E-readers, Computer Screens, or Paper: Does Reading Comprehension Change Across Media Platforms?

SARA J. MARGOLIN*, CASEY DRISCOLL, MICHAEL J. TOLAND and JENNIFER LITTLE KEGLER

The College at Brockport, State University of New York, Brockport, USA

Correspondence to: Sara J. Margolin, Department of Psychology, The College at Brockport, State University of New York, Brockport, NY 14420-2977, USA. Contact: smargoli@brockport.edu

Abstract

The present research examined the impact of technology on reading comprehension. While previous research has examined memory for text, and yielded mixed results of the impact technology has on one's ability to remember what they have read, the reading literature has not yet examined comprehension. In comparing paper, computers, and e-readers, results from this study indicated that these three different presentation modes do not differentially affect comprehension of narrative or expository text. Additionally, readers were not consistently compensating for difficulties with comprehension by engaging in different reading behaviors when presented with text in different formats. These results suggest that reading can happen effectively in a variety of presentation formats.

Keywords: technology, computers, reading comprehension, narrative text, expository text

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For over a century, educational institutions have relied on print materials, in the form of periodicals or books to make information accessible to students. Reading, and more importantly, comprehension, is a fundamental skill necessary for the successful completion of almost any type of class as well as in the job marketplace. With the introduction of computers and the ever-expanding array of electronic devices on which to read, educators remain skeptical as to their suitability for students' reading comprehension. As the amount of digital text being created grows exponentially each day, research is needed to determine whether comprehension in an electronic environment is comparable to comprehension of text presented in a traditional paper format. This present research seeks to answer this question in a controlled environment using both electronic and paper versions of texts.

Reading is a process that, once learned, allows an individual to mentally represent written text. According to the Construction Integration (CI) Model (Kintsch, 1998), this process generally follows a cyclical pattern where a reader forms a network representation of the text they are reading. Over the course of a reading cycle, while reading a single sentence, a reader begins by activating in their mental representation the verbatim information that is presented on the page (or the screen as it were), creating a surface level representation of the text. As this process moves forward a reader activates the meaning of the text they are reading, and expands their representation into the textbase level representation. Readers end on a representation of the text called the situation model, which includes the meaning of the words as well as conclusions and inferences drawn from the text that are integrated with what may already be known about a

particular topic. Zwaan and Radvansky (1998) argue that readers then regularly update their situation model when changes occur within the text, such as changes in space, time, location, or character, as long as sufficient overlap exists between the previous reading cycle and the new information. This process does not automatically occur, but rather is one that requires direct instruction, practice, and feedback (e.g., Williams, 2003).

More variables exist than simply space, time, location, and character that are involved in reading and creating a mental representation of the text. In fact, any part of the reading process may be dependent on one very important factor: working memory (e.g., Burton & Daneman, 2007; Margolin & Abrams, 2009; McVay & Kane, 2012; Waters & Caplan, 1996). Just and Carpenter (1992) describe their capacity theory of comprehension, where working memory resources are critical for comprehension during reading. Each reader may have the ability to hold some maximum amount of information in their working memory during reading and incorporating this information into what they have already read (a process consistent with the CI model described earlier). An individual's maximum ability for storage and integration of information is their maximum capacity. If the necessary working memory capacity for fully understanding and correctly creating a mental representation of a text is more than what the individual has available, difficulties arise. In certain situations, such as with increasing age (e.g., DeBeni, Borella, & Carretti, 2007; Light, 1988; Waters & Caplan, 2001), increased task demands (e.g., Miyake, Carpenter, & Just, 1994), or distraction (e.g., McVay & Kane, 2012), a reader's available capacity for processing text may be reduced, making difficulties with fully understanding the text more likely.

In one study, McVay and Kane (2012) aimed to determine what role mind-wandering (i.e., shifting one's attention away from the task at hand) plays in a reader's comprehension of

text, and what influence it has on working memory capacity. Participants completed a reading task, during which they were presented with thought probes. The thought probes were intended to get a reader to report their immediate thoughts as they were occurring during reading. Additionally, readers completed working memory capacity measures. Results indicated that mind-wandering played a significant role in reading comprehension, as did working memory capacity. Additionally, the results demonstrated that intruding thoughts resulting from mind-wandering would take away from the task at hand. In terms of Just and Carpenter's capacity theory of working memory, this would indicate that when mind-wandering occurs, or any distraction for that matter, fewer working memory resources would be available to hold and integrate the information necessary to understand the text.

Given that distraction is one of the variables that may influence comprehension by reducing a one's available working memory capacity, it is important to examine potential sources of distraction and determine whether these sources have a significant impact on the outcome of the mental representation of the text. One possible source that is particularly relevant to educators is that of computer technology. In a changing world of technology texts, ranging from news articles and electronic mail to scholarly research articles and full-length e-books, digital formats are available and can be read on a variety of screens. These screens exist across many different devices, from laptop and personal computer screens to e-readers (e.g. the Kindle). Although the new e-ink technology used in e-readers imitates the appearance of text on paper, a question still remains whether devices that use this technology, or other electronic devices (e.g., computers) can detrimentally impact comprehension.

Early research investigating reading with computers focused primarily on the process and efficacy of reading from computers, rather than outcomes like comprehension and learning.

Research examined topics such as the readability of texts on a computer screen (e.g., Mills & Weldon, 1987; Kolers, Duchnicky, & Ferguson, 1981) and the speed of reading and proofreading on paper versus a computer (e.g., Dillon, 1992; Gould et al., 1987; Muter & Maurutto, 1991; Reinking & Schreiner, 1985). However, the results of this research demonstrated mixed findings in these outcome measures of literacy. In some instances, the research suggested that in terms of reading speed and reading ability, traditional paper presentation was superior to computerized text (e.g., Gould & Grischkowski, 1984; Gould & Grischkowsky, 1986; Wright & Lickorish, 1983). Other researchers argued that although reading speeds differed, comprehension did not change because people tended to read at a speed in which they can maintain meaning and understanding (e.g., Mills & Weldon, 1987).

Researchers initially explained the observed discrepancies in speed of reading and accuracy of proofreading between paper and computerized texts in the context of physical novelties and constraints (e.g., backlighting and flickering of electronic text, differences in font and spacing across media, angle of observance and scrolling of electronic text as compared to page turning of traditional text) inherent in the use of –what was then—an emerging technology (e.g., Bevan, 1981; Gould & Grischkowski, 1986; Gould et al., 1987). With a marked advance in technology, higher-quality display systems have been able to more closely replicate the fonts and structure of traditional paper-based formats. More recent research comparing reading e-books on a computer versus traditional paper books has reported that students score somewhat higher on reading comprehension tests after reading paper books, yet they show an increasing satisfaction and curiosity with e-books (Jeong, 2012; Jones & Brown, 2011).

Research investigating reading with computers has benefitted greatly from the advances in technology but has primarily focused on online reading or reading with hyperlinked text (e.g.,

Coiro, 2011; Gil-Flores, Torres-Gordillo, & Perera-Rodriguez, 2012). This research has demonstrated that reading online may be at the very least more complex than reading traditional printed text (e.g., Coiro & Dobler, 2007; Dyson & Haselgrove, 2000; Hartman, Morsink, & Zheng, 2010; Henry, 2006; Leu, Kinzer, Coiro, & Cammack, 2004; Schmar-Dobler, 2003; Zumbach & Mohraz, 2008). For example, Leu et al. (2004) describe five components for online reading: identifying a problem, locating information, evaluating the information, synthesizing information, and communicating information. The description of these components suggests that reading online involves more than simply understanding what is encountered. It also suggests that the reader engage in other higher level processing of the material beyond creating a mental representation of the text. Zumbach & Mohraz (2008) found that a non-linear presentation (i.e., hyperlinked text, as is found on many Internet pages) led to decreased knowledge acquisition compared to a linear presentation of the same text. Additionally, the goal of reading or the question that drives reading may change as new information is encountered, and new questions may continually be developed if reading is occurring in this context (e.g., Graesser & Lehman, 2011). In their study, Coiro & Dobler (2007) asked skilled sixth-grade readers to read online and subsequently answer questions about which strategies they used while reading. Results showed that while reading online, these students used more than comprehension but also reasoning, information evaluation, and cognitive flexibility. According to Henry (2006), readers are employing strategies to search for information when reading online and are subsequently evaluating the relevance of the information they find. They narrow their focus, and then in the case of CI model (Kintsch, 1998), incorporate the information into the situation model of the text. The difference between Kintsch's model (1998) and this strategy is that online readers are evaluating and problem solving as they build their situation model because that is what is

necessary for the task. Additional researchers have examined how students' online experience affected their digital reading performance and have found that information-seeking activities had a stronger impact on their digital reading competency than their online social activities (Gil-Flores et. al., 2008).

While these new digital literacies are important for educators to research and understand, they focus mainly on online reading and hyperlinked text. Not every electronic text includes hyperlinks: some devices like the Kindle are simply electronic presentation methods, and given the low price point, have become very popular. In the same manner, e-books are often simply an electronic counterpart to their print versions and require that users read in a more linear fashion. Research on reading without hyperlinked text has focused on computers and has not demonstrated consistent results in its examination of recall (e.g., Green, Perera, Dance, & Meyers, 2010; Santana, Livingstone, & Cho, 2011), self-judgments of comprehension and memory (e.g., Moore & Zabrucky, 1995), or even comprehension (e.g., Mayes, Sims, & Koontz, 2001). For example, Moore & Zabrucky (1995) demonstrated that although reading times were significantly slower in computer reading, scores of self-judged comprehension did not differ across presentation mode, and participants performed significantly better on scores of overall recall in the computer condition. In a study of recall across different reading media, Santana et al. (2011) showed that the print reading group recalled significantly more news stories, more news topics, and more main points than did computer news readers. In terms of comprehension, Mayes et al. (2001) showed no significant difference in comprehension accuracy across the two presentation conditions but found a significant negative correlation between workload and comprehension. The participants who felt they were experiencing a greater workload, such as those reading on a computer, also scored lower on measures of comprehension.

Green, et al. (2010) aimed in determining whether the method of presentation impacted recall of material. The participants read a newspaper article as a paper-based or an electronic-copy. Recall was tested using objective recognition multiple choice questions, where participants were asked to simply remember information/facts from the article. The results suggested that paper-based presentation led to slightly, though not significantly, better recall. These tests of recall are different than tests for comprehension. Tests of recall are necessarily asking readers to assess a lower level of representation (i.e., textbase model) of the text, by requiring the reader to only retrieve the exact information that was presented in the text without drawing conclusions or making inferences (e.g., Kintsch, 1998). Tests of comprehension ask readers to tap into their situation model representation of the text, where a reader may be representing interpretations and conclusions they have drawn (e.g., Kintsch, 1998).

In order to further investigate the connection between technology and reading comprehension, the present research looked to explore a new technology known as an e-reader, whose intended function is the singular process of reading, rather than searching for and evaluating information online, and compared this technology to other presentation types. This type of reading is different than reading online, for which growing body of literature already exists (e.g., Coiro & Dobler, 2007; Henry, 2006). Here, there is no need to search or problem-solve to navigate through the hyperlinks, because these are not present on an e-reader device. Due to the e-reader's recent appearance, research regarding reading comprehension and e-readers has only emerged in the past few years. Studies examining comprehension between paper texts and e-reader texts do not reach the same conclusions, nor do they use equivalent methods to measure reading comprehension. Two studies found that text presentation (paper or e-reader) did not affect reading comprehension; however, one study used writing samples that were coded

qualitatively (Connell, Bayliss, & Farmer, 2012), and the other used a 20 question multiple choice test based on one expository text (Schugar, Schugar, & Penny, 2011). Clearly with such discrepancies in reporting research results and the relatively small sample sizes additional research is needed.

The present research also attempted to reduce the number of complexities often found when users read online texts by eliminating the online text distractions of hyperlinks, images, animation, audio and video as described by Coiro (2011). Similar to the Green et al. study (2010), participants read expository texts, i.e., texts that are read primarily for learning purposes (e.g., formally in a classroom or informally with a newspaper). Additionally, the present research also asked participants to read narrative texts, i.e., texts with a story. Narrative texts can be read for leisure or for educational purposes (e.g., a student reading *Wuthering Heights*). These two types of texts are both regularly used in educational settings and therefore deserve examination. As opposed to the one reading trial performed by Green et al. (2010), the present research explored reading on e-readers through multiple reading trials. In order to discern the efficacy of reading texts on a computer or e-reader, it is important to determine if there is a difference in comprehension and if there is any interaction between text type and media. Any existing differences in comprehension of electronic and printed texts may imply a need for change in current technology to support reading activities more effectively.

New e-reader technology has allowed electronic text to appear as though one is looking at a real piece of paper. As publishers continue to produce e-book alternatives for print textbooks, professors and students alike wonder if these alternatives allow readers to extract as much meaning from the text as traditional paper versions. The present research questions examine this issue in aiming to determine whether comprehension of text presented in electronic formats is

similar to reading on traditional paper and whether readers create a comparable situation model representation of the text that they read via these new methods of presentation.

METHOD

Participants

Three groups of 30 participants, totaling 90 individuals (23 male and 67 female), took part in this study. The number of male and female participants in each condition were comparable across the paper (6 male and 24 female), computer (10 male and 20 female), and e-reader conditions (7 male and 23 female). No individual experienced more than one condition. Participants ranged in age from 18 to 25 years (M = 19.06, SD = 1.28), were native speakers of English, had normal or corrected-to-normal vision and hearing, and had not been previously diagnosed with dyslexia or any other reading or learning disability. Participants were recruited from an introduction to psychology class at a four-year college in Western New York, and received partial course credit for their participation. The majority of the participants were of freshman status, whose most recent class averaged 1117 on the SAT ("New Faculty FAQ", 2012). Of the ninety participants, 59 were freshmen, 16 were sophomores, nine were juniors, and six were seniors.

Materials

Ten experimental passages were chosen for the present experiment: five expository and five narrative. The primary purpose of the expository texts was to convey facts and information, whereas the primary purpose of the narrative texts was to tell a story or chronicle an event. The two types of texts were matched on a number of factors, including length and reading level. The narrative texts were excerpts from literary works; three of which were retrieved from the college's library website and two of which came from other literature websites. The texts ranged

between 505 and 571 words long ($M_{narrative}$ = 541.8, $SD_{narrative}$ = 27.11) and written between a 10.7 and 12.9 grade level ($M_{narrative}$ = 11.5, $SD_{narrative}$ = 0.91) according to the Flesch-Kincaid grade level scale. The expository texts were short biographies of historical and pop-culture figures retrieved from biography.com. Each expository passage was between 492 and 572 words long ($M_{expository}$ = 542, $SD_{expository}$ = 32.17) and written between a 10.6 and 11.6 grade level ($M_{expository}$ = 11.5, $SD_{expository}$ = .91). The presentation of passages was counterbalanced such that each passage was presented in each position of order, using 10 versions. The same 10 passages were presented via all three media platforms: printed out in the paper condition, viewed as a .pdf on a computer in the computer condition, or the same .pdf file loaded onto a Kindle for the e-reader condition.

Participants in the paper-based condition read passages from a packet of standard 8.5 x 11 inch white paper on which the passages were printed with black 12 point Times New Roman font. Participants in the computer condition read passages displayed as a PDF file in Adobe Acrobat Reader 9, version 9.0.0 on a desktop Dell OPTIPLEX 380 personal computer equipped with an Intel Core 2 Duo 2.93 GHz processor and a 17-in. monitor. The participants were permitted to use either a mouse or the arrow keys on the keyboard to scroll through the document. The participants in the electronic reader condition read passages presented on a second generation Amazon Kindle with a 6 in. 600 x 800 resolution screen which displays black text on a matte white background, using electrophoretic ink (e-ink) technology. E-ink technology uses the movement of particles in a fluid that is being influenced by an electric field to display an image on the screen (”The miracle technology”, 2011). Rather than having a backlight like liquid crystal displays (LCD), e-ink displays are only visible using external light sources, which allows

the display to closely mimic ink on paper. Readers can use the device similarly to paper as well, highlighting text, turning pages forward and back, etc.

For each viewing situation, the passage was immediately followed by corresponding multiple choice comprehension questions with four possible answers. Fifty-six multiple choice questions were created to assess reading comprehension of these ten passages. Sample comprehension questions are displayed in the Appendix. Five or six questions (M = 5.6, SD = .52) corresponded to each of the passages. A Cronbach's alpha was calculated for this comprehension, and it was determined to be reliable, $\alpha = .80$. All participants recorded their answers to these multiple choice questions on a paper answer sheet. Questions were developed to require thought and reflection, rather than simply measure recall of the text. For example, a question pertaining to Michael Jordan's college degree had participants determine with which discipline his degree was associated. The answer could not be recognized from memory and triggered by exposure to a single word but rather required thought and understanding of the text. Participant reading behaviors were evaluated using a questionnaire with questions like "How often did you follow along each line of the text with a writing utensil or finger?", or "Did you skip around in the passage and read short sections and re-read before moving on?" The questionnaire also included a series of demographics questions regarding participant age, sex, academic major, class standing, and so forth.

Design

The present research used a two factor design, with type of text (expository and narrative) as a within-subjects factor and media presentation (paper, computer, and Kindle) as a between-subjects factor. The primary dependent variable was accuracy percentage for the comprehension

questions. Occurrence of various reading behaviors, as measured by the reading behaviors questionnaire, was also measured via self-report.

Procedure

The participants were randomly assigned to one of the three media presentation conditions. In individual presentation sessions with one of two student research assistants in an office space provided on the college campus, participants completed the experimental tasks as follows. First, each participant signed a statement of informed consent and was presented with instructions to read through each passage and answer the corresponding comprehension questions by recording their answers on the answer sheet provided. After completing the comprehension questions for a given passage, participants moved on to read the next passage until all 10 passages (five narrative and five expository) and their corresponding comprehension questions had been completed. Participants were instructed that they could take as much time as they desired to read each passage; they could read at their own pace. However, participants were not permitted to return to the passage after they had begun answering the corresponding questions, so that participants had equal exposure to the stimuli. After hearing the instructions, each participant was then given an opportunity to ask questions before beginning to read the first passage.

Upon completion of the reading task, each participant was given a demographic survey, followed by a survey of reading behaviors. Each participant was then debriefed and thanked for their participation. The entire session lasted between 45 minutes and one hour depending on how quickly the participant read each passage.

RESULTS

Comprehension accuracy

To determine the impact of the type of media used for reading on comprehension, a 2 (Passage Type) x 3 (Media Presentation) analysis of variance was conducted. See Table 1 for means, standard deviations, and standard errors. Results indicated a significant difference in comprehension between narrative and expository texts, F (1, 87) = 8.53, MSE = 0.05, $p < .004$, such that comprehension scores for narrative passages (M= 74.58, SD = 13.37) were lower than comprehension scores for expository passages (M = 77.88, SD = 13.05). Neither the main effect of media presentation $F < 1$, nor the interaction of the two variables were significant, F (1, 87) = 1.03, MSE= .01, $p > .36$.

Reading behaviors

In order to explore readers' behaviors during reading and their relationship to overall comprehension, several analyses were conducted on the following behaviors listed on the questionnaire: following the text with a finger or mouse, highlighting text, reading and re-reading text, taking notes, skipping around while reading, saying words silently, saying words aloud, and moving lips while reading. The percent occurrence of each of these behaviors is presented in Table 2. Pearson correlations between various reading behaviors and comprehension scores for participants reading on the computer revealed a significant correlation between following the text with a finger or mouse and overall comprehension, r = -.59, $p < .001$, and between moving their lips while reading and overall comprehension, r = -.37, $p < .04$. No significant correlations between reading behaviors and overall comprehension were demonstrated for participants reading on paper, $p > .08$, or for participants reading on the Kindle, $p > .13$. When examined separately for each type of text, correlational analyses showed no significant correlations between reading behaviors and comprehension for either narrative text or expository text, $p > .06$.

A stepwise regression analysis was conducted to examine the degree to which reading behaviors influence comprehension accuracy for each type of text and to determine whether any of these behaviors could explain the variance in comprehension scores. Variables were entered into the model in order, based on popularity of self-reporting the behavior (see Table 2 for percent of individuals reporting each behavior). Results indicated that for expository text, no reading behaviors accounted for a significant amount of variance in comprehension, $p > .28$, but for narrative text, highlighting text alone accounted for a significant amount of variance in comprehension accuracy, $R^2 = .12$, $p < .05$.

Additionally, a one-way multivariate analysis of variance (MANOVA) was conducted to examine whether rates of each behavior were different among the three media presentations. Results demonstrated no significant differences in rates of following the text with a finger or mouse, $F < 1$, highlighting text, $F(2, 87) = 1.85$, $MSE = .08$, $p > .16$, reading and re-reading text, $F < 1$, taking notes, $F < 1$, saying words silently, $F < 1$, saying words aloud, $F(2, 87) = 1.85$, $MSE = .08$, $p > .16$, or moving lips while reading, $F < 1$. However, significant differences were revealed among media presentation for skipping around while reading, $F(2, 87) = 3.41$, $MSE = .54$, $p < .04$, such that Kindle readers showed significantly lower reports of skipping around than those reading on paper, $p < .01$. Additionally, rates of this behavior did not differ for participants reading on paper or a computer, $p > .34$, nor did they differ significantly between Kindle readers and those reading on a computer, $p > .11$.

DISCUSSION

The present research attempted to determine whether reading using electronic media would result in comparable comprehension to reading using traditional paper presentation. Previous research on this topic has shown mixed results. While early research demonstrated

marked differences between paper and electronic presentation in speed of reading, accuracy of proofreading, and comprehension (e.g., Bevan, 1981; Gould, 1986; Gould & Grischkowski, 1986; Gould et al., 1987), more recent research has demonstrated smaller and less consistent differences in memory for text (e.g., Green et al., 2010; Huang, 2006). The present results are consistent with these more recent findings and extend these findings to comprehension, rather than memory, of text and to a new technology known as an e-reader.

The present research examined overall comprehension of text presented via different media: paper, computer and e-reader. The results indicated no significant differences among media presentation types. This lack of significant differences in comprehension accuracy across media platforms indicates that if comprehension differences exist, the present research did not find them and therefore are likely to be very small differences or at least moderated by some other factor. This result is important because it indicates that while worries may exist that even possible unfamiliarity with the e-reader may serve as a distracter and require some working memory resources to simply operate the device, the resources necessary for operating the device were minimal and did not significantly limit readers' comprehension during reading.

Additionally, the present research attempted to examine whether media presentation affected comprehension for narrative and expository texts differently. The present results indicated that there were only small differences in comprehension accuracy overall between narrative and expository texts. These differences were neither exacerbated nor diminished for any type of presentation, and this may only be due to the nature of the questions asked. As was found in Weaver and Bryant (1995), readers respond differently to thematic questions and detailed questions when these questions correspond to narrative and expository text. Because this was not the primary focus of the present research it was not examined further. This result is

important because it demonstrates that if differences exist across these presentation types, they are small enough that a general test of comprehension could not detect them. Additionally, these results indicate that readers were similarly able to create and update their situation model representations of the text without significant interference from the media platform. Readers may use these texts for learning factual information, such as what would be presented in an expository passage, or any reader may use these technologies either to learn new information as from a newspaper or medical pamphlet or to read novels as narrative text for entertainment.

Finally, this research examined reading behaviors as a self-report measure to determine if any traditional reading behaviors (e.g., following along with a finger) could have influenced comprehension in any of the presentation formats. Analyses revealed no considerable influence of these behaviors. In examining which behaviors readers reported engaging in during reading in the present experiment, results showed that only following along with a finger or mouse and moving lips along with reading were significantly related to comprehension. In terms of media presentation, differences were only present for skipping around while reading, where Kindle readers were least likely to engage in that behavior, presumably due to the physical make-up of the device. For the Kindle device used here, users did not see any hyperlinked text (which would require moving around in the text), and could only "turn the page". These results suggest that these self-reported behaviors were not markedly different for each type of media presentation, and that readers are able to read using paper, computer, and e-reader without necessarily introducing an unnatural strategy. Although these results are encouraging and do not negatively affect the users' experience, they are primarily exploratory in nature. These measures were self-reported and may not be entirely accurate in describing exactly what individuals were doing when reading with technology. Future research investigating reading behaviors, both self-

reported and observed, should examine these practices in addition to those that commonly affect new literacies, such as scrolling or using "on board" dictionaries or tools, to determine which behaviors could influence comprehension under these new circumstances.

It should be noted that the present research has limitations. First, the participants for this research were college students, a population in which many are familiar with technology, particularly with this current sample that are required to use computers for emailing, word processing, and accessing a learning management system. The results may differ with an older population, where readers may be less familiar with technology and therefore may be reluctant to use it or to try something new. In an older population, both age (e.g., DeBeni, et al., 2007; Light, 1988; Waters & Caplan, 2001) and distraction (e.g., McVay & Kane, 2012) may potentially impact working memory, resulting in poorer comprehension at least to some degree. Younger generations, who may be fluent with these technologies at a younger age, will need to be monitored to ensure that their comprehension skills for reading have been met before they are expected to learn how to evaluate and synthesize information from a variety of hyper-linked web sources using new technologies. Measures of familiarity with technology or frequency of use of the computer/e-reader in everyday situations were not taken, so there is no way to determine how much the every day practices with reading text using electronic media could have influenced participants' performance. The next step would be to determine familiarity with technology prior to the study, as well as determine whether pre- and post- measures of comprehension would differ with the introduction of technology. Because each participant read on just one medium, it would be valuable to measure the comprehension scores of one student as they read from each of the three mediums. It would also be helpful to determine participants' reading comprehension ability before the study took place and thus compare populations with similar abilities.

(Presumably the sample used was quite comparable, as they were students who had met the same admission requirements for one college.) Additionally, there were no real consequences for not processing the information accurately or appropriately, so the effort put forth by the participants may not be the same as the effort readers may put forth in a classroom setting where grades are the result. Finally, the comprehension measure used here was one-dimensional. Other measures, such as online measures (e.g., reading speed) or activation measures (e.g., probe word recognition) would give more information about the influence of technology on readers' comprehension processes.

The present research has demonstrated that electronic forms of text presentation (both computer and e-reader) may be just as viable a format as paper presentation for both narrative and expository texts. The implications of this research are present in both the business world in advertising for the e-readers and in educational settings. E-reader devices are indeed a reasonable alternative to reading paper books and newspapers and may allow consumers to read and gather information from that reading to an extent similar to that which they are accustomed. Importantly, this research has not demonstrated a difference in comprehension for readers using these different methods of presentation. These results suggest that if a difference exists, it is likely small or moderated by some variable for which readers may easily compensate (e.g., familiarity, comfort, or competency with digital media).

From an educational and classroom perspective these results are comforting. While new technologies have sometimes been seen as disruptive, these results indicate that students' comprehension does not necessarily suffer, regardless of the format from which they read their text. This knowledge informs educators and encourages the adoption of new strategies, by students, teachers, professors, and schools alike. Students (particularly those in post-secondary

education) may wish to load e-books of all of their texts on to a single e-reader or computer, allowing them to carry their books with them anywhere. These students have expressed their satisfaction and readiness to use e-textbooks due their portability, lower cost (in many cases), and note-taking features. Instructors will find this useful in that their students may be more likely to have their books with them in class for participation, in-class discussions, and so forth. Students have also reported they were likely to keep reading beyond the required chapters, because they were scrolling through the screens (e.g. Weisberg, 2011; Stites-Doe, Maxwell, & Kegler, 2013). Additionally, educational institutions may be able to purchase class sets of e-readers with e-texts on them at a lower cost than traditional print books.

Future research should investigate the impact of variables such as these to understand completely the possibility of e-texts taking their place alongside paper formats for informational reading (e.g. textbooks) or narrative reading (e.g. novels). Once these variables have been understood, they can better inform the new literacies research, and more specifically research on online comprehension. Research in this area is still in its infancy, and new models will need to be developed to help researchers and educators to address the advantages and disadvantages to using new technologies for reading texts (e.g., Rouet, 2006; Hartman et al., 2010). We need to ensure that text is being read and understood, even as we teach the interaction and the use of technology and the integration skills that accompany it.

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APPENDIX

SAMPLE COMPREHENSION QUESTIONS

NARRATIVE

As a child, the narrator was
- a. shy.
- b. well-liked.
- c. disliked.
- d. well-educated.

EXPOSITORY

In which category or discipline would Michael Jordan's bachelor's degree be included?
- a. History
- b. Languages
- c. Earth sciences
- d. Behavioral sciences

*Note: both of these questions ask the reader to extrapolate or draw conclusions about what was presented in the text, rather than simply recall the exact information verbatim.

Table 1. Comprehension accuracy (%) on paper, computer, and e-reader

	M	*SD*	*SE*
Paper			
Narrative	74.3	12.1	2.5
Expository	79.8	11.9	2.4
Computer			
Narrative	76.2	13.7	2.5
Expository	79.0	13.1	2.4
E-reader			
Narrative	73.2	14.5	2.5
Expository	74.9	14.0	2.4

Table 2. Reports of reading behaviors

Behavior	Media	Mean(%)	SE
Following text with a finger or mouse	Computer	43.3	9.2
	Kindle	40.0	9.2
	Paper	53.3	9.2
Highlighting text	Computer	10.0	3.7
	Kindle	3.3	3.7
	Paper	< .01	3.7
Reading and re-reading text	Computer	40.0	9.1
	Kindle	36.7	9.1
	Paper	53.3	9.1
Taking notes	Computer	<.01	1.9
	Kindle	<.01	1.9
	Paper	3.3	1.9
Skipping around	Computer	23.3	7.3
	Kindle	6.7	7.3
	Paper	33.3	7.3
Saying words silently	Computer	73.3	7.8
	Kindle	76.7	7.8
	Paper	80.0	7.8
Saying words aloud	Computer	10.0	3.7
	Kindle	3.3	3.7
	Paper	<.01	3.7
Moving lips while reading	Computer	26.7	8.6
	Kindle	30.0	8.6
	Paper	36.7	8.6