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Age of Technology: Are Age Differences Present In Comprehension of Non-Linear Hyperlink Text?

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by

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Abstract

The present research aimed to explore the effects of age and hyperlink text on reading comprehension, while assessing the role of working memory within the reading process; specifically any evident tax on working memory when considering the complex text. Expository passages were presented in three formats: hyperlink pages, PDF files, and printed versions in order to evaluate comprehension across reading platforms. Results indicated that successful and comparable comprehension may occur across the multiple platforms. Further, older adults showed to have significantly better comprehension than college-age participants, suggesting high levels of cognitive activity on behalf of the older adults. Working memory scores did not significantly differ when comparing older and younger adults. In addition, working memory was not shown to be impactful to the reading process within this study, potentially due to much practice and experience on behalf of the older adults. Implications of these findings as they pertain to website use and educational purposes are discussed.

Keywords: Hyperlink, comprehension, working memory, technology, computers, older adults

Age of Technology: Are Age Differences Present in Reading Comprehension of Non-linear Hyperlink Text?

The exponential growth of the internet in educational and workplace settings has prompted researchers to examine the comparability of digital and paper-based reading (e.g., Coiro, 2011; Coiro & Dobler, 2007; Davis & Neitzel, 2012; Foltz, 1996; Gil-Flores, Torres-Gordillo, & Perez, 2012; Leu, Kinzer, Coiro, & Cammack, 2004; Margolin, Driscoll, Toland, & Kegler, 2013; Zumbach & Mohraz, 2008). While much literature has uncovered differences when reading online and with hyperlink text, little has investigated reading comprehension and the role of working memory. Even fewer studies have been dedicated to the examination of hyperlink text as it relates to reading comprehension across the lifespan. In order to address this issue, it is necessary to first understand the differences in text linearity—distinguished by reading path. Hyperlink text utilizes a non-linear reading path consisting of "links" that interconnect with a network of both related and unrelated information. In contrast, printed text offers a linear reading path with information continuing from one page to the next. As suggested within recent research, the processes involved in linear text comprehension may only be a portion of the reading resources needed for comprehension of online and hyperlink text (e.g., Coiro, 2011). Additional components such as problem identification, locating information, evaluation or analysis of information, as well as synthesis of information may all act as elements that further complicate the reading process with regard to such text (Leu, Kinzer, Coiro, & Cammack, 2004.) Although not found within the stimuli of the current study, it is important to note as segue into the understanding of the complexities of online reading, that the potential for the introduction of extraneous or unrelated information found in hyperlink text may impede comprehension for a given online passage (Schmar-Dobler, 2003). Such extraneous information may alter information gleaned from the text when factors such as prior knowledge (Coiro, 2011) and a reader's established reading ability are also considered. While the use of hyperlink text is not particularly new, extensive research focused on its use in educational settings with school-age children (e.g., Coiro, 2011; Coiro & Dobler, 2007; Gil-Flores, Torres-Gordillo & Perez, 2012) is ill equipped to give much insight into reading development and comprehension as we age—particularly into our senior years. Although understanding this text format is salient to educators, the aging workplace population, as well as the growing use of technology in healthcare, has brought about the need to investigate comprehension of the hyperlinked text often found on websites older adults are accessing. In addition, it is necessary to examine how factors such age and changing working memory may be affecting what older readers glean when reading different reading platforms.

The Reading Process and Comprehension of Text

It is likely that a person will encounter situations in which they must read and comprehend text on a daily basis. From books to newspapers and especially online, reading and comprehension of what was read are essential to both educational and workplace success. Cognitively based views on reading comprehension (e.g., Kintsch, 1998) are seeded in the understanding of how a reader constructs a coherent mental-representation of situation described in a given text. The continuous and cyclical reading process proposed by Kintsch can be outlined by the Construction Integration (CI) Model. In this model, it is argued that there is no single representation of a text. Instead, there are three different levels of representations which a reader uses to successfully process information, and ultimately arrive at a broad representation of the text: a surface-level, a text-based level, and a level at which the information becomes integrated into a larger mental representation of the text—the situational model. Kintsch suggests the formation of a nodal network as individuals read, as well as a subconscious activation and integration of information during this process. According to Kinsch, the nodal network is comprised of both past knowledge that has been stored in long term memory, and information presented in the text. In order to form representations of the text, activation of the nodes spreads to knowledge that has already been acquired by the reader. At the surface level, while reading a sentence such as, "*Doug went to beach to find seashells for Tony,"* a reader, over the course of the reading cycle, activates what is read verbatim in their mental representation of the text. As the process continues, the meaning of the words being read is activated in the text-base level. At this level, the reader has now represented Doug and who he is, along with where he went (*the beach*), what he did (*find seashells),* and for whom he found the seashells (*Tony*). Finally, the situational model is formed, which includes inferences taken from the text that have been integrated with previous knowledge on a certain topic. The situational model for the previous sentence may include what type of beach Doug went to in order to find seashells. As the story progresses, additional information on Doug would be added to the representation that was already formed for his situation. Zwaan and Radvansky (1998) further explain that readers create a situational model of a given text however, they stress the multidimensionality of situational models, suggesting continuous updating across the five dimensions of time, space, causation, motivation, and protagonist. It is suggested that as a text is read, information being consumed that is consistent with a previous situational model will allow for quicker updating by the reader. In contrast, if the material is unrelated, updating cannot occur. In this instance, the reader would begin to create another situational model for new or altered information. The exploration and addition of these dimensions to the understanding of text comprehension has allowed for a deeper look into the reading process, acting as insight in explaining the immensely complex process of reading.

Teasing apart the reading process unveils a list of interconnecting elements that would not be complete without the inclusion of working memory. In fact, much research has found that working memory is an essential element in any part of the reading process (e.g., Margolin & Abrams, 2009; McVay and Kane, 2012; Waters & Caplan, 1996). As proposed by Just and Carpenter's (1992) Capacity theory of comprehension, working memory is vital for the reading process and comprehension as it relates to individual storage availability. This theory suggests that individual readers have different abilities, as well as different available space to utilize for storage of information when reading. When more working memory resources are needed to process and later retrieve the given information than what an individual has available to them, difficulties in comprehension may occur. Issues may also arise if the amount of resources necessary for a particularly difficult text exceed the resources the individual has available at that point in time. Known as *capacity constrained comprehension* (i.e., when task demands exceed available memory resources), readers with fewer working memory resources are at a disadvantage as it relates to successful integration of information, as they are unable to activate information from earlier in the text. Within the elderly population, as it pertains to available storage, it has been shown that working memory decreases as a function of age. Further, these differences in the processing of language as people age may be directly related to their working memory span (Waters & Caplan, 1996). Also examining working memory, Margolin and Abrams (2009) explored the effects of age on the comprehension of negation. Findings suggested that working memory was responsible for the most variance in comprehension in both negative and nonnegative sentences. Although negative sentences in this study did not specifically go beyond the limits of working memory, the results cement the role of working memory within the reading process as well as highlight its importance as it pertains text comprehension.

Comprehension of Hyperlink Text

When reading a book, one may simply leaf through the pages to find a part of the text they wish to read or re-read. If the book is set down or closed without marking a page, it is not difficult to turn to a page a number and begin reading once again. With the introduction of hyperlinks, an act as simple as turning a page or finding a specific paragraph has changed dramatically (e.g., Foltz, 1996; Zumbach & Mohraz, 2008). Now, with respect to hyperlink passages, returning to a page that a person was previously reading may involve a series of events that include typing, clicking, and possibly even searching. Leu, Kinzer, Coiro, & Cammack (2004) explain that in addition to the reading process, five components must be added when reading online: problem identification, locating information, evaluation or analysis of that information, synthesis of information, and communicating what was read. The ideas proposed by Leu et al. (2004) are consistent with research produced by Lankshear & Knobel (2003) in that reading is changing with the times. It is within these studies that the idea of "new literacies" has been explored and defined. Broadly conceived, the new literacies research states that technology has spurred the need to evolve the way reading is examined. Although contrived from how reading has taken place in the past, it is believed that differences in online reading and navigating of text are present. It is within this section that these differences are explored.

With significant overlap occurring, much of the research dedicated to exploring reading online falls into three categories: navigation differences amongst hyperlink text, changes in the reading process with respect to navigation differences, and the comparison of reading comprehension across print and hyperlink text. Early research put forth by Foltz (1996) acts as a proper segue into addressing the first of the aforementioned categories. Foltz suggests that the hyperlink text allows for the creation of a semantic network in which different related sections of a text are connected to one another. Within this network, text can be organized in such a way that clicking on one hyperlink item may lead to the opening of much more text. Additional opened text may also include hyperlinks that, when paired with the internet, may lead to an infinite number of connected nodes. Foltz suggests that the increased navigation load requires that rules for writing the most effective hyperlink text be created and followed. Amongst these rules is the inclusion of “maps” as well as a table of contents to assists in easing some of the effects that navigation may have on comprehension. However, it would be difficult to include maps and a hierarchical structure of links in a setting such as the internet, where each link could connect to a possible infinite number of other related or unrelated links. Dissimilar to the nodal structure proposed by Kintch (1998) within the CI model, the maps that characterize hyperlink text composition do not terminate as they do at the end of the *reading cycle.* Instead, while activation can spread to much related information, the possibility of numerous connections may continue to be made. In this way—such that navigation of hyperlink text is distinctly disparate from navigating printed text (Schmar-Dobler, 2003), it may be true that the reading process (and subsequently comprehension) for the text is altered as well. Further, research by Schmar-Dobler suggests the need for additional reading resources while reading hyperlink text. Similarly, Coiro and Dobler (2007) offer insight into the altered elements of the reading process when reading online. Through the use think-aloud protocols, this research examined the minds of participants as they read online. Participant responses suggested that successful online reading experiences required simultaneous utilization of elements that mirror those needed for linear text comprehension (e.g., sources of prior knowledge, inferential reading strategies, and self-regulated reading processes). However, results from this study also indicated more complex applications of such elements in certain reading situations. For example, accessing prior knowledge for the reading process in general includes knowledge on the given topic. When reading on the internet, the definition of prior knowledge is broadened to include prior knowledge of website structures, prior knowledge of web-based search engines, etc. Readers are now forced to figure out different features of the internet, as well as scan and skim the text to monitor and repair comprehension as they would with linear text. In this way, online reading comprehension may now involve processes that are unique to online text (e.g., Afflerbach & Cho, 2008; Coiro & Dobler, 2007). When readers begin the reading process in a hyperlink setting, the rules of reading change; there is no longer one text for that reader, but a series of links that must be subconsciously rated for value in content as it pertains to the reading goal. The potential for uncertainty arises due to the insurmountable number of choices that can be made by the reader who is working toward the ultimate goal of comprehension on a topic. Some of the links may relate to the topic, or they may trigger a completely different memory base that is not related to the task at hand. As working memory resources are limited, it could be true that unrelated information from hyperlinks may act as an unwanted guest within memory storage—taking up space without assisting in the completion of text comprehension.

Other research concerned with changes and differences in the reading process and their relation to information being gleaned, has found that reading online complicates comprehension of text by adding elements such as reasoning, cognitive flexibility, and the use of prior knowledge (e.g., Coiro, 2011). Although it may be true that these elements are already present within the reading process, it is argued that their role becomes much more essential when text navigation is considered. In order to evaluate differences in reading medias, Coiro specifically examined the extent to which additional reading comprehension proficiencies are needed when reading on the internet. Within this study, three independent variables were used: (1) offline reading comprehension (2) prior knowledge, and (3) online reading comprehension. Each student's level of offline reading comprehension was estimated using their 6th grade standardized reading score on the state's Reading Mastery Test. The second independent variable (prior knowledge) was measured using a six-item questionnaire, intended to measure a combination of task-specific and topic-specific knowledge required in the online reading task. Within this study, prior knowledge was operationally defined as the total number of accurate idea statements about the four topic-specific, and two task-specific concepts that were presented. In other words, the experiment investigated prior knowledge as it related to the specific topics they chose for the study, and not prior knowledge in a broader sense. The measure of online reading comprehension was divided into two parallel measures; one of which acted as an independent variable, and one of which was used as the dependent variable. The first measure (i.e., the third independent variable in the study) was the participant's performance on the Online Reading Comprehension Assessment-Scenario I (ORCA- Scenario I). The dependent variable was participant's performance on the ORCA II- Scenario II. Results of this study indicated that performance on one measure of online reading comprehension did in fact account for a significant amount of variance on a second measure of online reading comprehension—above the variance that can be accounted for by offline text comprehension and prior knowledge. Results also showed no significant effect on performance within the second task amongst the students with high levels of online reading comprehension. This research suggests that higher levels of online reading comprehension skills may help in compensating for lower levels of prior knowledge. As it pertains to the current study, results suggest less of a “dichotomy of old and new literacies” (p. 359) and more of a continuum of the practices that have been outlined within the reading process.

Also concerned with comprehension of hyperlink text, Zumbach and Mohraz (2008) examined the interaction of text format (hyperlink and linear) and text type (narrative and expository). Results of the study indicated that reading hyperlink text led to decreased knowledge acquisition (i.e., comprehension) of the information that was read, specifically in narrative passages. Expository passages (described as encyclopedia passages in this study), came from several articles within the area of bacteria, viruses and genes, and failed to yield the effect of hindered comprehension. These findings not only suggest that hyperlink text may be more challenging to comprehend, but that using a hyperlink format to present certain types of text (i.e., narrative) may not be beneficial to the reader, depending on the reading situation. In other words, formatting a story to be read with hyperlinks and with a nonlinear reading path, may hinder comprehension of a given text. In contrast, reading an informational piece of literature may become easier as the reader benefits from the organizational aspect that hyperlinks can offer. However, if the hyperlinks do not relate to the passage—as is seen in many online situations, it may be possible that learning outcomes could mirror those of narrative text in the same format.

Further tapping into the vein of research constructed around online reading, Sung, Wu, Chen, & Chang (2015) uncovered results similar to Coiro and Dobler (2007). The study was designed to utilize eye-tracking technology as well as a retrospective think-aloud technique to examine the online behavior of fifth-grade students. Results indicated that irrespective of reading ability, the students found it challenging to navigate while reading non-linear text. However, when the participants read with specific goals, they were able to adjust their reading speed and better focus their attention. Results of this study give support to the idea that reading hyperlink text requires resources above those utilized when processing linear text. In addition, it suggests that successful and informative online reading can be taught.

Although there is much research to suggest increased difficulty when reading or processing hyperlink text, some studies have yielded no differences between the two types of text (e.g., Davis & Neitzel, 2012; Foltz, 1996; Margolin, Driscoll, & Kegler, 2013). Recently, Davis & Neitzel examined sense-making behaviors of fifth and sixth graders as they read through and discussed expository texts. Interestingly, the results showed that participants approached the text as if it were devoid of hyperlinks, continuing the reading process as if the text were linear. Further, and largely consistent with much other reading research, both prior knowledge and prior reading accomplishments played a strong role in reading comprehension within this study. The findings suggest that the reading process may not be as disrupted or altered as suggested in other research. If readers are employing identical processes between linear and non-linear text, it may also be true that they are gleaning identical or near identical information. An earlier study investigating this conundrum conducted by Foltz (1996), hypothesized that when reading a textbook in hyperlink form, jumping from node to node may not present as coherent a chapter—as does linear text. It was thought that the complexity of the hyperlinks present, would in turn lead to decreased comprehension. The results of this study failed to yield a significant difference between the two types of text, suggesting that reading hyperlink text neither helps nor hinders reading comprehension. Studies such as this highlight the fact that research in this area of text comprehension is still inconsistent. The current work aims to investigate the inconsistency and to examine what differences may be found when considering age and comprehension across reading platforms.

Aging and Working Memory

Increased age is often accompanied by mild to moderate changes in an individual's working memory; including fewer and more inefficient memory resources (e.g., Bopp & Verhaeghan, 2005; Craik & Byrd, 1982; Schroeder, 2004; Waters & Caplan, 2011). Given that working memory is essential for creating a memory representation of the text, it becomes imperative to examine natural changes in cognition and how it may affect the reading process.

To aid in the understanding of cognitively based changes in memory as individuals age, the Processing Resource Theory (Craik & Byrd, 1982) puts forth a framework that highlights the importance of storage availability as it related to ageing. Within this theory, it is suggested that individuals already have a limited amount of available storage, and that age-related memory decline may be attributed to the decrease in available processing resources needed for encoding and retrieval of information from memory. It is suggested that much like physical energy declines with age, as does mental energy. Within the reading process, mental energy is the energy needed in order to process what is being read. Craik & Byrd argued that older adults largely retain the ability to encode and retrieve information effectively, however they fail to carry out these tasks without being constrained and guided by task instruction. When postulating the *why* within the question, "why are memory changes often seen as we age?" Craik & Byrd suggest the potential answer to be failure of metamemory (i.e. the ability of individuals to examine the content of their memories and make judgements about them); although not supported by any early research. A more attractive and plausible candidate to answer this question stems from older adults less recent practice in remembering (ie., less recent experience with academic recall). For example, when dealing with academic readings or other materials presented in verbal learning studies, it would make sense that older adults with less recent use of study or reading tools geared toward comprehension (skimming, scanning, etc.) may have overall poorer comprehension than their college counterparts.

Focusing on the contents of working memory as opposed to the capacity (i.e., CI model), Hasher and Zacks (1988) propose the Inhibition deficit (ID) Theory to explain why changes or deficits within working memory may occur. Within this framework, it is suggested that working memory is negatively impacted by trouble with inhibitory mechanisms. When functioning normally, inhibitory mechanisms serve to eliminate spurious information that is not necessary to create an accurate representation of the text that is needed for comprehension. Because these mechanisms are not perfect, peripheral information will occasionally enter into working memory. Such information may include personally relevant thoughts and daydreams. Hasher and Zacks suggest that if older adults are making more connections to the readings that are closely related to their own personal beliefs, then additional information will enter into working memory and create issues for them when they attempt to process what they have read. This theory also suggests that these processing complications may be attributed to a decreased level of working memory as individuals’ age.

Another theory that may aid in the understanding of age-related working memory changes pertains less to the contents or capacity, and more to the speed at which the information was processed and stored. The Processing Speed Theory (Salthouse, 1996) suggests both the faulty or insufficient encoding of information, based on a slowing down of computational processes as individuals' age (i.e., the "limited time mechanism"), as well as the degradation of cognitive performance, resulting from the unavailability of earlier stored information when later processing is complete (i.e., "simultaneity"). Salthouse gives support for his theory by showing that statistically controlling for speed, lessens the magnitude to which age-related changes in working memory are evident. Further, as it pertains to both working memory tasks within the current study, this theory would predict tasks that require reordering, as outlined by the idea and existence of "simultaneity," would yield stronger evidence for changes in the working memory of older adults.

Although not often explored in earlier research, Norman, Kemper, and Kynette (1992) proposed that working memory does decline with age, and that such declines may impact comprehension as they become exacerbated by syntactic complexity. Comprised of two experiments, the first is most salient to the current study as it dissects the relationship between working memory and reading comprehension. Within the experiment, college-age students and older adults (60-92) were given multiple working memory tests, a timed reading comprehension exam, as well as a reading test exploring the impact of syntactic complexity on comprehension scores. Results from the experiment showed declines in both working memory and comprehension for older adults—highlighting the clear limitations of working memory, as well as acting as further support in communicating the true complexities and intricacies of the reading process as they relate to age and memory. Schroeder (2004) also examined such elements as working memory and age on storage and the processing of information while reading. Within this study, two of each of the common measures of working memory (both simple and complex span tasks) were completed by each participant. Results indicated that declines in processing and storage abilities contributed to age differences in the span task performance—such that younger adults performed better on both memory span tasks. Additionally, younger participants recalled a higher percentage of the words in each span task. As well as exhibiting reliability for memory span tasks, this research supports the theories outlining working memory capacity, and their relation to increased or decreased comprehension of text based on available space.

Lastly, Bopp and Verhaeghan (2005) offer evidence that working memory changes with age through a meta-analysis, which included data from one hundred and twenty three studies. Utilizing a Brinley Analysis, researchers plotted the performance of older adults on memory-span tasks (e.g., forward and backward digit span tasks) as a function of performance of younger adults. Results were consistent with previous research in finding age differences in all aspects of the memory span. In addition, this analysis found that working memory was more impacted by age than short-term memory span. Discrepancies in age-related differences between working memory and short-term memory span were attributed to the function of each (i.e., short term memory involves storage of information while working memory involves storage and processing). Although this analysis did find a handful of studies to have a positive age effect (i.e., older adults out-performed younger adults on memory span tasks), the data in favor of changes in memory as individuals' age is still very strong.

Elderly Population Online

In recent years, the United States has seen an increase in the number of older adults that are not only living longer, but remaining in the workplace longer out of financial necessity and desire to stay productive (Lee, Czaja, & Sharit, 2009). According to the Bureau of Labor Statistics, the employment rate of workers 65 and over increased 101 percent from 1977 to 2007 (U.S. Bureau of Labor Statistics, 2008). The increase in longevity of careers of adults over 65 brings to life questions specifically concerned with how older adults may be fitting into a technologically saturated workplace. In addition, it must be noted that the use of technology to improve the quality of life of older adults, as well as for rehabilitation and general health purposes, has become a large area of study for both software developers and psychologist alike (Marston et al., 2016); making the need to determine if and where older adults may falter with technology even more salient.

As younger generations have grown with and continue to act as large consumers of technology, older adults are often portrayed as being incapable of keeping up. This image of older adults as being less technologically savvy than their younger counterparts may in-turn lead to their increased isolation from societies in which technology is constantly and rapidly changing (Jung & Sundar, 2016). If older adults are isolating themselves from the world of technology, it would make sense that they would be less able to use the technology in ways that are beneficial to them if given a task. For example, it has been found that older adults have a harder time recovering from online navigation errors leading to frustration, and in turn avoidance, of online usage (Hardt & Hollis-Sawyer, 2007). While frustration when using the internet and frustration with computer use in general are different topics, they both may play a role in how successful older adults may be at any given online task. Increased navigation errors, as well as increased frustration, may not stem from older adults inability to learn about technology, but may suggest that they learn differently than younger adults with regard to computer and online usage. In contrast, frustration with and subsequent avoidance of technology may not result from learning differences or lack of capability, but may be the product of negative attitudes stemming from fear or anxiety (Heinz, 2013).

Regardless of the many factors that may be impeding consumption, usage, and understanding of technology, the current research aims to address the issue lies just beneath all of the aforementioned issues—is reading comprehension of online text comparable across the lifespan? As technology continues to dominate workplace procedures, training protocol, and is extensively utilized in the improvement of healthcare and rehabilitation serviced for older adults, research such as this is essential in understanding how different aged employees are reading and comprehending information across various text platforms. The current study may serve to bridge the technological age gap, and aid in better development of various programs that include hyperlink text.

Hypotheses

The current study aims to investigate the differences in comprehension accuracy based on the factors of age and reading platform. After careful review of the literature, three hypotheses are proposed. First, considering that reading is taxing to working memory and that additional processes may need to be evaluated when reading online, it is hypothesized that hyperlink text will be more difficult for both older and younger participants to comprehend than printed text. Second, comprehension accuracy of older adults will be negatively impacted when reading hyperlink text over and above the difficulties seen in younger adult participants. The second hypothesis is based on the findings that working memory changes as individuals' age, and additional working memory resources may be required for navigation and comprehension of text. Lastly, it is proposed that, consistent with previous research, working memory will be a determinant in performance on comprehension questions such that lower working memory spans will be associated with less comprehension of text in all formats.

Methods

Participants

One hundred and eight individuals participated in the current study. Sixty six of these participants were college-age students (50 females) ranging in age from 18-34 (*M*= 19.72, *SD*= 2.46) and they were recruited from introduction to psychology classes at The College at Brockport. The other forty two participants were older adults (34 females), ranging in age from 65-85 (*M*= 74.23, *SD*= 5.24). Older adult participants were community-dwelling adults recruited from local Libraries, senior centers, and "Lifetime Learning Lectures" at the College at Brockport. All participants had not been previously diagnosed with any reading or learning disabilities, had normal or corrected to normal vision, and were fluent speakers of American English as determined by participant self-report at the time of recruitment.

Design

The current research utilized a 2 x 3 mixed factorial design, with age (young adults and older adults), and reading platform (hyperlinked, PDF, and paper) as factors. Age was a betweensubjects factor while reading platform was a within-subject factor. The dependent variable was accuracy percentage on comprehension questions. Working memory was also assessed in this study and the measure acted as a covariate.

Materials

Reading materials for the current study included six expository passages taken from *National Geographic's Magazine,* and ranged from 706-1045 words in length (*M* = 889.67, *SD* = 113.46). This online source was selected based on its existing use of hyperlink text in passages that have a primary goal of conveying facts and information. With respect to word content, all passages were presented exactly as they are on the National Geographic's website and were only edited to be presented in hyperlink, PDF, and printed versions. For editing purposes on the hyperlink versions, all advertisements, original hyperlinks, and additional tabs at the bottom of the webpages were removed in order to obtain higher internal validity. However, the background and webpage title remained identical to the original—aside from the insertion of the file the webpages were saved in within the web address name. The title and complete passage were the only text or object that appeared on the hyperlink versions of each text. In addition, the text and the title of the passage were all that was taken from the webpages; no advertisements or additional webpage material found in the original versions appeared in the printed or PDF versions of the text.

Using the Firefox "inspect" element under the "developer" option, hyperlinks were created by the investigator for each text. Number of hyperlinks per passage ranged from 4-5 (*M* = 4.33, *SD* = .52). All webpage content was saved to a desktop as a separate file and edited from this file. The editing process included the deletion of all original hyperlinks as well as all images and advertisements. In creating the hyperlinks, it was necessary to choose a trigger word that when clicked, would take the reader to a hyperlink destination. The trigger words chosen for each hyperlink destination were either the last word of the passage, or found in the last sentence of each given paragraph. In order to maintain consistency of text being read across platforms, as well as manipulate the reading path, the hyperlink destination content was created to include the paragraph that preceded the paragraph housing the randomly chosen word within the original version of the text. By doing such, each text contained identical content across reading platforms. See Appendix A for example of entire passage with hyperlinks and destinations. Hyperlinks are characterized by underlined text and hyperlink destinations are found in bold text.

In addition to text comparability as it relates to hyperlinks, all chosen passages were comparable to one another on such factors as length and reading difficulty; as measured by Flesch-Kincaid Reading Level (Flesch, 1951). Passage difficulty ranged from grade 10.1-12.2 (M =11.08, SD = .73).

Presentation of the passages was counterbalanced such that the presentation of each passage in all three formats rotated for every participant. For example, participant one began the experiment reading passages 1 and 2 in hyperlink format, passages 3 and four in printed format, and passages 5 and 6 in PDF format. The next participant read passages 1 and 2 in printed format, passages 3 and 4 in PDF format, and passages 5 and 6 in hyperlink format. This rotation continued for all 108 participants. Reading platform was also counterbalanced in that every three participants began reading on each of the three reading platforms. For example, the first participant read printed text first, hyperlink text second, and PDF versions of the passages last.

The next participant began reading hyperlink text, followed by PDF passages, and finally printed text. This counterbalancing method also continued for all 108 participants.

Participants read printed versions of the text from single spaced documents that were printed on standard 8.5 X 11 in. white paper with black 12-point Times New Roman font. PDF versions of the passages were presented to participants as files on Adobe Acrobat reader 11, version 11.0.10 on a DELL laptop computer equipped with an Intel Core i5 processor and a 14-in. screen. Hyperlink passages were presented on the same computers as the PDF files, and were open in their own window to appear as if they were available on an open internet setting. Considering that the hyperlink passages were saved and accessed from a desktop, no internet was needed to open the webpages. Participants had access to the mouse pad as well as the directional arrows on the keyboard to navigate both the webpage and PDF version of the passages. Navigation instructions as well as specific reading instructions for the hyperlink passages were given verbally and in printed format to each participant upon arrival at each reading platform. See Appendix B for navigation instructions.

Each passage was immediately followed by a set of researcher-developed multiple choice comprehension questions that corresponded to the given text. Fifty four multiple choice questions were created in order to assess reading comprehension. The number of comprehension questions for each passage ranged from 8-10 (M = 9, SD = 1). Questions were not developed to assess verbatim recall, but were structured as to require the reader to use thoughtfulness and reasoning when answering. Questions based on hyperlink destination content were created based on randomly chosen paragraphs within each passage. See Appendix C for sample comprehension questions. Participants used a corresponding answer sheet with the title of each passage above the blank answer space to mark down their answer to each question.

Both younger and adults were also tested on working memory capacity using the backward digit span test and the operation span task (Turner & Engle, 1989). For the backward digit span test, participants are given instructions to listen to set of numbers, and are then prompted to repeat the series back to the experimenter in backward order. For example, if the experimenter says, “1-2-3” the participants must respond with “3-2-1” to move on to the next set of numbers. Each successful attempt at repeating a number series increases the amount of numbers a participant must remember in the next set of numbers. For example, a participant that correctly repeats back a series of four numbers is then read a set of five numbers that they must repeat in backward order. If the participant repeats the numbers back incorrectly, they are given another trial with the same number of digits, but with a different set of numbers. When a participant gets both trials wrong, their backward digit span becomes the number of the last set they got at least one trial correct.

The Operation Span task presents participants with a simple math equation to verify (e.g., Is (9/3)-2=3?), followed by a word to remember. The two types of materials are presented multiple times (i.e., math equation, then a word, then a math equation, then a word, etc.) until the participant is prompted to recall the given words for the entire set aloud. Stimuli for this task was identical to that used in Turner & Engle (1989), and included twelve sets ranging from three to five words (three sets for each size). The process of verifying an equation, the presentation of a word, and the recalling aloud of the words by the participant continues until all twelve sets have been completed. To score The Operation Span task, proportions from each set are calculated and averaged together to determine a final score for the participant. For example, if a participant recalls a set of three words, they are given a 1 for that set (3/3), if the participant remembers three of the four words, they are given a .75, etc. An example calculation of all of the proportions is as follows: (1+.5+1+1+1+1+.75+.5+.75+.8+.8+.8)/12= .83. While there are other methods to score this task, this method was chosen for its straightforwardness in measuring the number of items participants could recall (see Conway et al. 2005) for a summary of scoring techniques).

Participants were also given a demographic questionnaire to collect such information as native language spoken, reading or learning disabilities, age, gender, time spent reading, and internet usage and habits. A copy of the questionnaire can be found in the Appendix D.

Procedure

All college-age participants were tested in the Cognitive Aging Laboratory on campus at the University at Brockport. Older adult participants were tested in the location that was most convenient for them in one of the three locations: The Cognitive Aging Laboratory, local senior centers, or public Libraries. In each of these settings, the experimental task was completed as follows. First, participants were asked to give their approval to participate in the study by reading and signing a statement of informed consent. Each participant was given a set of instructions detailing that they would be reading six different passages on three separate reading platforms. Participants were instructed to read one passage and then answer the questions that followed on their answer sheet before they began reading the next passage. Participants were made aware that they may take as much time as they needed to read through the passages, and that they should not read for memorization or speed, but read as they normally would at their own pace. In addition, participants were not allowed to refer back to the text when answering the comprehension questions. A set of instructions can be found in Appendix E. After reading the instructions, participants were given an opportunity to ask any questions they may have had on the experimental task.

Two passages were read on each reading platform. As stated previously, presentation of the text was counterbalanced in that every third participant began the experiment reading either hyperlinked, pdf, or paper format of the text first. The order in which the passages were presented was rotated in a manner that allowed for proper counterbalancing.

When participants finished reading and answering questions, they were given the two measures of working memory: the backward digit span test and the operation span task. They also completed a demographics questionnaire, as described previously. Upon completion of the three measures, participants were debriefed and thanked for their participation in the study. Each session lasted 1 to 1 ½ hours, depending on how quickly participants read.

Results

Analyses were conducted using IBM SPSS 23 statistical software. A 2 (age) x 3 (text format) mixed factorial analysis of variance (ANOVA) was conducted to determine the impact of these factors on reading comprehension. Means and standard errors are presented in Table 1. Results indicated that no significant main effect of text format existed F (2, 208) = .56, MSE = .008, p = .57. However, a main effect of age was demonstrated F (1,104) = 20.12, MSE = 1.02, p < .01 such that older adults had higher overall comprehension for the given texts than younger adults. No interaction between age and text format was discovered F (2, 208) = .56, MSE = .01, p = .345

An independent samples t-test was conducted to compare working memory scores in older and younger adults. There was no significant difference in scores for the backward digit span for older adults (*M* = 4.7, *SD = 1.1)* and younger adults (*M* = 4.5, *SD* = *.91)* conditions; *t*(104) = -.77, *p* = .44. An additional independent samples t-test was conducted to examine the comparability of working memory scores between older and younger adults on the operation span task. There was no significant difference in scores for older adults (*M* = .78, *SD* = .17) and younger adults (*M* = .82, *SD* = .13) conditions; *t*(104) = 1.48, *p* = .14.

To determine the influence of working memory on comprehension accuracy and its relation to the aforementioned variables, an analysis of covariance (ANVOCA) was conducted with text format, and age as independent variables, similar to the ANOVA presented above. The backward digit span and the operation span task were both utilized as covariates within this statistical test. Using the operation span as a covariate, the ANCOVA analysis revealed that there were no significant differences based on format type, *F* (2, 206) = .42, *MSE* = .00, *p* = .66, or age *F* (2, 206) = 1.24, *MSE* = .01, *p* = .29, nor were any significant interactions demonstrated, *ps* >.10. Using the backward digit span task as a covariate, the ANCOVA analysis revealed that were also no significant differences based on format type, *F* (2, 206) = 1.29, *MSE* = .01, *p* = .27 or age *F* (2, 206) = 1.19, *MSE* = .01, *p* = .30, nor were any significant interactions demonstrated, *ps* >.10. The removal of working memory within both ANCOVA statistical tests showed little impact on the comprehension scores. Such findings show that working memory did not account for a significant amount of variance in the study, suggesting its limited impact on the comprehension levels for the older or younger adults.

Discussion

The present research aimed to explore the effects of age and hyperlinked text on reading comprehension. In addition, it explored the role of working memory within the reading process—specifically, any tax that may have been evident on working memory when considering hyperlink text. Much of the previous literature devoted to the exploration of text comparability across reading platforms has not included a measure of working memory. In addition, such research has focused on school-age children, and is unable give much insight into comprehension across reading platforms as individuals' age.

Early research concerned with hyperlinked text was geared toward the explanation of the navigation of a new reading platform (e.g., Foltz, 1996). This research laid out the idea that hyperlinked text was a unique reading platform that should be treated as such. It was postulated that memory for text would be hindered, as navigation would put a heavy tax on working memory. However, in the case of this study, results failed to uncover any differences in comprehension of hyperlinked text when compared to text presented on paper. Unlike Foltz, many researches examining the habits of readers online found numerous differences within the reading process, and with comprehension (e.g., Coiro, 2011; Coiro & Dobler, 2007; Wu, Chen, & Chang, 2015; Zumbach and Mohraz, 2008). Such studies examined the additional reading resources needed as well as effects of navigation on comprehension. The inconsistencies, as they pertain to understanding comprehension across reading platforms, are what fueled the present study.

While much previous research has unveiled a bevy of complications with comprehension of hyperlinked text, the present research failed to support such findings. Instead, results of the current study were in line with research supporting effective reading across many reading platforms (e.g., Davis & Neitzel, 2012; Foltz, 1996; Margolin, Driscoll, & Kegler, 2013). According to the data above, successful and comparable reading comprehension can occur within each reading platform. While it may be true that individuals are employing a process that is unique to non-linear text (as purported by many current studies), it seems as though comprehension of text is mirrored across reading platforms. As readers were instructed to click each individual link as they came upon it within the passage, it is unlikely that individuals continued the reading process as if the text were devoid of hyperlinks (i.e., Davis & Neitzel, 2012). However, since readers were not made aware that the hyperlink destinations were merely a continuation of the original text, they may have utilized similar reading resources—connecting only the important content to their situational model for each text. It can be argued then, that navigation of hyperlinked text is only an element of online reading that scratches the surface of technical differences between the reading platforms, and has little to do with altering the comprehension process.

Methodological differences that may account for some discrepancies in findings, when comparing the current study to those suggesting hyperlink text to be markedly different than printed text, stem from the operational definition of *online text.* Studies such as those conducted by Coiro (2011) or Coiro & Dobler (2007) operationally define *online text* in a different way than presented in the current study. For example, they suggest online text to include information presented via one or more elements such as hyperlinks, images, animation, audio, and/or video, that are within an online networked system which is unbounded as a result of its continual expansion. Further, within the study conducted by Coiro (2011), participants had to locate information within an “internet treasure hunt” (p. 362). This process involved the location, critical evaluation, synthesis, and communication of the online information. It could be said that the complexity of the tasks given in other research examining online text, exceeded the reading comprehension tasks presented to participants in the current study.

Although not in line with original hypothesis, it is an astounding finding that older adults out-performed college-age students on comprehension across all reading platforms. Such findings are consistent with Margolin (2018) in the heightened comprehension ability of “cognitively active older adults,” as well as Carretti, Borella, Zavagnin & Beni, (2013) in the successful use of working memory training programs through elements such as updating and reasoning. Carretti et al., was able to show that older adults (65 and over) given working memory training (e.g., practicing verbal working memory tasks), performed better than controls on a criterion task—maintaining this heightened performance six months post-training. While not discovered through the use of actual training procedures, a negation comprehension study (Margolin, 2018) showed that older adults actively participating in Library activities and book discussion groups, exhibited overall better comprehension than their younger counterparts. The findings suggest that cognitive exercise and remaining active in this respect may help adults to both maintain what they glean from a given text, as well as improve their ability to rate their comprehension of the text.

Similar findings, with regard to being cognitively active, were put forth by Myhre, Mehl & Glisky (2017). Such research explored the use of Facebook.com, showing significant increases in the executive function of updating—a factor that is associated with intricate working memory tasks, in older adults who consistently used the social network site. Researches within this study concluded that the findings may be a reflection of the heightened cognitive demands associated with online networking (i.e., navigation challenges). Based on the findings of the current study, it is likely that their results strongly connect to the aspect of cognitive activity as individuals' age.

Also interesting, and quite divergent from much other research examining memory span, the comparison of working memory scores from older and younger adults yielded no significant differences. In addition, it was shown that working memory was not a large factor within the comprehension element of the current study. While it may have accounted for some variance, its removal was non impactful as it relates to level of comprehension. These findings are largely out of line with research supporting working memory changes as individuals' age (Bopp & Verhaeghan, 2005; Craik & Byrd, 1982; Schroeder, 2004; Waters & Caplan, 2011). In addition, it is not consistent with much research that stresses the importance of working memory within the reading process (Margolin &Abrams, 2009; McVay and Kane, 2012). It is possible that such inconsistencies arose as a result of experience, where older adults compensated for age related changes in working memory by remaining cognitively active.

Reviewing the methodological differences, as they pertain to the working memory aspect of the current research, it may be best to examine them by stripping away all other elements of the study. That is, simply comparing the working memory scores of the older and younger participants to see how they relate to the findings of other studies. For example, Bopp & Verhaeghen (2005) found sixteen studies of the one hundred and twenty three they examined to have a positive age effect, where older adults exhibited higher working memory scores than the younger adults. Since the investigation of Bopp & Verhaeghen failed to examine forward and backward digit span methodology between studies used in their analysis, differences were strongly attributed to either sampling or the cohort effect. It is likely that the current study differs from a larger body of research in the sample used when comparing elements such as level of education and hours spent reading and writing.

Within the ID framework laid out by Hasher & Zacks (1988), it is suggested that the degree of age-related decline on certain tasks is dependent on the resources the individual has available to them, as well as the demands presented by subcomponents of the given task. Further, Hasher and Zacks propose that when the demands are minimal, as should be the age-deficits. Additionally, within the review of this framework, it is suggested that comprehension and memory for text are impaired for older adults when a message is presented rapidly rather that slowly. Therefore, it could be argued again that (1) the material and/or navigation load were not substantial enough to create deficits in any participant, let alone the older adults (2) a lack of time constraint may have contributed to education becoming the most important element when considering performance on the comprehension questions.

Without the heightened level of cognitive activity that appears to be behind the current findings, both cognitive decline and working memory may play a large role in comprehension of online text. However, the current study failed to find this processing difficulty and is limited in the sample that was chosen. Recruitment of participants from Libraries and “Lifetime Learning Lectures” may be to blame for this limitation and lack of comparison ability to a larger and much different population. In addition, the current study may have benefited from the inclusion of extraneous information within the hyperlink passages. For example, it may have increased navigation load to have individuals search through multiple pages and hyperlinks before answering questions about a given topic. Similarly, it may have also been beneficial for the study to take place on an open internet setting, where navigation errors may have been more likely. Perhaps the task of clicking through a non-linear text comprised of linear content was not difficult enough to put strain on working memory or hinder comprehension of text. Lastly, the current study is limited in motivation of college-age students to complete the task. The comprehension score was not tied to a letter grade for the students and likely impacted their willingness and eagerness to complete the questions to the best of their ability. In contrast, it is possible that older adults felt the need to perform well on task after understanding what was being investigated.

Despite its limitations, the present research is saturated with implications as they relate to older adults consumption of online text and information. If older adults present no deficits with the understanding of hyperlink text, the creation of websites does not need to be tailored to a specific consumer. In addition, it may be comforting to educators that the assumption of text comparability across reading platforms may not be an assumption at all, but a reality. Although geared toward the understanding and bridging of a technological age gap, the current study showed that older adults are bridging this gap with the power of their minds.

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Appendix A

Expository Passage

*Hyperlinks are characterized by the underlined text. Text present within the hyperlink destination is bolded.
Note: Participants were instructed not to click the URL link at the beginning of the hyperlink passages and the PDF versions of each text.

Are We Loving Yellowstone to Death?

By: Todd Wilkinson

Published in National Geographic Magazine May, 2016

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Just a few miles south of Bozeman, Montana, in the rolling foothills of the Gallatin Range, spacious dream homes pepper the landscape. Forty years ago, wapiti, the Shawnee name for elk, poured out of the mountains in December and spent winters grazing in farmers' alfalfa fields.

Today an ever expanding human footprint weighs on these hills, as it does on many corners of the Greater Yellowstone Ecosystem where public and private lands intersect. The Greater Yellowstone's 22.6 million acres include both Yellowstone and Grand Teton National Parks, plus national forests, wildlife refuges, and surrounding chunks of 21st-century America: highways, towns, parking lots, malls, and suburbs.

Dennis Glick, founder of conservation group Future West, assesses the scene.

Future West works to realize a future where communities have a shared sense of place, robust economies, and sound stewardship of natural, cultural, and community assets. For the second half of the 20th century, he, like many U.S. conservationists, believed that if anything would destroy the integrity of Yellowstone and neighboring lands, it would be the noose of natural resource extraction tightening around the national park's borders.

Hard-rock mining, conservationists believed, would foul the rivers. Oil and natural gas wells would fragment wildlife habitat; industrial-strength logging would lay waste to national forests; and livestock grazing on public lands would cause conflicts with grizzly bears, wolves, and other predators.

But Greater Yellowstone survived the era of natural resource extraction that swept across the West for a century. Ask Glick now to identify the most ominous threats facing the ecosystem, and he doesn't hesitate. "Number one would be the effects of climate change: droughts, big wildfires, and diseases that were never here before."

But close on the heels of climate change is people.

"It isn't that we are behaving callously," he says. "Humankind may very well be loving this place to death."

Visitors from around the world are swarming to the region in record numbers. Last year both Yellowstone and Grand Teton set visitation records, and they are expected to shatter those marks again in 2016. Meanwhile waves of others summoned by an instinct to live closer to nature—"lifestyle pilgrims," as Glick calls them—are leaving cities and relocating to Greater Yellowstone.

"Greater Yellowstone management is on the map for doing things right," Glick says, "protecting big pieces of public land so it now supports every major mammal species that was here before Columbus arrived on the continent." But how people develop a few million acres of private land has huge implications for the ecological integrity of public land and the wildlife that depends on it. As long as adjacent private lands remain open and undeveloped, species can survive. For example, nine major elk herds pass through Greater Yellowstone on epic migrations. Although they spend a majority of their time on public land, they also spend crucial winter months on private ranches.

Back in the day, Glick says, most population growth in this region occurred in existing communities or, if in rural areas, remained tucked into draws out of the wind or above the floodplain. "Nowadays," he says, "rural sprawl has been the dominant development pattern, and it has ripple effects for public lands."

Andy Hansen, a conservation biologist and professor at Montana State University, points out—in a study due to be published this summer—that the number of private land tracts with no homes or few homes is declining. And the number of parcels with one home per 40 acres increased 328 percent from 1970 to 2010, he says.

By 2013, 30 percent of Greater Yellowstone was considered “developed,” and some wildlife migration pathways were believed to be imperiled. By 2020, between 5 and 40 percent of the ecosystem’s most biologically rich habitats will undergo conversion from ranch and farmland to exurban development.

Today Yellowstone and Grand Teton, plus Glacier National Park, located along the U.S. border with Canada, are the only national parks in the lower 48 states that support populations of three major North American predators: grizzlies, wolves, and mountain lions. In Yellowstone and Grand Teton high predator population success is due to the parks’ good neighbors: surrounding private lands that support habitat for the prey species—elk, deer, and pronghorn—that the predators eat.

But over time the severing of corridors will likely contribute to a decline in migratory elk, mule deer, and pronghorn populations inside the national parks.

People are also pushing deeper into grizzly habitat, causing conflicts that typically result in bears being removed or killed. And climate change, a looming wild card, is expected to reduce the carrying capacity of public lands, making private lands on the periphery of Greater Yellowstone all the more important.

In recent decades local land trusts have protected important parcels of private land through conservation easements. But the process isn’t keeping up with the rate at which land is being steadily fragmented.

Foresighted federal environmental laws preserved Yellowstone and the national forests. But protecting private lands requires a different kind of thinking. And at a time when anti-regulation sentiments serve as an obstacle to community planning in the West, the coming decades will be critical.

In the long term what will save Greater Yellowstone from experiencing the same fate as most other regions in the lower 48? "I'll say it in one word: 'restraint,'" Glick says. "In 1872 the creation of Yellowstone National Park was an exhibition of restraint against the prevailing forces of Manifest Destiny, and we are reaping huge benefits. What's going to save Greater Yellowstone comes down to the same ethic. But I'm sorry to say I'm not seeing much of that these days. If we are going to act, the time is now."

Appendix B

Hyperlink Navigation Instructions

For this portion of the experiment, you will be reading a passage that includes hyperlink text. For the given passages, all hyperlinks are characterized by words underlined in yellow (e.g. word). It is required that you click on each hyperlink and read the first paragraph that appears after you have reached the hyperlink destination. Be sure to click on every hyperlink that appears in both passages that you will read.

After you have read the first paragraph, move your mouse to the “back” button located in the upper left hand corner of your screen, and click to navigate back to the original passage.

If you have any questions, please ask your experimenter now, otherwise you may begin reading.

Appendix C

Sample Comprehension Question

Dennis Glick suggests that the nature of those who are responsible for the changes seen in Yellowstone National Park are:

A. Malicious

B. Loving

C. Cruel

D. None of the Above

Appendix D

Demographics Questionnaire

Questionnaire Participant ID #

____

Date of Participation:_____________

Date of Birth: ____/_____/_________

Gender: _____ Male _____ Female

Which hand is your dominate hand? ______ Left _______ Right ______Ambidextrous

Number of Education Years Completed (e.g., through high school is 12 years): _________

Is English your native language? _____ Yes _____ No

If you answered NO, what is your native language? _________________________

What is your ethnicity? (optional)

____ Caucasian/White

____ Asian or Pacific Islander

____ African American

____ Native American

____ Hispanic or Latino

____ Other, please list __________________________

Compared to others your age, how would you rate your health? (Check One)

___ 1- Not Healthy

___ 2- Somewhat Healthy

___ 3- Healthy

___ 4- Healthier than average

___ 5- Very Healthy

Do you currently have any hearing problems? _____ Yes _____ No

If yes, please list hearing problems ____

Do you currently wear glasses or contacts? _____ Yes ______ No

If yes, what are they used for? _____ Reading ______ Distance ______ Both (bifocals)

Have you ever suffered any type of brain injury or stroke? ____ Yes ____ No

On average, how many hours a day do you spend: (Circle one)

writing?	0	1	2	3	4	5	6	7	8 +
watching television?	0	1	2	3	4	5	6	7	8 +
reading?	0	1	2	3	4	5	6	7	8 +
surfing the internet?	0	1	2	3	4	5	6	7	8 +
reading on the computer?	0	1	2	3	4	5	6	7	8+
reading on e-reader devices (e.g. Kindle Fire)?	0	1	2	3	4	5	6	7	8+

On other activities involving

reading and/or writing?

(please list)

________________________ 0 1 2 3 4 5 6 7 8 +

________________________ 0 1 2 3 4 5 6 7 8 +

Do you own a computer? (circle one)

Yes No

How many years have you been using computers? __________

How often do you access the internet?

A. Once every few months
B. Once a month
C. Once a week
D. Several times a week
E. Every day
F. Several times a day

How often do you use your computer for purposes other than accessing the internet?

A. Once every few months
B. Once a month

C. Once a week

D. Several times a week

E. Every day

F. Several times a day

Where do you must often use the internet?

A. Work

B. Home

C. Library

D. Relatives

E. Other_(please specify)______________________

What types of websites do you frequent? (Check all that apply)

A. Social Networking Sites (e.g. Facebook)

B. Healthcare

C. News

D. Sports

E. Gaming

F. Retail Sales (e.g. Amazon)

G. Weather

H. Other (please specify)___________________________

Have you ever been asked to complete training for work purposes on a computer?

A. Yes

B. No

How comfortable do you feel with using computers?

A. Not very comfortable

B. Somewhat comfortable

C. Comfortable

D. Very comfortable

How comfortable do you feel with surfing the internet?

A. Not very comfortable

B. Somewhat comfortable

C. Comfortable

D. Very Comfortable

Appendix E

Instructions

In this study, you will read a total of six different passages. Two of these passages will be presented you on paper, two of them in .pdf files, and two that will include hyperlinks. You will not be timed in your reading, so take as long as you need to finish each passage. Do not try to memorize the passages, simply read as you normally would.

After completing each passage, please answer the questions presented to you. Fill in your answer sheet with the answer choice that best answers the questions or best completes the statement, making sure that your writing is neat and clear. You will not be allowed to look back to the passage to help answer the questions, just try to use what you remember from your reading to answer the questions.

When you have finished answering all the questions for a particular passage, move on to the next passage. After completing the passages in the one reading platform, you will move on to the passages presented in the next format.

After completing all the passages, your experimenter will give you information about the next step.

If you have questions, please ask your experimenter now, otherwise you may begin reading.

Table 1. Means and Standard Deviations for Comprehension Accuracy (%)

Presentation Type	Age Group	*M*	*SD*	95% Confident Interval (Lower Bound)	95% Confidence Interval (Upper Bound)
Paper	Young Adult	.628	.018	.592	.665
	Older Adult	.722	.024	.675	.768
Hyperlink	Young Adult	.612	.020	.572	.653
	Older Adult	.753	.026	.701	.805
PDF	Young Adult	.635	.020	.594	.675
	Older Adult	.750	.026	.698	.802