Eye Movements During Mindless Reading

Erik D. Reichle[1], Andrew E. Reineberg[1], & Jonathan W. Schooler[2]

1. University of Pittsburgh
2. University of California, Santa Barbara

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(2) Address all correspondence to:

Erik D. Reichle
635 LRDC
University of Pittsburgh
Pittsburgh, PA 15218, U.S.A.
Office: (412) 624-7457
Fax: (412) 624-9149
E-mail: reichle@pitt.edu

Mindless reading occurs when our eyes continue moving across the page even though our minds are thinking about something unrelated to the text. Despite its ubiquity, very little is known about mindless reading. The present experiment examined eye movements during mindless reading. Comparisons of fixation-duration measures collected during intervals of normal versus mindless reading indicate that fixations in the latter were longer and less affected by lexical and linguistic variables. Also, the eye movements immediately preceding self-caught mind-wandering were especially erratic. These results suggest that the cognitive processes that guide eye movements during normal reading are not engaged during mindless reading. We discuss the implications of these findings for theories of eye-movement control in reading, the distinction between experiential- and meta-awareness, and reading comprehension.

> “Most readers have probably had the experience of moving their eyes across the text while at the same time their mind wandered so that nothing was comprehended…[t]his ‘daydream mode’ would be difficult to study experimentally.” –Rayner & Fischer (1996, p. 224)

The phenomenon of mindless “reading” is ubiquitous—we have all had the experience of suddenly realizing that, although our eyes have been moving across the printed page, little or none of what we have been “reading” has been processed in a meaningful manner. Despite its ubiquity, however, very little is known about what happens in the mind during mindless reading. This is unfortunate because, if estimates of how often the mind wanders are accurate (e.g., 30% of daily life; Kane et al., 2004), and if claims that mind-wandering is detrimental to reading comprehension are correct (Schooler, McSpadden, Reichle, & Smallwood, 2009; Schooler, Reichle, & Halpern, 2004; Smallwood, McSpadden, & Schooler, 2008), then an understanding of mindless reading (e.g., being able to identify when it is occurring in real time) might ameliorate a significant source of reading difficulty. Furthermore, the phenomenon of mindless reading provides an excellent contrast to normal reading, providing a “window” to examine a variety of theoretical issues related to the perceptual and cognitive processes that support reading (Reichle, Liversedge, Pollatsek, & Rayner, 2009), as well as the nature of consciousness (Schooler, 2002).

The present study provides important new information about mindless reading by using an experience-sampling method that has previously been used to study mind-wandering in other tasks (including self-paced reading; Sayette, Reichle, & Schooler, 2009) in conjunction with eye-tracking technology to examine the moment-to-moment consequences of mind-wandering during reading. One obvious advantage of using eye tracking is that it speaks directly to the nature of the eye-mind link—that is, the degree to which cognition plays an active role in guiding the eyes during reading (Rayner, 1998). It also provides an extremely sensitive measure with which to ascertain the time course of mind-wandering during reading—how often it occurs, how often readers vacillate between normal and mindless reading, etc.

Theories of eye-movement control during reading can be divided into two "camps" (for a review, see Reichle, Rayner, & Pollatsek, 2003; Rayner, 2009). On one hand, *cognitive-control* theories posit a tight eye-mind "link", with on-going cognition (e.g., lexical processing) determining or modulating when the eyes will move from one word to the next (Engbert, Nuthmann, Richter, & Kliegl, 2005; Just & Carpenter, 1980; Reichle, Pollatsek, Fisher, & Rayner, 1998; Reilly & Radach, 2006; Salvucci, 2001). In contrast, *oculomotor-control* theories do not posit an eye-mind link, but instead maintain that readers' eye-movement behavior is determined by global constraints imposed by visual and oculomotor factors (e.g., limited retinal acuity; Feng, 2006; McDonald, Carpenter, & Shillcock, 2005; Yang, 2006). It is perhaps not too surprising that both classes of theory explains a wide range of phenomena associated with readers' eye movements, with empirical attempts to adjudicate between the theories often producing equivocal results (cf., Inhoff, Eiter, & Radach, 2005; Pollatsek, Reichle, & Rayner, 2006).

One example that is particularly relevant to the experiment reported in this article involves a paradigm known as *z-string reading* (Nuthmann & Engbert, 2009; Rayner & Fischer, 1996; Vitu, O'Regan, Inhoff, & Topolski, 1995). In this paradigm, participants are given strings of "text" that are comprised entirely of the letter z (e.g., "Zzz zzzzzz zz…”). The participants are instructed to “pretend” that they are reading the z-strings while their eye movements are recorded. The logic of this approach is that, to the degree that eye movements during z-reading resemble those during normal reading, one might argue that cognition (e.g., lexical access) plays little or no role in guiding eye movements during reading, and that they are instead guided by visual and/or oculomotor factors. Although fixations tended to be longer in z-reading than normal reading, and although the effects of lexical variables (e.g., word frequency) were necessarily absent in z-reading, the experiments have been inconclusive, with advocates of oculomotor-control theories claiming that eye movements during z-reading resemble those in normal reading (Vitu et al., 1995), and advocates of cognitive-control theories claiming otherwise (Rayner & Fischer, 1996). The experiments are also inherently difficult to evaluate because it is not clear what participants are actually doing when they are pretending to read z-strings.

The present experiment avoids the limitations of the z-reading paradigm by measuring readers’ eye movements during periods of both normal and actual mindless reading. The logic of this approach is that, by comparing the variables that influence eye movements in normal versus mindless reading, one can assess the degree to which cognition influences eye movements during normal reading. Our central hypothesis was that fixations during mindless reading should be qualitatively different from those associated with normal reading, revealing longer fixation durations (as observed during z-reading) and lesser sensitivity to lexical variables (e.g., word frequency), the effects of which are normally indicative of on-line cognitive processing.

The present study also explored the potential role of meta-awareness (Schooler, 2002) in modulating such differences. Simply put, *meta-awareness* refers to intermittent periods when one becomes aware of one's awareness, to explicitly "take stock" of whatever one is thinking about, whereas *experiential awareness* corresponds to what one normally experiences when engaged in any on-going activity or task—the normal stream of consciousness. In the present study, experiential awareness corresponds to what transpires during normal reading, when one is engaged in the text, as well as during mindless reading, when one is engaged in thoughts unrelated to the text. Meta-awareness, then, occurs when one realizes that one's mind has been wandering.

Prior research (Schooler et al., 2004) has distinguished mind-wandering episodes that occur with versus without awareness using two measures: (1) *self-caught mind-wandering*, in which participants press a button whenever they notice their mind wandering, indicates episodes that individuals have self-evidently become aware of; and (2) *probe-caught mind-wandering*, in which participants are caught mind-wandering by random experience-sampling probes, indicates episodes that have (until the probe) evaded meta-awareness. Differences between self- and probe-caught measures have helped illuminate the role of meta-awareness in mind-wandering; for example, alcohol consumption (Sayette et al., 2009) attenuates meta-awareness of mind-wandering, as evidenced by dramatically reduced ratios of self- to probe-caught episodes. Given the differential sensitivity of these two measures to meta-awareness, we predicted differences in the eye movements prior to self- versus probe-caught mind-wandering, under the assumption that the former should be associated with participants' dawning awareness of having lapsed into mindless reading.

Method

Participants. Four undergraduates (3 females) at the University of Pittsburgh participated for payment. Participants were paid $7 per hour with a $20 bonus for completing the experiment. All subjects were native English speakers with normal vision. None of the participants were familiar with the text used in the study.

Apparatus. An Eyelink 1000 eye-tracker (SR Research) monitored the gaze location of participants' right eyes during reading. The eye-tracker had a spatial resolution of 30-min arc and a 1000-Hz sampling rate. Participants viewed the stimuli binocularly on a monitor 63 cm from their eyes; 3.1 characters equaled approximately 1° of visual angle. Chin and forehead rests were used to minimize head movements and ensure comfort.

Materials. Participants read the entirety of Jane Austen's *Sense and Sensibility*. The novel consisted of 50 chapters containing 7-17 pages per chapter and a maximum of 25 lines per page. Four-alternative multiple-choice questions were created (3-4 per chapter) to measure participants' comprehension of the material. Participants read the material over multiple days so that they would adapt to both reading on the eye-tracker and the general procedure; this was done to make the reading as routine as possible and thereby maximize the probability of observing mindless reading[1].

Procedure. Each participant read the novel at his/her own pace across 12-15 (M = 13.5) hour-long sessions. Each session and chapter began with a calibration of the eye-tracker. Calibration was not done more frequently to avoid being intrusive and possibly reducing the frequency of mind-wandering. Participants read at their own pace by pressing the "F" key to move forward through the text and pressing the "B" key to move backwards through the text. Participants were provided the following definition of *zoning out*: “at some point during reading, you realize that you have no idea what you just read,” and that “not only were you not thinking about the text, you were thinking about something else altogether.” Participants were instructed to press the “Z” key whenever they caught themselves zoning out. Participants were also prompted every 2-4 minutes (time sampled randomly from a uniform distribution) after the previous self-reported zone-out or prompt to indicate whether they had been zoning out at the time of the prompt; participants were instructed to press the “Y” key if they had and the “N” key if they had not. Participants answered comprehension questions about the chapters that they had read during the last 5 minutes of each session.

Results

Behavioral measures. Table 1 shows several behavioral measures for each participant, including the total number of hour-long sessions that the participants spent reading, their overall accuracy in answering text-related comprehension questions, and the number of times that they were caught zoning out by themselves (*self-caught zone outs*) or probes (*probe-caught zone outs*). To adjust for differences in the total number of probes that participants received, we also report the *probe-caught ratio*, or proportion of probes that caught participants zoning out.

Insert Table 1 here

On average, participants correctly answered .81 of the comprehension questions (chance = .25), indicating that they understood the text. Participants self-reported zoning out 8-36 times during the study (*M* = 22.5), and were caught zoning out by .045-.153 of the probes (*M* = .093). The latter result is particularly striking because it suggests that participants were zoning out approximately 9% of the time (on average) without being aware that they were doing so. All of these mind-wandering results are consistent with previous studies that have used self-paced reading (but not eye tracking) to study mind-wandering during reading (Schooler et al., 2004; Sayette et al., 2009).

Global eye-movement measures. Individual fixation locations and durations were excised (using *Pegasus*; Loboda, 2009) from six intervals (2.5, 5, 10, 30, 60, and 120 seconds) preceding the points in time when participants: (1) pressed a button to indicate self-caught zone outs (i.e., *self-caught mindless reading*); (2) responded affirmatively to probes that they had been zoning out (i.e., *probe-caught mindless reading*); and (3) responded negatively to probes that they had not been zoning out (i.e., *normal reading*). The 120-second interval thus spanned the (minimal) time from the preceding prompt or self-reported zone-out. Individual fixations that extended prior to the interval onsets were excluded from analyses to equate for the overall interval lengths across conditions. The last fixation within each interval was also excluded because it was interrupted either by participants pressing the "Z" button (in the self-caught condition) or by probes (in the other two conditions). Finally, although fixation durations less than 80 ms or more than 1000 ms are typically discarded as outliers in eye-movement experiments (Inhoff & Radach, 1998; Liversedge, Paterson, & Pickering, 1998), this precaution was not followed in the present study because of the possible erratic nature of eye movements during mindless reading (e.g., fixation were predicted to be longer than normal).

Figure 1 shows several global eye-movement measures for the six intervals, including the mean number of first-pass fixations, regressions, fixated words, and off-text fixations (e.g., gazes not on individual words). Data from each interval were examined using repeated-measure *ANOVA*s with one factor (normal reading vs. self-caught mindless reading vs. probe-caught mindless reading). *ANOVA*s indicating significant or marginally significant results (all Fs ≥ 4.20, all ps ≤ 0.072) were further examined using 2-tailed matched-sample t-tests. These contrast indicated that, relative to normal reading, there were fewer first-pass fixations [$t(3) = 6.88$, $p = 0.006$, Cohen's $d = 7.94$], regressions [$t(3) = 9.32$, $p = 0.003$, $d = 10.76$], and words fixated [$t(3) = 5.40$, $p = 0.012$, $d = 6.24$], and more off-text fixations [$t(3) = 4.72$, $p = 0.018$, $d = 5.45$] during the 2.5 seconds immediately preceding self-caught zone-outs. There were also fewer first-pass fixations [$t(3) = 7.14$, $p = 0.006$, $d = 8.24$] and words fixated [$t(3) = 8.20$, $p = 0.004$, $d = 9.47$] during the 2.5-second interval preceding self-caught than probe-caught zone-outs. These differences suggest that participants' awareness of having been mind-wandering immediately prior to self-reporting zone-outs may manifest itself in more erratic patterns of eye movements than those observed either during normal reading or prior to probe-caught zone-outs. Although there were also more off-text fixations during probe-caught mindless reading than both normal (both ts ≥ 3.72, both ps ≤ 0.034, both ds ≥ 4.30) and self-caught mindless reading [$t(3) = 4.58$, $p = 0.019$, $d = 5.29$] during two of the longer intervals, these erratic eye movements were not associated with participants' self-awareness of mind-wandering because participants did not catch themselves mind-wandering but were instead caught by probes.

Insert Figure 1 here

Local eye-movement measures. Figure 2 shows several local measures of eye-movement behavior: (1) *first-fixation duration*, or the duration of the initial fixation on a word conditional upon it being fixated during the first pass through the text; (2) *gaze duration*, or the sum of all first-pass fixations on a word; and (3) *total-viewing time*, or the sum of all fixations on a word (including those occurring after inter-word regressions). These measures are reported for fixations taken from the same intervals used in the previous analyses (see Figure 1). These measures also reflect the full time-course of processing—whereas first-fixation and gaze duration are early measures that are influenced by a variety of lexical variables (e.g., word frequency; Rayner & Duffy, 1986; Schilling, Rayner, & Chumbley, 1998), total-viewing time is a late measure, being influenced by higher-level linguistic variables (e.g., semantic plausibility; Clifton, Staub, & Rayner, 2007). As with the first set of analyses, data from each interval were examined using repeated-measure *ANOVA*s, with all significant or marginally significant results (all Fs ≥ 3.49, all ps ≤ 0.099) then being examined using 1-tailed (for normal vs. mindless reading) and 2-tailed (for self- vs. probe-caught mindless reading) t-tests. These contrasts indicated that first-fixation durations, gaze durations, and total-viewing times were shorter for normal than self-caught mindless reading during the four longest intervals (all ts ≥ 2.35, all ps ≤ 0.05, all ds ≥ 2.71). Gaze durations were also shorter for normal than probe-caught mindless reading during the 30- [$t(3) = 4.34$, $p = 0.012$, $d = 5.01$] and 120-second [$t(3) = 2.43$, $p = 0.047$, $d = 2.81$] intervals, as were total-viewing times during the 30- [$t(3) = 4.12$, $p = 0.013$, $d = 4.76$] and 60-second [$t(3) = 2.59$, $p = 0.041$, $d = 2.99$] intervals. As Figure 2 shows, however, the fixation-duration measures tended to be shorter during probe- than self-caught mindless reading, particularly for total-viewing times during the 10-second interval [*t*(3) = 3.88, *p* = 0.03, *d* = 4.48]. These results indicate that longer fixations are indicative of mindless reading, and that the mind appears to wander for a considerable amount of time (up to 120 seconds) before being caught, but that these behaviors appear to be more pronounced in self-caught mindless reading. This suggests that the lengthening of fixations may be one factor that contributed to the participants' awareness of having lapsed into mind-wandering (although see the General Discussion for an alternative account).

Insert Figure 2 here

To determine if lexical and/or higher-level language processing affected eye movements during mindless reading, we completed several step-wise multiple-regression analyses (one for each interval) to control for between-participant differences and using (1) the inverse of word length, (2) the natural logarithm of word frequency (as tabulated by Francis & Kucera, 1982), and (3) whether the words occurred at clause/sentence boundaries as predictors of first-fixation duration, gaze duration, and total-viewing time. Tables 2-4 show the results of these analyses, which indicated that all three predictor variables had more pronounced effects on the fixation-duration measures during normal than mindless reading. The finding that fixation durations were shorter for shorter and/or more frequent words during normal reading is consistent with numerous eye-movement experiments (Just & Carpenter, 1980; Kliegl, Grabner, Rolfs, & Engbert, 2004) and may reflect some combination of both sub-lexical (e.g., the extraction of orthographic information) and lexical (e.g., the activation of word meaning) processing. Although it is unclear why the clause/sentence-final words were fixated for less time during normal reading (they are usually the recipients of longer fixations; Just & Carpenter, 1980; Rayner, Sereno, Morris, Schmauder, & Clifton, 1989; Warren, White, & Reichle, 2009), one possible explanation for this discrepancy is that the semantic/syntactic content of the novel used in the present study was somewhat redundant, making clause/sentence "wrap up" less necessary or easier. The key finding that fixation-duration measures were less affected by predictor variables during mindless reading suggests that decisions about when to move the eyes are less affected by cognitive processing during mindless than normal reading, but that this reduction of cognitive control (on average) becomes more pronounced over time. Because of the inherent variability of eye-movement data, however, it is not possible to know whether our participants mind-wandered until they were caught, or whether they alternated between brief periods of mindless and mindful reading. It is therefore impossible to know whether lexical and linguistic processing completely stops during mind-wandering, or whether processing intermittently stops and starts. It is also possible that the two types of processing are differentially engaged during mindless reading (e.g., lexical processing might be more likely to start and stop while linguistic processing might be more likely to completely stop). Future research is clearly needed to examine this important issue.

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Insert Tables 2-4 here

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Finally, because our method is inherently correlational in nature, it was important to determine if properties of the text (e.g., overall difficulty) contributed to the observed differences between normal versus mindless reading. We addressed this issue two ways. First, we completed *ANOVA*s and *t*-tests (as in our previous analyses) on three properties of the words included in our previous analyses: (1) inverse word length; (2) natural logarithm of word frequency; and (3) the number of clause/sentence-final words. As Figure 3 shows, these analyses revealed only four significant differences: words were shorter during normal than self-caught mindless reading in the 10- [$t(3) = 3.47$, $p = 0.04$, $d = 4.01$] and 60-second intervals [$t(3) = 3.31$, $p = 0.045$, $d = 3.82$], words were more frequent during normal than self-caught mindless reading in the 60-second interval [$t(3) = 3.75$, $p = 0.033$, $d = 4.33$], and there were more clause/sentence-final words during probe- than self-caught mindless reading in the 5-second interval [$t(3) = 4.96$, $p = 0.016$, $d = 5.73$]. Second, we examined global measures of eye-movement behavior, fixation-duration measures, and properties of words during a 120-sec interval following participants' responses to probes (after indicating normal and probe-caught mindless reading) and after self-reported zone-outs[2]. As Figure 4 shows, there was only one significant difference—words were longer in self-caught mindless reading than normal reading [$t(3) = 4.04$, $p = 0.027$, $d = 4.66$]. Together, these analyses strongly suggest that the observed differences between mindless versus normal reading are not being driven by differences in the text being sampled, and that the patterns of eye movements that are indicative to mindless reading are specific to intervals of mindless reading.

Insert Figures 3 & 4 here

General Discussion

The present study revealed several differences between the eye movements observed during mindful versus mindless reading. The first is that fixation-duration measures were longer during self- and probe-caught mindless reading, and that these differences were evident as early as 60-120 seconds prior to when the mind-wandering was caught, but that this pattern was more pronounced for self-caught episodes. The second is that, 10-30 seconds prior to mind-wandering being caught, the fixation-duration measures were less affected by on-going lexical and linguistic processing. Finally, in the 2.5-second interval immediately preceding self-caught mind-wandering, participants were less likely to make first-pass fixations, fixate words, or make regressions (all of which are indicative of normal text processing), but were instead more likely to be looking somewhere other than the text. We will discuss the theoretical implications of these findings in turn.

The findings that fixations become longer in duration and progressively less sensitive to lexical and linguistic variables suggest that readers lapse into periods of mind-wandering that are extensive (1-2 minutes) in duration and that, during these lapses, eye movements become progressively de-coupled from on-going text processing. One implication of these results concerns the nature of eye-movement control during normal reading: When participants were reading mindfully, their eye movements showed a sensitivity to lexical and linguistic variables that was less apparent when they were reading mindlessly, consistent with the hypothesis that the decisions about when to move the eyes are normally related to cognitive processing, as stipulated by cognitive-control theories (Engbert et al., 2005; Just & Carpenter, 1980; Reichle et al., 1998; Reilly & Radach, 2006; Salvucci, 2001). These differences also further document the tractability of mindless reading as a topic of investigation (Sayette et al., 2009; Schooler et al., 2004, 2009; Smallwood et al., 2008) by providing the first demonstration that eye movements can be used as on-line indicators of mind-wandering. This covert measure of mind-wandering may also enable the investigation of questions that have been impossible to address with intrusive self-report measures, including: Is it possible to develop an on-line method to catch people mind-wandering before they notice it themselves? And if so, can comprehension be improved by sensitizing people to mindless reading? Although the resolution of such questions awaits future research, the present study indicates that eye tracking provides an invaluable tool for studying mindless reading, and that it may ultimately lead to technology to ameliorate a major source of comprehension difficulty.

Finally, two differences between self- and probe-caught mind-wandering in the present study further elucidate the possible role of meta-awareness in reading: Self-caught mind-wandering was associated with longer fixations than probe-caught mind-wandering, with the former also being associated with more off-text fixations immediately before mind-wandering reports. Because of the correlational nature of these data, it is not possible to determine whether the observed differences reflect increased cognitive demands of the dawning meta-awareness (which might draw resources away from reading) or whether pronounced deviations from normal reading behaviors instead serve as cues to notice that the mind has wandered. This latter case raises the possibility of enhancing reading comprehension by sensitizing readers to aberrations in their gaze behaviors. For example, participants might be advised to keep an eye out (so to speak) for situations in which their eyes are moving especially slowly or not focusing on the text. Although future studies are necessary to test such predictions, our findings suggest that the mind and eye are tightly coupled, and that eye movements can be used to study even one of the most elusive aspects of the mind—self-reflection.

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Footnotes

1. Although several experiments (Sayette et al., 2009; Schooler et al., 2004) indicate that mindless reading is amenable to study using self-paced reading (where participants press buttons to move through pages of text), pilot work suggested that the frequency of mind-wandering that is observed using self-paced reading in conjunction with eye tracking is reduced because of the novelty of eye tracking and intrusions caused by recalibrating the eye tracker. We therefore ran four participants over several days (rather than many participants for one session each) to habituate them to the eye-tracker and thereby offset the reduction in the expected number of mind-wandering episodes. Our efforts were successful because the observed number of episodes was only modestly reduced from previous studies (e.g., see Schooler et al., 2004).

2. Because participants pressed buttons to respond to prompts and to self-report mind-wandering, their eyes were often directed towards the keyboard, making it impossible to examine differences in the rates of inter-word regressions immediately following self- versus probe-caught zone-outs.

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Table 1. Mean (and standard-errors of means) behavioral measures.

Participant	Reading Time (Hours)	Comprehension Accuracy	# Self-Caught Zone Outs	# Probes	# Probe-Caught Zone Outs	Probe-Caught Ratio
1	15	.801	36	179	8	.045
2	12	.754	25	124	19	.153
3	13	.895	8	148	20	.135
4	14	.807	21	155	6	.039
M	13.5	.814	22.50	151.50	13.25	.093
SE	.65	.029	5.78	11.32	3.64	.030

Table 2: Results of multiple-regression analyses of three dependent measures (first-fixation durations, gaze durations, and total-viewing times) using the inverse of word length, the natural logarithm of word frequency, and whether or not a word was clause- or sentence-final during normal reading, as a function of the time interval preceding the "no" responses to the probes.

Interval (sec.)	Dependent Measure	Const. (B_0)	1 / Length (B_1)	ln(Frequency) (B_2)	Sentence/Clause Final (B_3)
2.5	FFD	211	-	-	-
	GD	287	-5.99*	-2.04*	-
	TVT	322	-70.11**	-3.13**	-
5	FFD	202	-	.93*	-
	GD	296	-59.89***	-2.21**	-
	TVT	349	-83.87***	-4.08***	-
10	FFD	204	23.13***	-	-7.75*
	GD	297	-42.66***	-2.92***	-
	TVT	385	-101.86***	-5.31***	-
30	FFD	211	-	-	-9.2***
	GD	309	-62.61***	-3.26***	-7.42*
	TVT	442	-149.94***	-6.68***	-13.79**
60	FFD	209	-	.41*	-10.34***
	GD	308	-60.86***	-3.18***	-
	TVT	462	-159.52***	-7.17***	-13.3***
120	FFD	213	-	-	-12***
	GD	317	-70.47***	-4***	-9.58***
	TVT	490	-180.65***	-18.11***	-22.5***

Notes:
1. *FFD* = first-fixation duration; *GD* = gaze duration; *TVT* = total-viewing time
2. * $t \geq 1.96, p < .05$; ** $t \geq 2.58, p < .01$; *** $t \geq 3.29, p < .001$.

Table 3: Results of multiple-regression analyses of three dependent measures (first-fixation durations, gaze durations, and total-viewing times) using the inverse of word length, the natural logarithm of word frequency, and whether or not a word was clause- or sentence-final during self-caught zone-outs, as a function of the time interval preceding the button presses indicating self-caught zone-outs.

Interval (sec.)	Dependent Measure	Const. (B_0)	1 / Length (B_1)	ln(Frequency) (B_2)	Sentence/Clause Final (B_3)
2.5	FFD	207	-	-	-37.17*
	GD	226	-	-	-
	TVT	237	-	-	-
5	FFD	215	-	-	-
	GD	233	-	-	-
	TVT	253	-	-	-
10	FFD	233	-	-	-
	GD	274	-	-	-
	TVT	283	-151.69**	-	-
30	FFD	223	33.47*	-	-14.85*
	GD	310	-	-3.93***	-
	TVT	499	-136.02**	-10.58***	-
60	FFD	216	-	-	-13.37**
	GD	292	-87.22***	-	-
	TVT	499	-188.94***	-6.66***	-
120	FFD	223	-17.35***	-	-
	GD	317	-111.2***	-	-15.65*
	TVT	515	-239.3***	-6.68***	-24.86*

Notes:

1. *FFD* = first-fixation duration; *GD* = gaze duration; *TVT* = total-viewing time
2. * $t \geq 1.96$, $p < .05$; ** $t \geq 2.58$, $p < .01$; *** $t \geq 3.29$, $p < .001$.

Table 4: Results of multiple-regression analyses of three dependent measures (first-fixation durations, gaze durations, and total-viewing times) using the inverse of word length, the natural logarithm of word frequency, and whether or not a word was clause- or sentence-final during probe-caught zone-outs, as a function of the time interval preceding the "yes" responses to the probes.

Interval (sec.)	Dependent Measure	Const. (B_0)	1 / Length (B_1)	ln(Frequency) (B_2)	Sentence/Clause Final (B_3)
2.5	FFD	209	-	-	-
	GD	238	-	-	-
	TVT	251	-	-	-
5	FFD	201	-	-	-
	GD	289	-111.92**	-	-
	TVT	323	-131.85**	-	-
10	FFD	222	-	-	-
	GD	329	-78.39*	-3.95*	-
	TVT	390	-219.21***	-	-
30	FFD	248	-	-	-
	GD	359	-108.28***	-4.01***	-
	TVT	500	-203.33***	-6.84***	-
60	FFD	244	-	-	-
	GD	368	-100.5***	-5.39***	-
	TVT	544	-246.35***	-9.08***	-
120	FFD	234	-	-	-7.42*
	GD	366	-111.27***	-5.21***	-
	TVT	566	-288.48***	-9.49***	-

Notes:

1. *FFD* = first-fixation duration; *GD* = gaze duration; *TVT* = total-viewing time
2. * $t \geq 1.96$, $p < .05$; ** $t \geq 2.58$, $p < .01$; *** $t \geq 3.29$, $p < .001$.

Figure Captions

Figure 1. Mean global eye-movement measures during normal reading, self-caught mindless reading, and probe-caught mindless reading, as a function of interval duration. The four panels show: (A) number of first-pass fixations; (B) number of regressions; (C) number of words fixated; and (D) number of off-text fixations. The error bars indicate standard errors of means, with significant differences indicated.

Figure 2. Mean local eye-movement measures during normal reading, self-caught mindless reading, and probe-caught mindless reading, as a function of interval duration. The three panels show: (A) first-fixation durations; (B) gaze durations; and (C) total-viewing times. The errors bars indicate standard errors of means, with significant differences indicated.

Figure 3. Properties of fixated words during normal reading, self-caught mindless reading, and probe-caught mindless reading, as a function of interval duration. The three panels show: (A) word length; (B) natural logarithm of word frequency; and (C) number of sentence/clause-final words. The error bars indicate standard errors of means, with significant differences indicated.

Figure 4. Global eye-movement measures, fixation-duration measures, and word properties during a 120-second interval *after* responses indicating normal reading, self-caught mindless reading, and probe-caught mindless reading. The three panels show: (A) mean number of first-pass fixations, regressions, words fixated, and off-text fixations; (B) mean first-fixation durations (*FFD*), gaze durations (*GD*), and total-viewing times (*TVT*); and (C) mean word length (in characters), natural logarithm of word frequency, and number of sentence/clause-final words (*final*). The errors bars indicate standard errors of means, with significant differences indicated.

Figure 1.

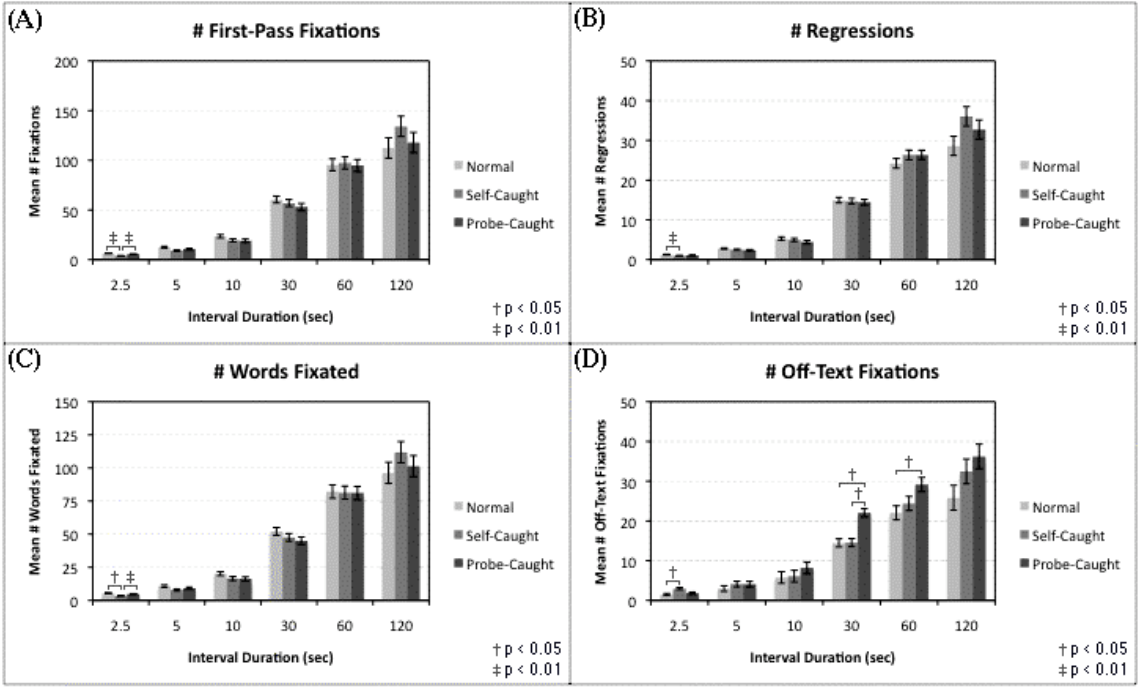
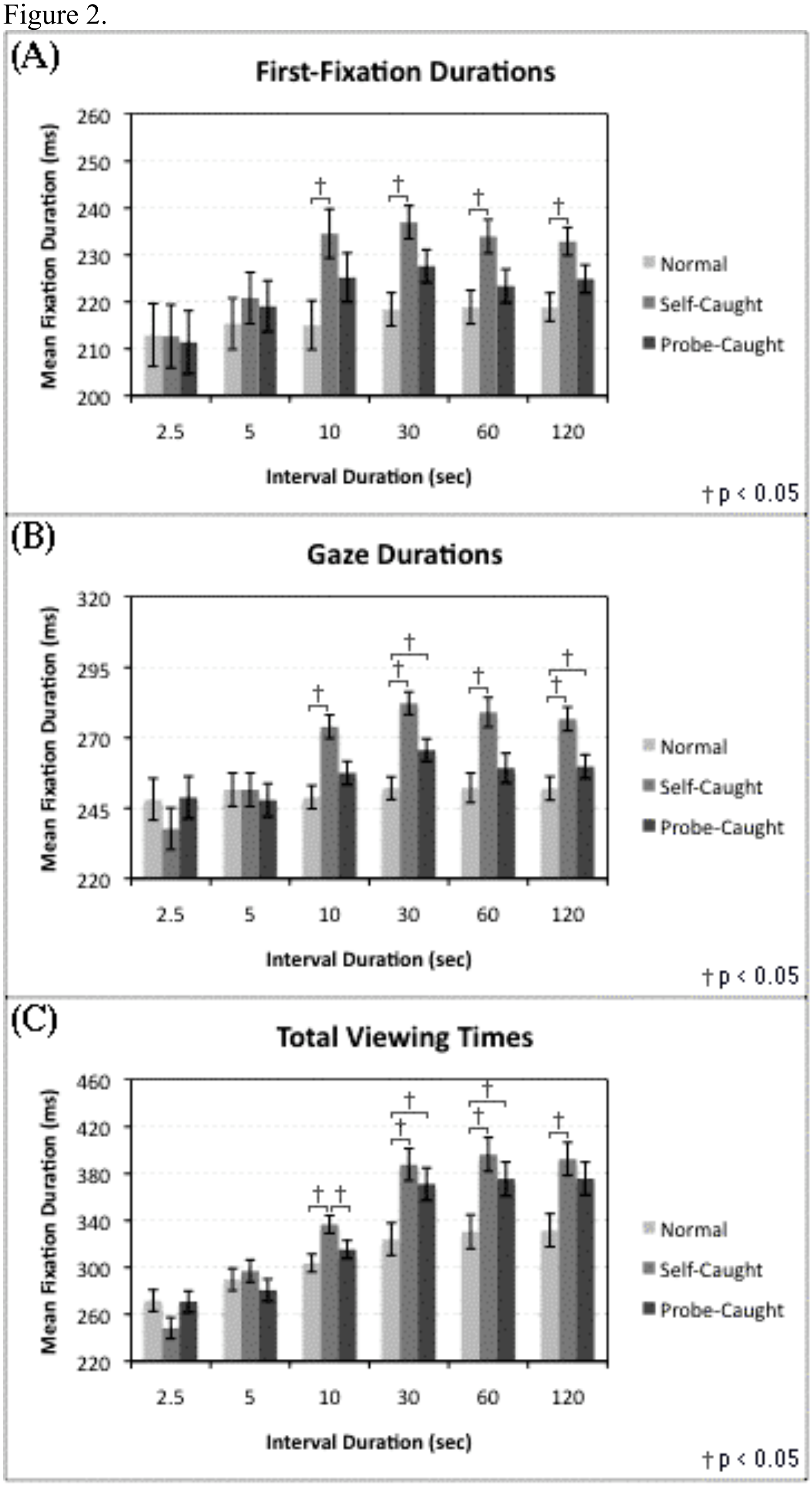
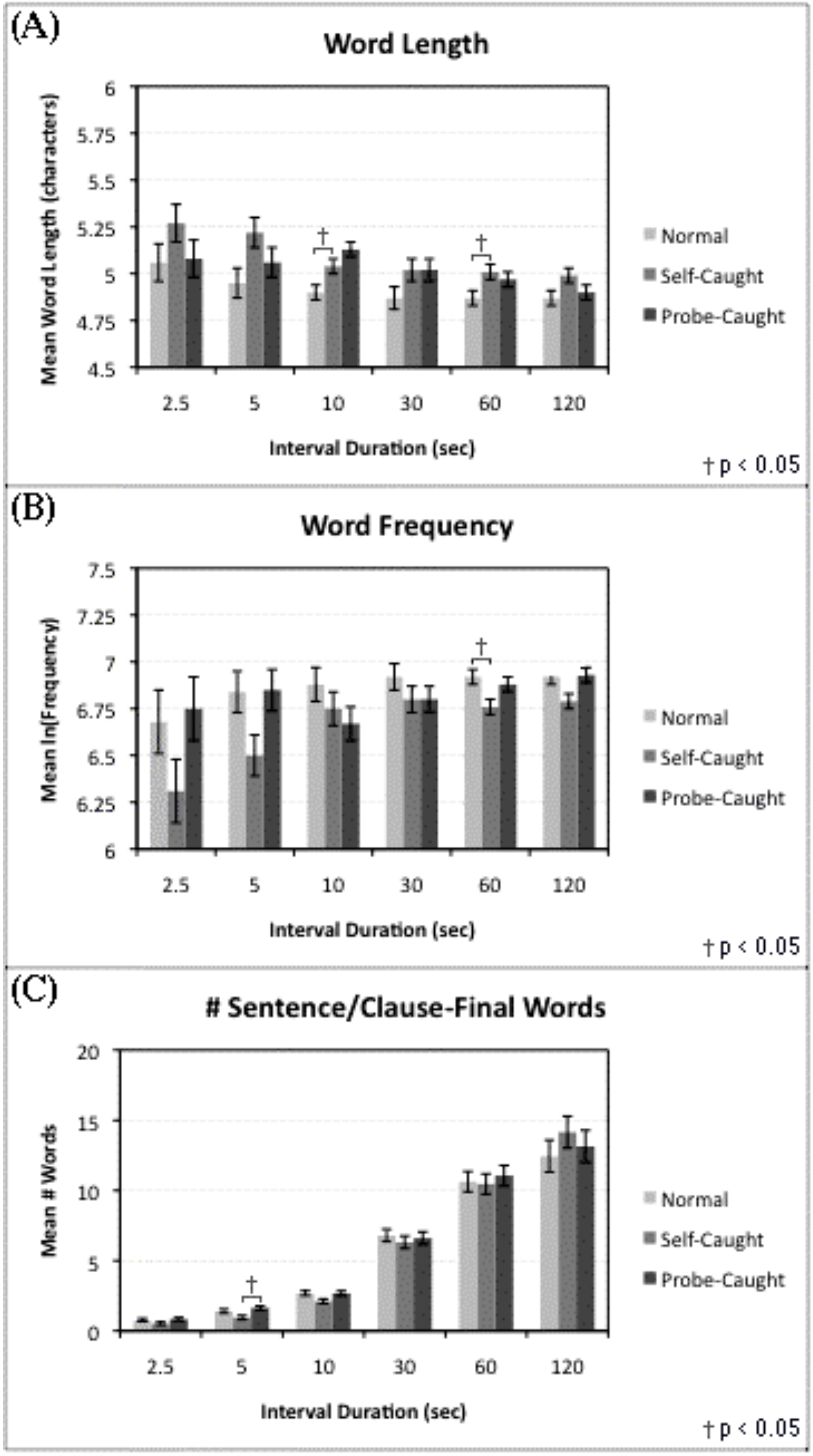

(A)
First-Pass Fixations
Mean # Fixations
200
150
100
50
0
‡ ‡
2.5
5
10
30
60
120
Interval Duration (sec)
Normal
Self-Caught
Probe-Caught
† p < 0.05
‡ p < 0.01
(B)
Regressions
Mean # Regressions
50
40
30
20
10
0
‡
2.5
5
10
30
60
120
Interval Duration (sec)
Normal
Self-Caught
Probe-Caught
† p < 0.05
‡ p < 0.01
(C)
Words Fixated
Mean # Words Fixated
150
125
100
75
50
25
0
† ‡
2.5
5
10
30
60
120
Interval Duration (sec)
Normal
Self-Caught
Probe-Caught
† p < 0.05
‡ p < 0.01
(D)
Off-Text Fixations
Mean # Off-Text Fixations
50
40
30
20
10
0
†
†
†
†
2.5
5
10
30
60
120
Interval Duration (sec)
Normal
Self-Caught
Probe-Caught
† p < 0.05
‡ p < 0.01

Figure 2.



(A)
First-Fixation Durations
Mean Fixation Duration (ms)
260
250
240
230
220
210
200
2.5
5
10
30
60
120
Interval Duration (sec)
Normal
Self-Caught
Probe-Caught
†
† p < 0.05
(B)
Gaze Durations
Mean Fixation Duration (ms)
320
295
270
245
220
2.5
5
10
30
60
120
Interval Duration (sec)
Normal
Self-Caught
Probe-Caught
†
† p < 0.05
(C)
Total Viewing Times
Mean Fixation Duration (ms)
460
420
380
340
300
260
220
2.5
5
10
30
60
120
Interval Duration (sec)
Normal
Self-Caught
Probe-Caught
†
† p < 0.05

Figure 3.

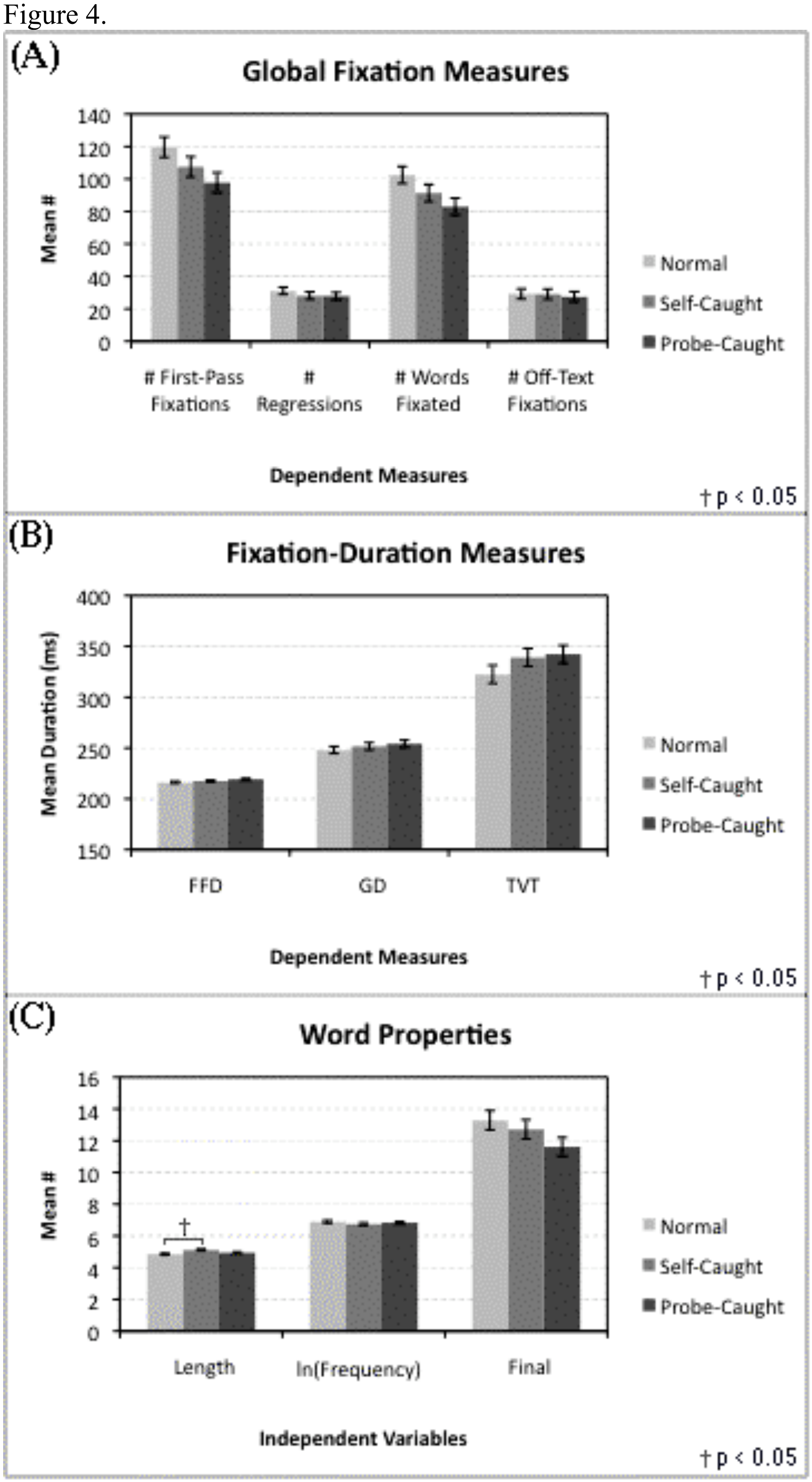


(A) Word Length

(B) Word Frequency

(C) # Sentence/Clause-Final Words

Figure 4.


(A)
Global Fixation Measures
Mean #
140
120
100
80
60
40
20
0
First-Pass Fixations
Regressions
Words Fixated
Off-Text Fixations
Dependent Measures
Normal
Self-Caught
Probe-Caught
† p < 0.05
(B)
Fixation-Duration Measures
Mean Duration (ms)
400
350
300
250
200
150
FFD
GD
TVT
Dependent Measures
Normal
Self-Caught
Probe-Caught
† p < 0.05
(C)
Word Properties
Mean #
16
14
12
10
8
6
4
2
0
†
Length
ln(Frequency)
Final
Independent Variables
Normal
Self-Caught
Probe-Caught
† p < 0.05