistant provided the memory test and rating questions and upon completion provided instructions for the second task. Upon completion of both reading blocks the research assistant administered the follow-up questionnaire, recording each response verbatim. Participants were then debriefed and thanked for their time.

3.3 Results

Table 3.1 displays measures of central tendency for each variable of interest across the probe-caught and self-caught measures. Each variable is discussed below. Paired samples t-tests confirmed that the order in which participants completed the task did not impact their mind wandering, re-reading or memory test performance (all p s > .30).

<u>Measure</u>	<u>Probe-Style</u>	
	<u>Self-Caught</u>	<u>Probe-Caught</u>
Mind wandering reports - Mean	13.3 (7.26)	4.37 (2.29)
Mind wandering reports - Range	1-41	1-8
Mind wandering reports - Percentage of 12	n/a	37% (19)
Re-reading reports as a percentage of mind wandering reports - Mean	40% (29)	33% (37)
Re-reading reports as a percentage of mind wandering reports - Median	29%	17%
Number of words re-read - Median	18	23
Memory Performance - Mean	69% (18)	67% (17)
Interest Rating (1-5) - Median	3	2
Difficulty Rating (1-5) - Median	2	2
Motivation Rating (1-5) - Median	2.5	4

Table 3.1. Summary of task statistics for Experiment 2. Standard deviations appear in parentheses.

3.3.1 Mind wandering reports

Mind wandering reports were significantly higher for the self-caught session (13.3) compared to the probe caught session (4.37), $t(29) = 6.90$, $p < .001$, 95% CI [-11.58, -6.29], $d = 1.51$. This indicates that participants reported a self-caught mind wandering episode for roughly every one and a half minutes of reading. For probe-caught reports participants responded that they were mind wandering, on average, 37% of the time.

3.3.2 Re-reading reports

Eighty-six percent of participants reported at least one instance of re-reading following a mind wandering report. There was no significant difference between re-reading as a percentage of mind wandering during self-caught ($M = 40\%$) and probe-caught ($M = 33\%$) sessions, $t(29) = 1.05$, $p = .30$, 95% CI [-19.80, 6.33]³, suggesting that participants were equally likely to re-read regardless of how mind wandering was reported.

Amount of text re-read was non-normally distributed. A Kolmogorov-Smirnov non-parametric test revealed no significant difference in the amount of words re-read between self-caught ($Median = 18$ words) and probe-caught ($Median = 23$ words) sessions, $Z = .57$ $p = .90$. In both conditions participants were most likely to re-read within the same paragraph as they had reported mind wandering (96% self-caught; 85% for probe-caught), followed by re-reading within or at the start of a prior paragraph (4% self-caught; 15% for probe-caught).

Lastly, I examined whether mind wandering or re-reading changed between the first half and the second half of the passage. For self-caught mind wandering reports there was no significant difference between mind wandering in the first versus second half (54% versus 46%), $t(29) = 1.18$, $p = .25$, 95% CI [-5.38, 19.91]. In contrast, for probe-caught reports there was a significant increase in mind wandering from the first half to the second half (31% versus 69%), $t(29) = -4.15$, $p < .001$, 95% CI [-55.91, -19.02]. Re-reading rates did not change across passage half in either the self-caught or probe-caught sessions, $ps > .30$.

³ Re-reading reports as a percentage of mind wandering were non-normally distributed, $ps < .001$, as per Shapiro-Wilk tests of normality. A non-parametric Wilcoxon Signed Ranks test comparing probe-caught and self-caught sessions revealed equivalent results as the t-test reported, $Z = -1.19$, $p = .24$.

3.3.3 Memory test

There was no significant difference in memory performance between self-caught (69%) and probe-caught (67%) sessions, $t(28) = .44$, $p = .67$, 95% CI [-6.90, 10.62]. Performance was significantly better than chance (50%) for both blocks, $p < .001$. For the self-caught session only 10% of re-reading reports overlapped with the material that was tested on the memory task, and there was no overlap for the probe-caught condition. There was no correlation between memory performance and re-reading for either self-caught or probe-caught sessions, $ps > .31$.

3.3.4 Interest, difficulty, and motivation Ratings

There were no significant differences in the interest, difficulty or motivation ratings between self-caught and probe-caught conditions, all $ps > .12$.

3.3.5 Follow up questionnaire

Two research assistants coded the participant responses using categories created based on participant responses (see Appendix A). For why one re-reads, the most frequent response (over 40%) referred to text clarification, with the next most common response (14%) relating to information recovery. The interrater reliability was found to be Kappa = 0.63 ($p < .001$). For why one chose not to re-read, the most common response (51%) was that participants felt they still understood or that not much information had been missed. The interrater reliability between the raters was Kappa = 0.75 ($p < .001$).

3.4 Discussion

The purpose of the present experiment was to replicate and extend Experiment 1 by (i) investigating re-reading following probe-caught mind wandering reports, (ii) examining if the findings generalize to a non-plot based text, and (iii) acquiring subjective reports on re-reading behaviour.

Probe-caught methodology is the norm for mind wandering research as it is thought to better capture mind wandering instances, however the present experiment does not support this conclusion. Mind wandering rates were significantly higher for the self-caught session (13.3) compared to the probe caught session (4.37), indicating that participants were able to report more mind wandering in the self-caught session compared to the probe-caught session. The implications of this will be further discussed in the General Discussion.

Re-reading was equally likely to occur following a probe-caught report compared to a self-caught mind wandering report. Additionally, the median amount of words re-read, 18 and 23, was consistent across self-caught and probe-caught sessions. Given this frequency of words re-read, it follows that individuals most often began re-reading within the same paragraph of text that they caught themselves mind wandering in, for both self-caught and probe-caught reporting.

One factor that did differ between methodologies was that probe-caught mind wandering increased over time on task, a result consistent with prior research (Giambra, 1995; Risko, Anderson, Sarwal, Engelhardt, & Kingstone, 2012; Smallwood et al., 2007b). There was no change in self-caught mind wandering over time on task, consistent with the finding in Experiment 1.

In contrast to the finding of Experiment 1 where re-reading decreased in the second half of the task from the first, the present study found no change in re-reading reports over time. This may be linked to the fact that Experiment 1 used a fictional, narrative text, and the present study used a non-fiction, non-plot based text. In a narrative, storyline and character development require close attention early on. However, as individuals move forward in the plot they may re-read less once these crucial pieces of information have been established and a strong sense of narrative progression is obtained. In contrast, participants in the present experiment could not

rely on building a model or framework to move forward, meaning it may have been more difficult to glean what is going on when the "story" is constantly changing, keeping re-reading rates stable across the task.

The subjective reports on the decision to re-read add further support for re-reading as a natural and necessary re-engagement technique. Majority of the responses for why individuals reported re-reading related to clarifying or understanding information. Regarding why individuals chose not to re-read, participant responses most commonly suggested that individuals felt they had a strong grasp of the material or had not missed enough to warrant re-reading. These subjective reports shed light both on how individuals perceive the consequence of mind wandering (e.g., not feeling like they missed information while mind wandering) and the cases where re-engagement is necessary (e.g., too much information was missed).

Chapter 4: General Discussion

A great deal of research has been committed to understanding the causes, contents and consequences of a wandering mind. However, there has been no investigation of how individuals re-engage with their task following a mind wandering episode. This thesis used a novel paradigm to examine if, and how, reading behaviour is affected following a mind wandering episode. Specifically, there were three main questions I hoped to answer: (i) whether one compensates for material that was missed while mind wandering by re-reading, (ii) if methodology (self-report method or text style) impact these reports, and (iii) what are the situations where one does not compensate for mind wandering behaviour by re-reading.

Across two experiments, the results suggest that individuals frequently report re-reading following a mind wandering occurrence. Experiment 1 indicated that these re-reading events were most often within the same paragraph, with the amount of words re-read typically spanning 1-2 lines of text or less. Experiment 2 replicated and extended the findings of Experiment 1 to demonstrate that individuals were equally likely to report re-reading after a probe-caught instance of mind wandering, as compared to a self-caught instance. Additionally, re-reading was a method of re-engagement for both a narrative and a non-narrative text, although re-reading rates declined over time during narrative text and not non-narrative text. Lastly, and novel to Experiment 2, were the reports on why participants chose to re-read versus not. Majority of these reports indicated that re-reading was done in cases where information needed to be clarified before moving forward, and participants opted not to re-read when they felt that information was still well understood.

The collective results of the amount of words re-read, re-reading location and subjective reports suggest that a critical reason for re-reading is to recover the meaning of the point that is

currently being made in the text and to integrate the information necessary for understanding the passage. These findings imply that individuals experience a lack of information after mind wandering and compensate for that lack by re-reading the text.

4.1 Limitations and Future Directions

4.1.1 Impact of re-reading

One major limitation of this thesis is that it cannot address directly how re-reading impacts text comprehension and whether precluding the opportunity to re-read negatively impacts comprehension and retention of the text. As noted in the introduction, previous work has reported negative correlations between probe-caught mind wandering and memory. This relationship has not been reported in self-caught mind wandering studies, and no relationship was observed in the present study. However, if mind wandering prevents integration of ideas and the encoding of information, this impact should be evident regardless of how mind wandering is reported.

One important finding of this thesis was that self-caught reports captured a greater number of mind wandering instances than probe-caught methods. It may be worthwhile for future research to address these differences as they may reflect qualitative, and not just quantitative, differences in mind wandering. Consistent with this possibility is the finding that mind wandering increases over time for probe-caught reports but not self-caught reports. Regardless, it is promising to note that the usage of both self-caught and probe-caught methodologies in the present thesis demonstrated no significant difference in re-engagement behaviours.

In the present experiments, memory test questions rarely overlapped with mind wandering and re-reading reports. This limited my ability to consider whether there was a

negative impact on comprehension for not re-reading following a mind wandering report. In future studies, investigations may wish to address how the ability to re-read moderates text comprehension. This could be done by using memory test questions that are not based on specific terms but rather concepts or ideas of the text.

The present paradigm allowed for free viewing of text material, with full pages presented and the ability to move forward or backward afforded to the participant. This is atypical in mind wandering research. Reading material is often presented in a limited way (e.g., word-by-word or line-by-line) with the ability to move backwards through the text precluded (Foulsham et al., 2013; Franklin et al., 2011; Jackson & Balota, 2012; Smallwood et al., 2009; Varao Sousa et al., 2013). In tasks such as these, where no opportunity to review is permitted, a greater cost to memory performance may be reported compared to tasks where the opportunity to re-read is provided. It is possible that without the ability to re-read, individuals are not able to effectively re-engage with the task and this may impact their overall ability to build narrative models and/or understand the material. At present this is speculation, although the subjective reports in Experiment 2 are consistent with this idea. Future studies could manipulate whether the text is received word by word, line by line or in full pages to determine whether there is a difference in mind wandering rates and memory performance for those who are provided the opportunity to re-read versus not.

4.1.2 Eye tracking

Perhaps one of the most pressing issues is to gain a more fine-grained analysis of re-reading behaviour, one that extends beyond the natural pen-and-paper paradigm used here. Extending the present paradigm to include eye tracking measures would enable one to characterize re-reading behaviour more completely. Existing research has investigated eye

movements during mind wandering episodes and found systematic differences: fewer fixations, longer fixation durations, and fewer within-word regressions (Foulsham et al., 2013; Reichle et al., 2010; Uzzaman & Joordens, 2011). While these are valuable contributions, by exploring post-mind wandering eye movements one can determine how individuals systematically go back to a desired location, acquire a more precise measure of how much time is being spent on re-reading itself, and determine what is happening when individuals choose not to go back and re-read the text. With respect to this latter point, eye movements of those who choose not to re-read may be especially revealing. For example, it may be that for these mind wandering occurrences individuals are actively choosing to disengage with the task (i.e., intentional mind wandering) and “pause” their eye movements until they re-engage with the reading task. Such a scenario might account for a significant portion of the mind wandering reports that were not followed by re-reading in the present studies.

4.1.3 Other settings

A final important question for future investigation is how re-engagement takes place in other tasks and what role response effort may play in the decision to compensate. For example, when listening to an audiobook or watching a video, will one pause and rewind following a mind wandering episode, if provided the opportunity? The present work suggests that individuals will re-engage by reviewing when they feel it helps with understanding or is necessary for moving forward in the task. However the threshold for this decision may vary with the ease of the re-engagement process, as defined by the task or the effort required. A working hypothesis is that while the specific strategy used to re-engage with material following mind wandering will vary, re-reading is representative of a general phenomenon that will manifest in different tasks.

Importantly, future work could investigate how one re-engages in settings when there is no text cue or trigger indicating what information has been missed (e.g., while in a conversation or while driving). In these cases, what environmental cues are available or created by individuals to help with re-integration and re-engagement of attention? One specific setting where a better understanding of re-engagement behaviours would prove extremely valuable is in educational environments where mind wandering episodes have been reported to occur up to 40% of the time (see Szpunar, Moulton, & Schacter, 2013 for review). While this thesis focused on re-engagement behaviour during reading tasks, the high frequency of mind wandering in lecture settings suggests that this environment would be a worthwhile place to continue the investigation of re-engagement techniques and their impact on memory.

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Appendices

Appendix A: Experiment 2 Subjective Responses

1. Coding scheme for why individuals chose to re-read:

- 1 = To clarify or better understand
- 2 = To help with focus and paying attention
- 3 = The information was forgotten
- 4 = There was a test
- 5 = They were bored or lost interest
- 6 = They never reported re-reading
- 7 = Other

2. Coding scheme for why individuals chose not to re-read:

- 1 = They still understood or remembered information
- 2 = They did not miss much
- 3 = They were bored or not interested
- 4 = They had already clarified information
- 5 = They felt that continuing reading would help them to understand
- 6 = They always went back
- 7 = Other

Appendix B: Interest, Difficulty and Motivation Rating scales

1. On a scale of 1-5 please rate your interest in the material you just read:

1 = I was NOT interested in this material at all and I did not enjoy reading it.

2 = I was only slightly interested in this material and would not like to read further on this topic.

3 = I was interested in this material, but it is not one of my favorite topics.

4 = This material was so interesting that I truly enjoyed reading it.

5 = This is the most interesting material I've read in the past year and I would like to read even more on this topic.

2. On a scale of 1-5 please rate how difficult you found the passage:

1 = This material was easy to read and to understand.

2 = This material was not hard to read and I did not have much trouble understanding what I was reading.

3 = This material was difficult, but I was able to understand what I was reading.

4 = This material was not the most difficult material I've ever read, but it was still so difficult that I had to work to try to understand it.

5 = This is the most difficult material I've read in the past year or so, and I had to work as hard as I possibly could to try to understand it.

3. How motivated were you to remain attentive to the passage as you read? On a scale of 1-5 please rate your motivation during this task.

1 = Very unmotivated.

2 = Somewhat unmotivated.

3 = Neither motivated nor unmotivated.

4 = Somewhat motivated.

5 = Very motivated.