RETHINKING DYSLEXIA AND LITERACY: AN INVESTIGATION OF ASSISTIVE TECHNOLOGY AND THE LITERATE PRACTICES OF COLLEGE STUDENTS WITH DYSLEXIA

By

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ABSTRACT

RETHINKING DYSLEXIA AND LITERACY:
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This thesis details a research study supported by Michigan State University's Usability/Accessibility Research and Consulting center (UARC) and Writing in Digital Environments (WIDE) research center, which sought to better understand both the writing and reading practices of college students with dyslexia and the role that assistive technology plays within them. To do this we utilized usability testing as a methodological base and focused on tasks that were indicative of the types of literacy skills required of college students, which included a heavy emphasis on tasks that involved both reading and writing (e.g. writing a summary of a paper being read) and skills associate with what Jeanie Chall calls higher level literacy (1983).

Overall this study had two significant findings: 1) dyslexic participants were just as likely to utilize strategies indicative of higher level literacy skills as non-dyslexic counterparts, and 2) strategy (the way that participants approached the tasks) was a much stronger determiner of participant success than either whether or not they were dyslexic or used assistive technology. These findings have implications for the design of future assistive technology, the policies of university disability resource centers, writing and reading pedagogy, and future research into the literate practices of individuals with dyslexia.

This work is dedicated to my mother,
Katherine Ann Jackson,
Whose own struggles as someone with dyslexia will never be fully understood
By those she left behind

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Introduction

In many ways, this research study began when I first came to Michigan State University as a Master's Student and registered as a student with a learning disability at the campus Resource Center for Persons with Disabilities (RCPD). One of the primary recommendations that RCPD made was that I purchase Kurzweil 3000, an assistive technology designed for individuals with learning disabilities. This software is built around a text-to-speech feature, with key secondary features taking a supporting role. Essentially the program reads to the user, highlighting the sentence being read in yellow, and the word being read in green as it moves through the document (see Figure 1).[1] In addition to recommending that I purchase the LearnStation version of the program, RCPD also offered to scan my print reading materials into .kes files, the format used by Kurzweil 3000.

While I have known that I am dyslexic since I was a child, I had not been formally diagnosed until after acquiring my bachelor's degree and had never actually registered with a resource center before or sought any formal accommodation, making this my first experience with both an assistive technology and the accommodation process. I am a strong reader in the sense that I am capable of understanding complex and high level texts; however, I am not a quick reader, and I have difficulty sustaining reading for long periods, particularly in crowded or noisy spaces. For most of my education I have relied on an approach to school which emphasizes classroom participation, focused and strategic reading, and note taking practices which draw on

[1] Kurzweil 3000 also provides word processing capabilities and specific features which Kurzweil Education Systems promotes as enhancing learning, including word prediction and built in note taking features (Kurzweil Education Systems. n.d.). All screenshots of Kurzweil 3000 in this paper are of Kurzweil 3000 reading Sam Dragga and Dan Voss' "Cruel Pies: The Inhumanity of Technical Illustrations" (2001).

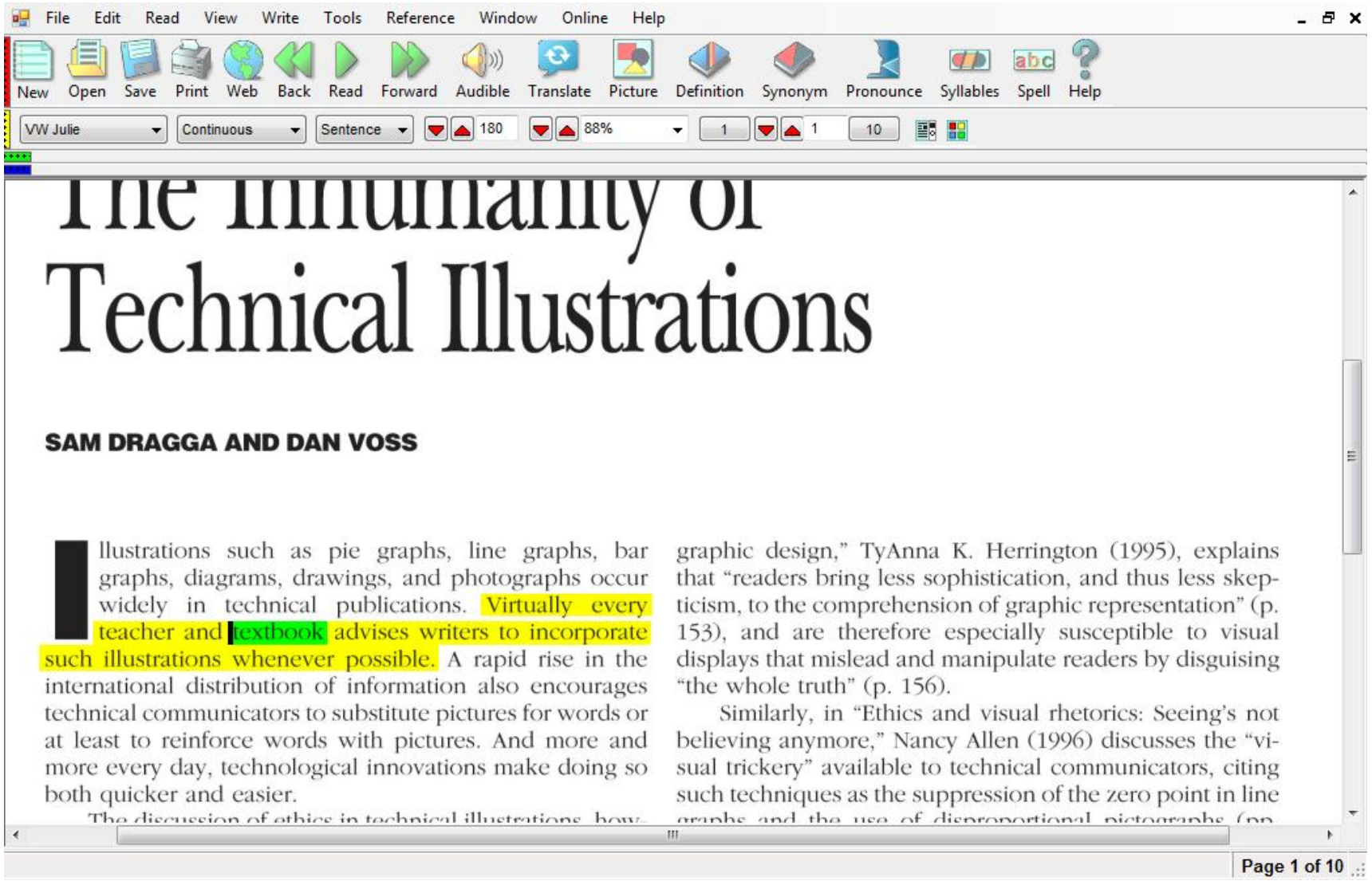

Figure 1. A screenshot of Kurzweil 3000 reading a document. The sentence being read is highlighted in yellow, and the word being read is highlighted in green. For interpretation of the references to color in this and all other figures, the reader is referred to the electronic version of this thesis.

my spatial reasoning skills and strong long-term memory, but after the first semester of my master's program I felt extremely overwhelmed by the volume of reading that I was being assigned (over 700 pages a week during my first semester), and I decided that I should try the product.

For about a semester, I used Kurzweil 3000 to read most of the documents which I already had in electronic form (this constituted about half of my required reading), and I continued to read material that I only had print access to without the assistance of Kurzweil 3000. I did this partly because I was still experimenting with the product, and partly because with the extremely quick turnaround that was expected by my classes, I was worried about the time it would take for RCPD to scan my printed materials. Over the course of this semester, I found that Kurzweil 3000 did help me sustain reading for longer periods of time, particularly in noisy environments. At first, I had difficulty using the software when it was set to any speed much higher than default, but over time I was able to train myself to better understand the software and increased the speed to something resembling a person speaking very quickly, which was slightly above my natural reading speed.

For a while, these benefits were enough to maintain my interest in the product, but because Kurzweil 3000 did not substantially improve my reading speed, I still relied on reading selectively, only instead of identifying and consuming the elements of text that were most pertinent to my approach to the material, I ended up reading the introduction of papers and whatever text beyond that I had time for. Ultimately I was not able to fully integrate Kurzweil 3000 into the writing and reading practices that I have been developing throughout my primary, secondary, and undergraduate studies, and I eventually stopped using the product. This experience with assistive reading technology raised several questions for me, in particular 1) why

didn't Kurzweil 3000 work for me and 2) was my experience generalizable to the dyslexic graduate student population, or am I an isolated case?

To help answer these questions I first did considerable research into reading, writing, and dyslexia, which included pervious assessments of Kurzweil 3000, and theoretical perspectives on reading, as well as studies of real-world reading practices and the literacy history of highly successful dyslexics. Eventually, reviewing this research resulted in a research study conducted through the Usability/Accessibility Research and Consulting lab (UARC), and the Writing in Digital Environments research center (WIDE). Overall this literature guided us towards developing a study methodology that sought not only to assess Kurzweil 3000, but also better understand the role that technology plays in the literate practices of students with learning disabilities and investigate further the specific effects dyslexia has on the types of tasks required of college level students.

Rethinking Reading

The largest and most thorough study to assess Kurzweil 3000 is a longitudinal study conducted by the Iowa Text Reader Project from 2006 to 2007 (Hodapp, J. B. and Rachow, C. 2010), which followed the implementation of Kurzweil 3000 in Iowa Middle schools over the course of twenty-seven weeks. This study found that Kurzweil 3000 improved the reading speed of students and also surveyed participating students and teachers who associated Kurzweil 3000 with improved academic performance and engagement (p. 200). But for assessing Kurzweil 3000's effectiveness in a college level setting, this study is limited in two very important ways. First it focuses on a very specific population who face very different tasks and conditions than college level students, and second it primarily focuses on reading as a means of consuming

information (through measuring comprehension and speed), rather than as a complex discursive activity with multiple purposes, situations, and techniques.

This approach to understanding and assessing reading is also consistent with the position outlined by a white paper released by Kurzweil Education Systems (the developers of Kurzweil 3000), which took the form of an annotated bibliography outlining how specific research (primarily within cognitive and educational psychology) supports the use of Kurzweil 3000 in the classroom. As a whole, this paper advocates for a model of silent sustained reading, where documents are read in their entirety, from beginning to end, without interruption, claiming for instance that "despite commonly held beliefs, good readers read every word. They do not skim or rely on context for decoding," and comprehension is the "ultimate goal of reading" (Kurzweil Education Systems, 2004, p. 3).

In many ways this theoretical framework is non-controversial because it is how reading is typically conceptualized, and providing an alternative mode of access to individuals with learning disabilities (in this case text-to-speech) is an intuitive approach. However, both the efficacy and successful implementation of these strategies is largely determined by how the designers' conceptualization of reading plays out in the design, and to ensure that these technologies actually provide appropriate accommodations, we need to reexamine this conception of reading to ensure that any assessment of Kurzweil 3000 is responsive to the actual needs of individuals with disabilities.

Alternative models. There are several diverse perspectives and theoretical frameworks which provide alternatives to the silent sustained model, but the most prevalent within rhetoric and composition is the emphasis literacy studies places on literacy as a means of participation and knowledge generation (Gee, 2007, 1999; Cazden, C., et al. 1996). A representative example

of this which addresses the specific issues raised in this paper is James Paul Gee's discussion of what he calls the "problem of content" (2007). In this discussion, Gee argues that an academic discipline is not a collection of facts and information, but is instead "a lived and historically changing set of distinctive social practices" (p. 22). Essentially, participation within a discipline, or other discourse community, requires the ability to use the social and discursive practices valued by that community to produce meaning within it. To illustrate this Gee points to the fact that many students who have passed entry-level college physics courses can correctly name and define Newton's laws of motion, but when asked, cannot answer simple questions which can be deduced from those same rules (p. 24). These students might be able to consume and reproduce the passive content of a discipline, but are not able to operate independently within that discipline, and are not able to contribute new meaning to it.

Surprisingly, this perspective is also supported by prominent scholars outside of literacy studies. Although Jeanne Chall was an outspoken critic of the whole language movement (see Chall, 1989), her theories on reading development, which are prominent within educational psychology, largely support literacy studies' emphasis on knowledge generation and participation. In Stages of Reading Development (1983), Chall characterizes literacy development as moving through six stages, some spanning only a few years of development, while others span much longer periods of time (see Figure 2 for an outline of all six stages). In this framework, as readers progress through each stage, they build on and consolidate the skills they developed in the previous one. But many of these important skill sets, and the stages that emphasize them, are not fundamentally about knowledge consumption. While stages 0-2 focus

Stage 0, Prereading: Birth to Age 6
Readers start to learn letter names and the sounds associated with them, develop an understanding of the structure of language, and begin to understand the nature of words (words are composed of parts, and many words share parts, some words rhyme, etc.).

Stage 1, Initial Reading, or Decoding: Ages 6-7, Grades 1-2
Readers learn the letters of the alphabet and associate them with the corresponding components of spoken language. Readers in this stage move through phases, sometimes focusing on meaning, and other times the mechanics of print. More advanced stage 1 readers, as well as readers in later stages, can move between these two modalities when needed or desired.

Stage 2, Confirmation, Fluency, Ungluing from Print: Ages 7-8, Grades 2-3
This stage is largely characterized by consolidation of the skills learned in stage 1. Here, the reader gains fluency through emersion in texts that have familiar themes, stories, and use of language.

Stage 3, Reading for Learning the New: a First Step: Ages 9-14, Grades 4-8 and/or 9
Before stage 3, the emphasis has been on gaining the ability to read, but in stage 3, this emphasis switches to reading as a way to learn. This stage most closely resembles the idea of reading as a means of consuming content. Because background world knowledge, vocabulary and cognitive abilities are still being developed by most readers in this stage, material in these grades is largely limited to a single viewpoint.

Stage 4, Multiple Viewpoints: Ages 14-18, High School
At this point, the reader has gained sufficient background knowledge to engage and understand multiple viewpoints. This is reflected in the textbooks high school students are expected to read, which treat subjects in greater depth and contain a greater variety of viewpoints.

Stage 5, Construction and Reconstruction—A World View: Ages 18 and above, College
The central aspect of stage 5 reading is the ability to construct knowledge from background information and the viewpoints expressed by others. This stage emphasizes the ability of the reader to not only consume information, but to use print selectively in accomplishing their purpose. As Chall puts it, a stage 5 reader "knows what not to read, as well as what to read" (p. 24).

Figure 2. A chart detailing Chall's six stages of reading development.

on learning the basic principles of decoding and applying them[2], and stage three (the closest to the model of silent sustained reading) is characterized by reading to learn content, stages four and five shift emphasis to skills devoted to analysis, synthesis, and knowledge generation.

Stage five, the highest level of literacy development, in particular emphasizes "reading that is essentially constructive," (reading which facilitates the production of meaning) (p. 24), a position remarkably congruent with literacy studies. Furthermore, the essential skills that Chall argues are at the core of the fifth stage in many ways defy the notion of silent sustained reading. As Chall puts it, the stage five reader reads to "the degree of detail and completeness that one needs for one's purpose, starting at the end, the middle, or the beginning" (p. 24). In this stage, where readers use print "selectively" (Chall, 1983 p. 24), the ability to decide what to read, and the flexibility to read in ways that suit a person's immediate need both grow in importance relative to speed and accuracy. In fact, what Chall calls "ungluing from text," a process where readers transition from being primarily concerned with accuracy to focusing on meaning, begins as early as stage two.

Bringing both of these perspectives together allows us not only to see that literacy is much more complex than the ability to consume and reproduce content, but reading in support of literacy (whether we see it in terms of skill or social participation) requires the ability to seamlessly move between diverse modes, including judging what text is useful and synthesizing viewpoints from multiple texts. In seeking to better understand assistive technologies like Kurzweil 3000, this research makes it clear that it is less important to consider simply whether or not they provide access to content, and instead we need to consider whether they provide access to the discursive practices necessary for participation within academia and society as a whole.

[2] Chall would later characterize the skills emphasized in these stages as "print skills" or the "print aspects" of literacy (Chall, 1994).

For college students, this would mean support for high level literacy skills and techniques (Chall's stages four and five). While it would be naive to suggest that print level skills are not essential to many aspects of participation, shifting the focus from reading as a means to access content towards reading as a situated discursive activity significantly changes how we understand the role of assistive technology, requiring us to better investigate and understand both the real-world techniques and strategies that support higher level literacy, as well as the relationship between dyslexia and higher level literacy (e.g., do impairments in print level literacy translate to either impairment in higher level literacy or a difference in how dyslexics approach higher level literacy tasks?): issues explored in the next two sections.

Reading and knowledge work. While there has been significant research in the sciences providing insight on the cognitive and neurological dimensions of reading, there has been relatively little research into the reading strategies and techniques individuals use to complete specific real-world tasks, and this lack of research has a strong impact on the development of technologies intended to support reading. In *The Myth of the Paperless Office* (2002) Abigail Sellen, and Richard Harper argue that a lack of understanding of how reading is actually done in the workplace led to the failure of early e-reading devices. When they and their colleagues at Xerox PARC questioned why these devices were not successful, they found that they were ill suited for the tasks they were assigned. According to Sellen and Harper, this was largely because the designers had been too focused on the ease of reading on screen instead of the reasons why or the ways in which people read as a part of knowledge work (p. 77). To better understand reading, Sellen and Harper first conducted a diary study, in which fifteen participants with diverse jobs (an airline pilot, a residential architect, and two lawyers to name a few) completed a daily log of their use of documents for five consecutive days. The participants were then

interviewed at the end of each day to expand on the diaries. Because the researchers sought to include all usage of documents, no matter what type, this study included details on Post-it notes, electronic documents, and pager messages. The researchers then followed up on these results in a laboratory study designed to test and further explore their diary study findings.

Unlike the studies used in Kurzweil Education System's whitepaper which primarily focused on the cognitive aspects of reading, these studies wanted to understand the breadth of reading activities and how those activities were integrated into the work practices of individuals. Overall, Sellen and Harper's findings redefine how we understand reading, revealing a picture of reading that not only defies the silent sustained model, but supports the theoretical work discussed in the previous section. Rather than finding a uniform mode of reading, the researchers discovered ten distinct categories which individuals moved between to fit particular tasks and situations, including reading to identify documents, reading to search for answers to questions, and reading to support listening (see Figure 3 for a graph detailing the percentage of time the 15 participants in the diary study spent on each category). Furthermore, the researchers discovered that 1) documents are rarely read from start to finish, 2) reading involves multiple documents as often as it involves only one, 3) reading, "especially in the workplace, is never undertaken by itself" (p. 78), and 4) reading is done in conjunction with a writing activity over 75 percent of the time.

Contrary to the silent sustained model, the overall picture of reading that Sellen and Harper depict is fundamentally nonlinear. Readers skim, skip sections, cross reference, spread documents out on workspaces, and seamlessly navigate within and between them, displaying many of the skills essential to Chall's stage five. As Sellen and Harper put it, reading "isn't simply a matter of the speed with which the eyes and brain can perceive the meaning of words"

(p. 77). Instead it is a complex and diverse activity which supports and is fundamentally integrated into almost every facet of knowledge work. More importantly, reading takes on distinctive modes, each requiring different forms of support.

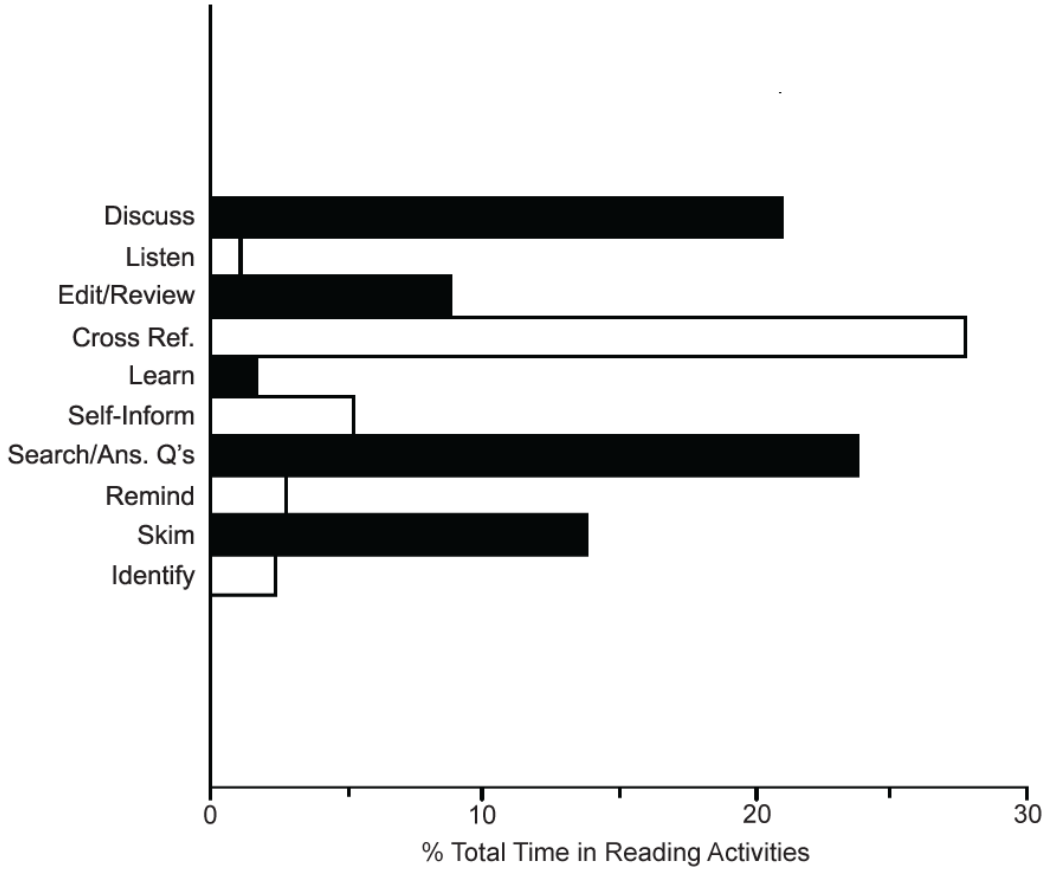

Figure 3. The frequency of reading categories averaged across the fifteen individuals in Sellen and Harper's diary study.[3]

While this model of reading presented by Sellen and Harper directly contradicts Kurzweil Education Systems assertion that "despite commonly held beliefs, good readers read every word. They do not skim or rely on context for decoding" (Kurzweil Education Systems, 2004, p. 3), it also helps us to reframe the role assistive reading technologies should play within knowledge work. In a position that echoes both Chall (1983), and The New London Group's focus on

[3] Reproduced from the *Myth of the Paperless Office*, by Abigail Sellen and Richard H. R. Harper, published by The MIT Press (2002, p. 84). For a summary of each category see Appendix A.

redesign (Cazden, C., et al., 1996), Sellen and Harper argue that if reading technologies (like e-readers, and Kurzweil 3000) are to be successfully integrated into knowledge work, they need to, among other things, support both an ability to fluidly navigate within and between documents, and an ability to interweave documents: to pull disparate sections and ideas together in the production of new documents.

Sellen and Harper's studies are limited in that they did not include reading within academia and reading for pleasure, but the dramatic results from these studies suggest that we probably know as little about the specific practices involved in these activities as we once did about reading in the workplace. While reading a novel may conform to silent sustained reading, reading a magazine, a comic book, or blog likely don't, and reading in academia, particularly at higher levels, requires a great deal of skimming, cross referencing, and searching. If anything, these studies demonstrate a need for further research, but, like Chall and Gee, they also suggests that we need to rethink how we approach the design and assessment of assistive technologies. All reading technologies need to support not only reading to learn or reading to self-inform (the two categories form Sellen and Harper's study that most closely resemble silent sustained reading), but reading to search for answers, reading to support discussion (which involves quickly finding passages in a document relevant to the conversation at hand), and reading to cross reference, all of which fundamentally ask more of the reader than simply the ability to consume words sequentially from beginning to end. In examining the role of assistive technology, instead of asking whether or not they help individuals with learning disabilities comprehended written documents, we need to ask broader questions that allow us to understand how they support their participation within the workplace, academia, and social activity.

Dyslexia and high level literacy. The implications that dyslexia has for the high level literacy skills as described by Chall, the diversity of modes of and purposes for reading observed by Sellen and Harper, and participation within literate discourse more broadly (and by extension the role assistive technology should play in it) are not well understood. In a paper detailing her work with The Harvard Adult Literacy Center, Chall herself (1994) noted that among adults who had low literacy due to a learning disability, their difficulties where mainly focused on print level literacy. For instance, one of the centers clients had the vocabulary of a high school graduate, but scored at a second to third grade level when asked to recognize printed words (p. 31). Furthermore, learning disabilities only seemed to affect higher level skills indirectly (Chall felt that another client would have scored higher in word meaning had he been exposed to more vocabulary through reading). This experience suggests that even though dyslexia can still affect print level literacy skills into adulthood, it likely leaves the ability to develop higher level literacy skills (which are less dependent on word recognition, decoding, and speed) intact.

A more thorough study into the literate practices and history of adults with dyslexia was conducted by Rosalie Fink (1998). In order to search for clues about how individuals with dyslexia can become successful in fields and professions that require a high level of literacy, Fink interviewed and obtained additional background information from sixty highly successful individuals with dyslexia and ten individuals without dyslexia as a control group. The dyslexics who participated in her study were highly educated (fifty nine of the sixty had graduated college, over half had attained masters or doctoral degrees, many had published academic papers, and one was a Nobel laureate, (p. 316). In this study, like Chall (1994), Fink found that while many of the participants still had difficulty with print level literacy (particularly speed and efficiency) they "demonstrate all the salient characteristics" of higher level literacy, including the fact that all the

participants “read materials that are technical, specialized, and abstract,” and “nearly all do a substantial amount of daily writing in their professions” (p. 328). A passage from Fink’s interview of Sylvia Law, an attorney and law professor at New York University, demonstrates not only that individuals with dyslexia can develop higher level literacy skills, but that these skills can be essential parts of successful adult dyslexic literacy practice, possibly even compensating for continued impairments in print level literacy:

> When you're immersed in a field, you kind of know what the forest looks like, and you're looking to see if there's a particular tree in here. So it's easy to just skim and zero in on the important stuff in the law. You know, the most important sentence in a 100 page document, where it says, 'The court says ....' So there are a lot of techniques and filtering devices that I use to get through lengthy legal documents. (p. 327)

Both Fink’s study and Chall’s experience at The Harvard Adult Literacy Center still leave some questions unanswered. In particular, while Fink’s study does demonstrate that it is possible for some dyslexics to develop higher level literacy, because it focused on a very selective subgroup, it does not demonstrate that dyslexics in general are just as capable of developing these skills as their non-dyslexic counterparts (only that this applies to at least a subgroup). This leaves open the possibility that either dyslexia may cause an impairment in higher level literacy skills not accounted for in these sources or that impairments in print level literacy may preclude the development of higher level skills (a least for a subset of dyslexics). In part, because of this uncertainty and because of the importance of understanding the higher level literate practices of individuals with dyslexia in more detail, we specifically designed our study to provide opportunities to further investigate these questions.

Methods

Overview

Overall the study consisted of 24 participants divided into three groups of eight each, all of whom had taken at least some college level courses. Or first test group, (made up of participants with dyslexia) utilized methodology based on usability testing and involved completing three tasks using Kurzweil 3000 to read an academic article. From this base, we then expanded and modified the study to include additional groups (one with dyslexic participants, the other with non-dyslexic participants) who completed the same tasks, but used a paper version of the article instead (Groups Two and Three respectively) (see

Figure 4 for a chart of the different groups).

	Kurzweil 3000	Paper
Dyslexic	Group One	Group Two
Non-Dyslexic		Group Three

Figure 4. A table detailing the specific groups, including what technology they used as well as whether or not the participants had dyslexia.

The three group design enabled us to control for different factors that influenced test outcomes by comparing metrics from different groups, and also allowed us to ask questions about dyslexia and literacy that were broader than what a standard usability evaluation of Kurzweil 3000 would have allowed. This design allowed us to ask separate interlocking research questions (see Figure 5):

Comparison	Research Question
Group One (Dyslexic Participants using Kurzweil 3000) to Group Two (Dyslexic Participants Using Paper)	What role does assistive technology play in supporting the reading practices of students with dyslexia?
Group Two (Dyslexic Participants Using Paper) to Group Three (Non-Dyslexic Participants Using Paper)	Are individuals with dyslexia impaired in tasks that draw primarily on higher level literacy skills?
Group Three (Non-Dyslexic Participants Using Paper) to Group One (Dyslexic participants Using Kurzweil 3000)	Does Kurzweil 3000 provide effective accommodations/equivalent access?
All Groups	What role does strategy play in high level reading and how does it interplay with technology and disability?

Figure 5. Group comparisons and related research questions

Study design. ***Usability testing.*** Usability testing is a user-centered design technique which helps to identify problems with and strengths of existing or potential designs (usually of websites, software, or user interfaces) through one-on-one testing with actual users. In a typical usability study, participants who represent real users are asked to perform three or more tasks that are designed to reflect the core functionality of the product. Participants are usually asked to "think aloud" (describe their specific actions and impressions as they complete the tasks) in order to help researchers understand their thought processes, including what their expectations of how the system should function are, and how they attempt to recover from breakdowns with their work processes. Studies then involve an exit survey designed to evaluate user satisfaction and participants are then interviewed and debriefed so that researchers can collect their final thoughts, subjective feelings about the product, and specific suggestions for improvement.

From these sessions, usability researchers collect quantitative and qualitative data including task times and success rates, user satisfaction ratings, verbal and written user feedback, and observations of breakdowns in participant workflow. These data are then analyzed and the system is evaluated based on three key usability criteria: effectiveness (how accurately and completely did participants finish tasks), efficiency (how long it took participants to complete tasks successfully) and satisfaction (how well did users feel the system supported them in completing the tasks) (International Organization for Standardization, 1998).

By starting from and then building on this methodology, we were also able to expand on previous work done at UARC, particularly a review of the usability literature on dyslexia done by McCarthy and Swierenga (2010) that found a relative lack of formal usability studies focused specifically on users with dyslexia (p. 148, 151), and a usability evaluation of the Michgan.gov voting website, which raised questions regarding what context and for what types of tasks individuals actually use Kurzweil 3000 (Swierenga, Porter, Ghosh, McCarthy, 2008).[4]

Writing studies. Finally because the tasks involved both reading and writing, we also drew upon methodologies from writing studies in both study design and data analysis. In particular, Geisler and Slattery's (2007) method of using activity theory as a framework for analyzing screen capture video of digital writing was incredibly useful, both because it was compatible with common usability techniques and supported our broader methodological goal of understanding the writing practices of individuals with dyslexia and the contexts in which they take place.

[4] For more on usability testing and methodology see Dumas & Redish (1999) or Rubin & Chisnell (2008), or for the role that usability can play within technical communication see Johnson (1997).

Location and equipment. All sessions were conducted at the Usability/Accessibility Research and Consulting (UARC) lab at Michigan State University in East Lansing Michigan, with the exception of one participant (from Group One) whose session was conducted in a conference room in Angell Hall at the University of Michigan in Ann Arbor Michigan. The usability lab at UARC includes three computer stations which face each other in a triangle, a white board, and a small couch in order to present a comfortable and inviting environment. The room also includes five adjustable overhead cameras to observe and record sessions, and each computer monitor can be mirrored on either one or more of the other monitors, or monitors in an adjacent control room so that multiple researchers can observe a session.

Figure 6. The usability lab at UARC where all but one of the test sessions took place.

For our study, participants sat at one of the computer stations with a researcher sitting just behind and to the right of them (see Figure 6). This allowed the researcher to observer the session, including what was happening on the screen, and facilitate the session while remaining as unobtrusive as possible. If a second researcher were present for a session, they would usually sit at one of the other terminals, which was wired to show the test computer's screen.

All sessions were recorded using Morae usability testing software by TechSmith, which recorded the action on the screen, keystrokes and page changes, and also used a webcam to capture video of the participant as they completed the tasks as well as anything said by the participant or one of the researchers during the tasks or post-session interview (see Figure 7).

To complete the tasks that required a written response, participants were allowed to use Microsoft Word on the test computer, a pen and notepad we provided, or their own computer. Because we wanted the reading observed to be as close to participants usual practices as possible, we also allowed participants to access the internet throughout the task (e.g., in order to look up an unfamiliar word in the test document). We always collected participant responses to the tasks in whatever format they were created, and we collected task time data and made qualitative observations from both the Morae recordings and the time stamped notes we took during the session.

Dyslexic Participants Using Kurzweil 3000 (Group One)

Recruitment. For Group One, we sought out participants who both had dyslexia and at least some experience with either Kurzweil 3000 or a similar assistive technology. To contact these participants we distributed fliers both through Michigan State University's Resource Center for Persons with Disabilities, and on bulletin boards across Michigan State University and University of Michigan campuses, and we also contacted participants of previous UARC studies.

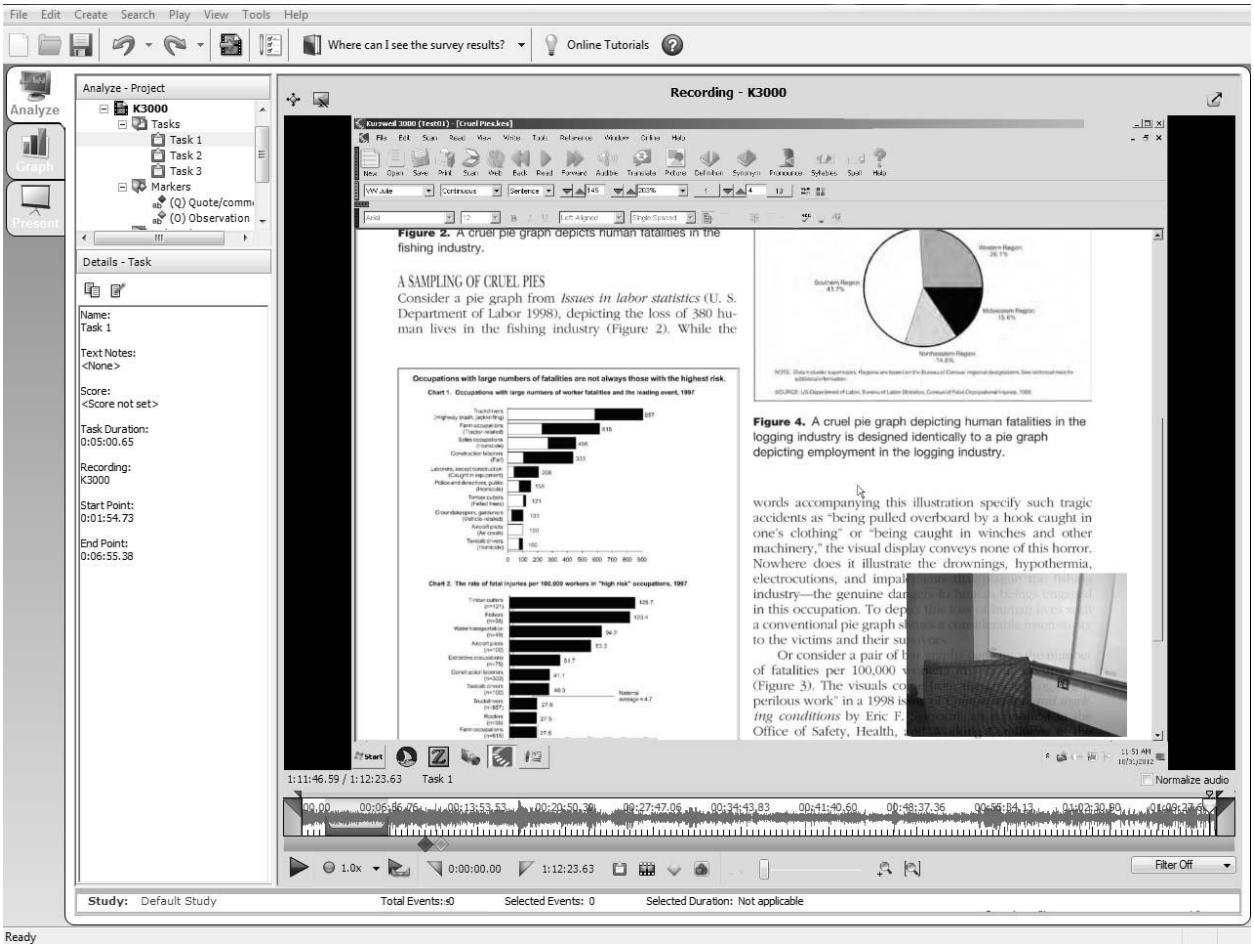

Figure 7. A screenshot of Morae Manager, which includes the video recording of both the screen with a document displayed in Kurzweil 3000, and the participant seat (bottom right).

During the recruitment process we confirmed with each participant that they had either dyslexia or a related reading disability[5] and inquired about their experience with assistive technology. We then scheduled participants who fit the criteria for the study for a session time at the UARC. As incentive, we also offered fifty dollars in compensation to participants in all groups of the study.

[5] We included the "related reading disability" terminology in all our calls to the public because although dyslexia is still the dominate terminology of most scientific research on the subject, some participants may have been given different terminology at diagnosis. Specifically, in the upcoming DSM-V dyslexia has been replaced by Specific Learning Disability Reading, and Specific Learning Disability Writing, and this terminology has previously been in use by many diagnosticians.

Because this group had the most specific participant criteria, recruitment spanned most of the summer and fall of 2012. While it would have been beneficial to have had as many participants with a high level of experience with Kurzweil 3000 as possible, finding these participants proved to be difficult so we also included participants who had some experience with Kurzweil 3000 but did not use it routinely, as well as three participants who had experience with similar assistive technology, including one participant who had experience with Solo 6 and two who had previously used a similar text-to-speech feature in Apple's Preview software.

Pre-session procedures and questionnaires. Before beginning, we provided participants with an overview of the session, answered any questions they may have had and obtained written consent. In order to ensure that the consent process was clear, straight forward, and accessible, we offered each participant the opportunity to read the consent paper work themselves, have us read it to them verbatim, and/or have us give them a detailed synopsis of it.

Participants were then asked to fill out a brief questionnaire (see Appendix B), which included basic demographic information and several questions about their computing and internet habits (standard questions for UARC studies), as well as three questions about their reading practices and the specific technologies they preferred to use to read. This questionnaire was then followed up by the Adult Reading History Questionnaire (see Appendix C): a standardized instrument which includes twenty-six additional questions about the participants' specific reading practices and history (See Lefty & Pennington, 2000 for an overview of the ARHQ).

After completing the consent paperwork and both questionnaires, we informed the participants that we would now be moving on to the tasks and read a script which outlined how we would present them. Because both the circumstances of the session and the tasks resembled

conditions students might encounter as part of an exam or standardized test, we were concerned that participants would read either in a way that they felt they were expected to or that they felt was appropriate to those circumstances. For instance if a student anticipated that one of the later tasks would ask specific comprehension questions, they may be more likely to read in a more linear and through manner than if they were reading for another purpose. To try to elicit reading behavior that was more indicative of the participants usual practices the script emphasized that 1) participants should feel free to use the software in whatever way they felt was appropriate to accomplish the given task, 2) they could read the document in any order and to any degree of completeness that they felt was appropriate, and 3) there was no right or wrong way to use Kurzweil 3000 or read the document. As per typical usability methodology, we also emphasized that the purpose of this study was to better understand how assistive technology does or does not support real-world reading practices, and we were evaluating the technology and not the participants' performance.

In order to ensure that the sessions stayed within an hour and a half, we allocated time limits for each task. Because we didn't want time limits to affect the participants' practices, we did not inform them of the limits ahead of time, and merely gave them warnings when their time was nearly up and asked them either to finish what they were doing or in the case of the first task, to give us the best answer they could. The limit was rarely needed, and was most often invoked in the first task which had a five minute limit. This is likely because many participants were unsure of how to frame their answers for this task and took their time. However, time limits never resulted in a task failure (for this or any other task), as all participants were able to give us a response that fit the given parameters.

We presented the tasks to the participants one at a time (not revealing the second task until they had completed the first and so on). Participants were also given a large-type paper copy of the tasks to refer to during the session. This copy was covered at the start of the session and when a task was read to the participant the cover sheet was lowered to reveal that task (either by the participant or one of the researchers). During the task, participants were invited to inform us of any technological difficulty they were having completing the task, or any other observations of either the tasks or the technology they might have.

Tasks. In order to ensure that the tasks we presented participants fit real-world tasks associated with college level work, we referred to previous research. Because both Chall (1983) and Sellen and Harper (2002) emphasized the importance of reading to write (p. 82), we designed two of the three tasks to require a written response.

Task One. The first task consisted of giving us basic generic information about the document, including who they thought the audience for the document might be, and where it might be published (such as an academic journal or in a book). We used Sellen and Harper's reading category "reading to identify" in which readers read a document only to identify the specific document, or which category it belonged to (2002, p. 83) as the basis of this task. We were particularly interested in how quickly participants were able to ascertain basic information about the document, if doing so was a central part of their reading strategies, and what features of the document they used in order to do this (i.e., did they rely on cues from the text itself, or did they scan the document for other features, such as the presence of footnotes?).

Task Two. The second task asked participants to create an outline of the document. Because we wanted the outlines to reflect their usual practices, we used language that emphasized that they only needed to create outlines that provided what they felt were the main

points of the article and a few supporting details. We chose this task because we were interested in how well Kurzweil 3000 supported the participant's ability to quickly and easily develop a mental model of the document, what Sellen and Harper might call *"getting to grips with* the information in question" (2002, p. 103), as well as what strategies participants used to do so. Furthermore, the skills required to accomplish this task (that is quickly and effectively develop a complex understanding of the document, that included understanding and identifying the main claims of the document, as well as how those claims are structured within the document) are also indicative of the types of skills necessary for Chall's (1983) higher stages of reading development, and the reading practices of many of the highly successful dyslexics described by Fink (Sylvia Law's description of her reading practices in particular, Fink 1998, p. 327)

Task Three. The final task involved writing a brief one to three paragraph summary of the article. We had participants do this task because once they had created a complex understanding of the document, we wanted to understand how they would deploy it to create a new document that provided a greater degree of detail and required some degree of integration or synthesis of the information they had assimilated. For this task we paid special attention to what resources participants used to complete it, specifically did they primarily refer to the outline they created, their memory of the document, or the document itself (or if they use some combination).

The document. All participants of this study read Sam Dragga and Dan Voss' "Cruel pies: The inhumanity of technical illustrations" (2001). We chose this text because 1) we were relatively sure that participants would not have previously read it, 2) it contained a variety of features including graphs and charts, a bulleted list, and section headings, all of which are features which Kurzweil 3000 would need to read in a successful way in order to allow college level students to effectively engage with the diversity of documents they need to be able to read,

and 3) it was relatively short (ten pages including numerous charts and graphs and two pages of works cited). In order to make the first task difficult enough we redacted some but not all of the publication information from the document, for instance we removed the name of the publication but not the volume and issue number (see Appendix D for a sample page).

We also took steps to make sure that the document, which we originally acquired as a PDF, was read well by Kurzweil 3000 (specifically, we made sure that the document had high image quality, that one page of the document represented a single page of the original article, that the text was not skewed, and that margins were consistent throughout) but these features of the document are rarely guaranteed in real-world situations when students often receive low quality PDFs from teachers or libraries (one participant from this group commented that Kurzweil 3000 read this document significantly better than most of the documents they had read with Kurzweil 3000).

Post session questionnaire and interview. After the final task was completed, we had participants fill out a post-study questionnaire based on the Technology Acceptance Model (TAM), a standardized Likert scale questionnaire which collects subjective data from participants in order to predict how likely they are to adopt the technology in the future.[6] Because we had already included two previous questionnaires and we were concerned about time limits, we used Fred Davis' 1989 revised TAM questionnaire (as cited in Chuttur, 2009, p. 8), which included only twelve questions (six each for perceived usefulness and perceived ease of use) (see Appendix E). This questionnaire was followed by interview questions which focused on the strategies that participants used to complete the tasks, and any technological breakdowns that might have occurred (see Appendix F for an overview of questions).

[6] See Chuttur (2009) for an overview of the history and methodology of the TAM.

Dyslexic and Non-Dyslexic Participants Using Paper (Groups Two and Three)

Because the goal of the three group design was to compare metrics between groups, we kept the procedures as similar as possible, however, to account for differences in these groups there were a few changes to the procedure, all detailed below.

Recruitment. Because we did not specify in our original flier that participants needed to have experience with Kurzweil 3000, we were able to recruit participants for the dyslexic using paper group (Group Two) at the same time as we recruited for Group One, however for the non-dyslexic paper group (Group Three) we created an additional flyer calling for participants in a usability study and posted it around the Michigan State University campus. In order to ensure that we only had participants without dyslexia in this group, we asked them the same screening questions as the other two groups, and if respondents happened to either have dyslexia and/or experience with Kurzweil 3000 or another assistive technology, we would simply place them in either Group One or Two. Given that the eligibility requirements for these groups were both lighter than for the first, recruitment for these groups went much more quickly than the first, with Group Three taking only a matter of a few weeks to recruit and run the sessions.

The document. Because the purpose of these groups was to capture participants reading from paper instead of Kurzweil 3000, we presented participants with a printed version of the document. We chose to use a printed document instead of an electronic from (such as a pdf in Adobe Reader) because we felt that it would give us the best contrast between the groups, and because our previous research suggested that paper would be the most effective technology for completing these specific tasks (Sellen, and Harper, 2002).

This paper version of the document included all the same redactions as the Kurzweil group version, but we also added large red page numbers at the top left of both the front and back

of pages. We did this so that we could tell which page participants were on during our in person observations and on the video (see Appendix D for a sample page). Before the session started, we placed this document face down in front of the participants and instructed them to turn it over at the beginning of Task One.

Audio and video recording. Because the participants were reading from paper, for these two groups we were not able to rely on recording the on-screen action to adequately capture what the participants were reading. To compensate for this, we adjusted the position of the webcam, which is usually positioned to record the participant themselves, to observe the workspace on the table instead (see Figure 8). The obvious disadvantage of this approach was that we were not able to record the participants' faces during the sessions as the webcam was being used for a different purpose. We took this approach because it meant all data from each group existed in the same program (Morae), making analysis procedures more comparable between groups, however it did make analysis more difficult in some ways because we could not see participant reactions to specific events during the session, and it was more difficult to understanding what participants were doing at a given moment in the video, especially what they were looking at and if they were focused on a particular element or scanning the document or computer screen. This configuration still allowed us to capture any other activity the participants used the test computer for, such as looking-up things online, or using Microsoft Word to write the responses to Tasks Two and Three.

During the session we also asked participants to follow along with their reading using their pen or finger to help us understand which portions of the document they were reading at a given point, either during or observations or in the recording. We intended this to be as minimally invasive as possible and told participants that they didn't have to follow along with

each word, or line, but that they only had to indicate which portion of the document they were reading (roughly which paragraph, or which figure they were looking at).

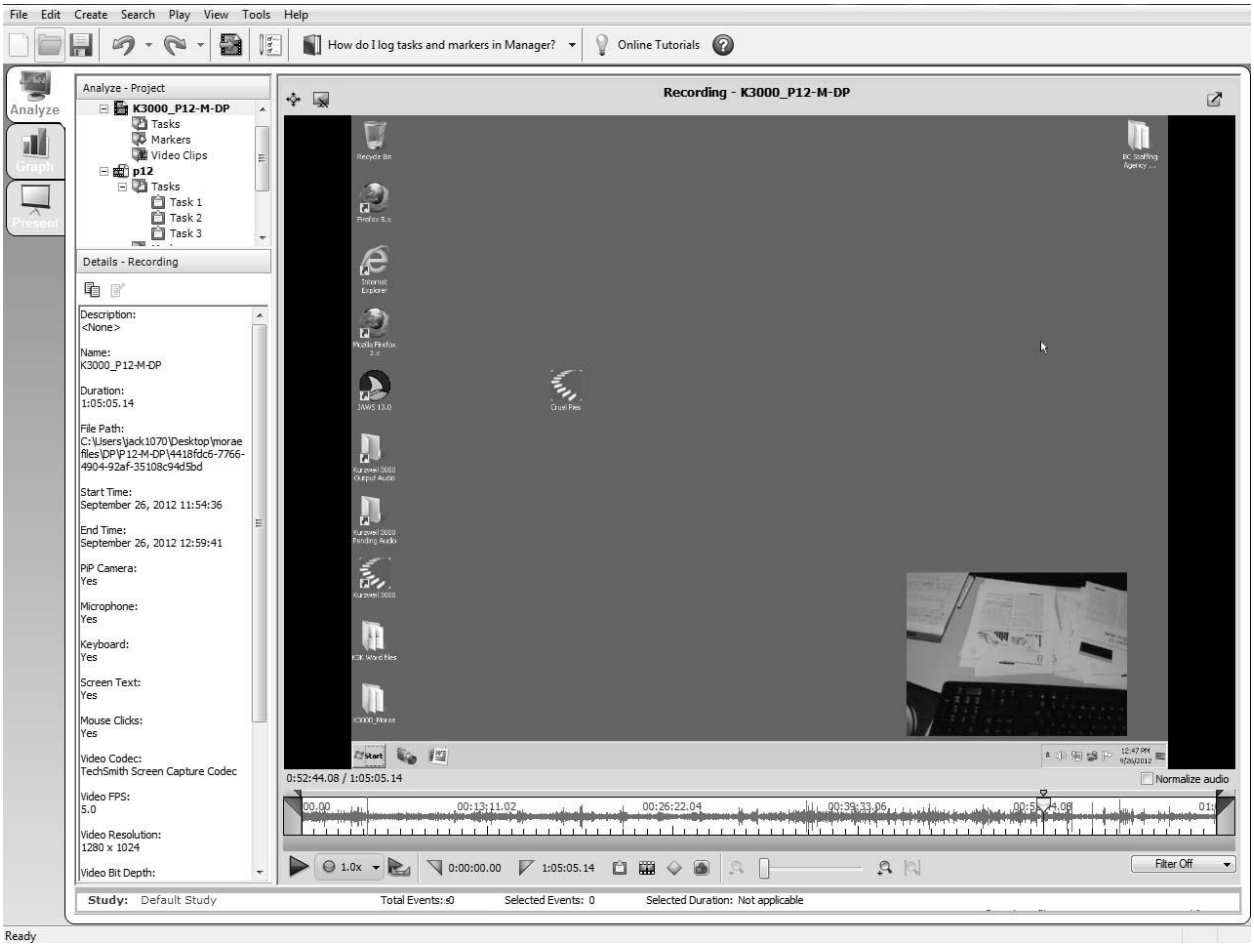

Figure 8. Morae and web cam configuration for Groups Two and Three.

TAM questionnaire. While the first two questionnaires from the pre-session remained the same, we altered the wording of the TAM questionnaire to fit the new presentation of the document (the TAM is designed to be tailored to the specific technology it is being used to evaluate). Also, because the TAM questionnaire was originally geared towards electronic information technologies, we took special care in crafting the wording for the paper version of the questionnaire, and when presenting the questionnaire to participants we let them know that

some of the questions might seem odd, asked them to fill it out as best they could, and offered to clarify any of the questions for them (see Appendix D for both versions of the questionnaire).

Analysis

Measuring task times. Our first preliminary look at task time data was based off of notes taken during the sessions, but to ensure accuracy and consistency we used Morae to review the recordings and tag them with precise start and end times. As stated above, we encouraged participants to inform us of problems or observations they made during sessions. Because most comments were brief (mostly short questions about either the tasks or the software) this did not have a strong impact on task time data, and in most cases we did not exclude these interactions from the task time, however if interactions between participants and researchers took more than 20 or 30 seconds, we did exclude those sections from the task time. We did this because we felt that it was important to ensure that task time data accurately reflected the effectiveness of the strategies used by participants: something strongly illustrated by the case of one participant in Group Two (dyslexic using paper) who paused the task and spoke for long stretches of time (one three minute break and two shorter breaks each under 30 seconds), providing detailed information about their[7] approach to the task and the strategies they usually employed when reading similar documents. During the session we allowed these interruptions of the task for two important reasons. First, we wanted participants to feel comfortable during the session, and second we wanted to make sure that we were observing reading and writing practices that were as close to participants' real-world practices as possible. And as this participant explained to us, taking breaks from reading was part of their normal practices (and is a strategy that is sometimes recommended to students with learning disabilities).

[7] To obscure participants' gender, this work uses singular "they" to refer to all participants.

In evaluating these practices it is also important to note that this participant was one of the most academically accomplished participants, currently working on a Master's Degree in Human Resources, and this participant also had some of the most sophisticated study practices which included seeking out classmates to discuss course material, reading assignments selectively, and supplementing textual course material with non-textual material (for example, as a business student, this participant regularly watched business and news television programming, which helped them develop an understanding of the current key concerns of the field, as well as its central vocabulary and the types of arguments and claims that were considered valued by it). Furthermore, these were often the activities this participant pursued during "breaks" from reading, making the interruptions from the task to speak with a researcher about the task more generally a standard part of their real-world activities.

Because one of the objectives of the study was to observe and understand unique and diverse practices (particularly ones that allowed their practitioners to succeed in college as this student had) we did not want to penalize a set of practices and wanted to ensure that they be included in our analysis in a way that accurately reflected the role they played in that participant's success as a student. For this participant and participants with similar situations, we created composite task times omitting the sections of the videos when the participant was not working on the task (if we were in doubt from the video about whether a participant was "working" on a task we counted that time towards the task time). We also created composite task times for Task One when participants gave us a preliminary answer for the task, then spent some additional time reading the document before finishing or refining the answers. For these participants we counted the additional time towards the task time, but not the time they spent giving us the answer.

Analyzing participant strategies. To better understand what strategies participants were using during the task, and what impacts those strategies had on other metrics including task time, we conducted a qualitative analysis of strategy which focused primarily on Group One and included a review of the visual record of the tasks, observations we made in our notes, and data collected during the post session interviews. We paid particular attention to how participants approached reading the document asking questions such as: did they skim sections or try to read the document from beginning to end? If they did skip sections, what sections did they skip, and what was their overall strategy in doing so?

Evaluating participant responses. We wanted to better understand how the strategies and technologies used by participants impacted the quality of their submissions, but at the same time we also wanted to avoid subjectively assessing the responses, both because of time constraints and because we wanted to ensure that print level literacy variables like punctuation and spelling did not affect our analysis. To do this we used two objective variables: outline complexity (measured by simply counting the number of main and sub points in the outline), and the word count of the summary.

Both of these variables are indirect indicators of the quality of participants' responses, however we are relatively confident that these variables tell us something meaningful about the submissions because as detailed in the results section, for all groups both variables correlated strongly with each other, and also fit the models of effective strategy taken from our previous research.

Breakdown analysis. For the Kurzweil 3000 group, we also paid extra attention to breakdowns in participant work flow. Breakdowns are not the same as errors. That is, a breakdown occurs not when a system malfunctions, but when it either fails to support a user

action, or supports it in a way that is unexpected, unintuitive, or cumbersome, causing the user to stop directly engaging in the task and forcing them to resolve the breakdown. For more on how breakdowns are useful in human computer interaction design see Bødker (1989). To do this we documented in our notes what breakdowns in work processes participants encountered, if any, and how those participants found ways to solve or work around those breakdowns, and we also asked participants about breakdowns that we noticed during the post-session interviews (see Appendix F for the specific questions we used).

Results

Demographic Overview

Most participants were between the ages of 18 and 29, with one participant age 42. Participants had a wide range of academic backgrounds that ranged from college freshmen to participants with Master's degrees who were now pursuing PhDs, and every group had at least one graduate student. Participants also came from a wide range of disciplines including but not limited to Zoology, Communication, Athletic Training, Political Science, Psychology, Business, and Biochemistry and Molecular Biology.

Group One (Kurzweil 3000)

Higher level literacy strategies result in faster task times. Even before we finished data collection, it became clear that Task Two (creating an outline of the document) would be the most interesting portion of the study, largely because during data collection, we observed a large variety of approaches to accomplishing this task and task time varied substantially between participants. During task time analysis, in order to better understand Task Two performance, we ordered participants based on their Task Two times and created a scatter plot (see Figure 9) which included all the task times for the group as well as the total task time.

This scatter plot allowed us to better see correlations between Task Two and the other task times, indicating among other things that overall task time correlated very strongly with Task Two (both metrics have similar trends), and participants near the median time for Task Two spent relatively more time on Task Three than other participants. These observations made sense given that most participants in this group spent more time on Task Two than any other task, and half the participants spent more time on Task Two than both of the other tasks combined. But the most important observation we made from the scatter plot was that participants seemed to break

into two subgroups. In particular the three participants with the fastest Task Two time spent relatively the same amount of time on Task Two as Task Three (creating a summary of the document), whereas other participants (particularly the final four participants) spent a great deal more time on Task Two than on Task Three.

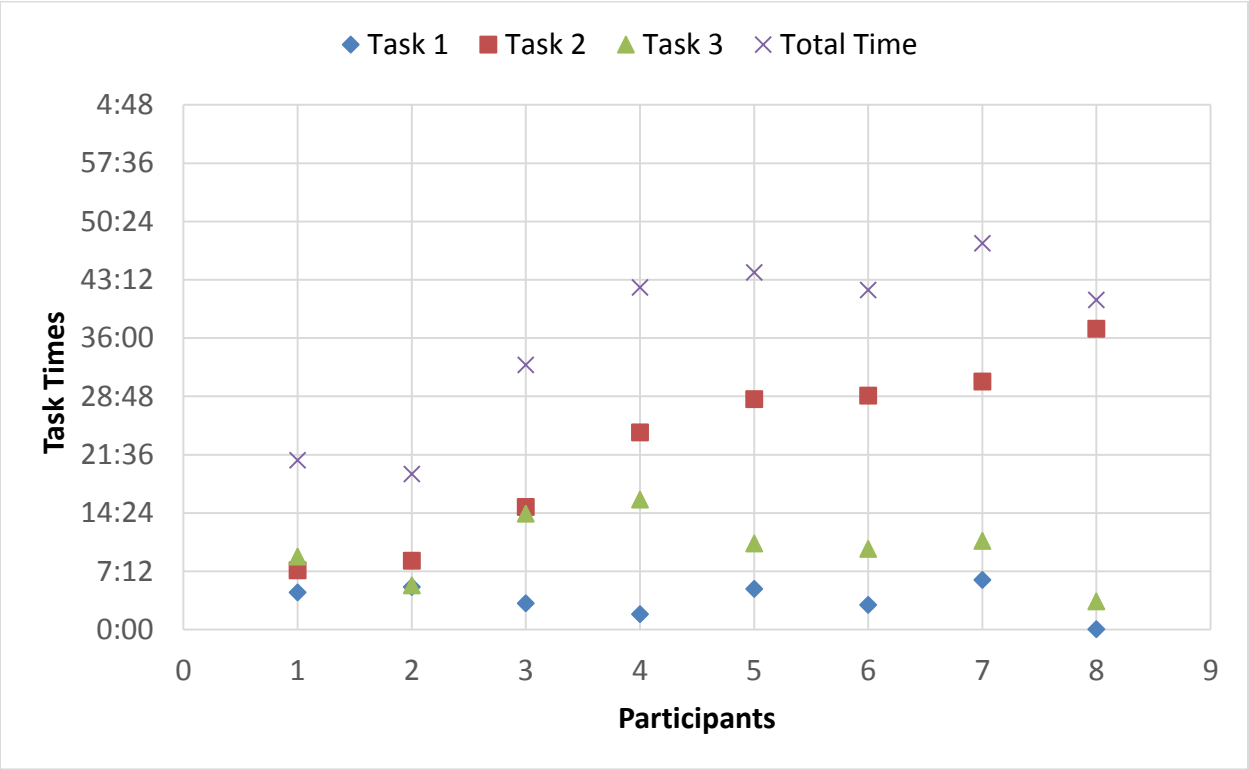

Figure 9. Group One (dyslexic participants using Kurzweil 3000) task time scatter plot.

To us this grouping indicated that participants on the left side of the graph (participants with faster Task Two times) were utilizing a different set of strategies from the participants with much longer Task Two times (in particular strategies that resulted in dramatically shorter Task Two and overall task times). To explore this, and better understand the role that strategy played in Task Two, we referred to our qualitative analysis of participant strategies, which demonstrated that these two subgroups did utilize substantially different strategies. In particular the subgroup with faster Task Two times used the text-to-speech feature infrequently, instead they skimmed the document "unassisted" for long periods of time and then used the text-to-speech feature to

read sections they wanted to read more closely. In contrast, participants in the second subgroup utilized strategies that were dominated by trying to read as much of the document as possible with the text-to-speech feature, usually in a highly linear fashion. For example, the participant with the longest Task Two time actually read the document in full from start to finish using the text-to-speech feature. Another member of this subgroup did skip sections of the document but almost always returned to read those sections in full, and a third member read about two thirds of the document before skimming the final sections (likely because this participant felt that they understood the main points of the document at that point, or wanted to finish the task more quickly).

The task time data make it clear the strategies of the first subgroup resulted in substantially reduced task time, particularly on Task Two, but these strategies are also highly consistent with the types of strategies, skills, and techniques associated with high level literacy. That is, these participants were able to skim the document, find the sections that were most relevant to the task, then focus most of their attention on those sections. The only difference between these participants and how readers using high level literacy strategies are typically conceptualized is that reading a section more closely meant using the text-to-speech feature. By taking agency of their own reading, these participants were able to dramatically reduce the time that it took them to complete Task Two (and in most cases Task Three as well) by employing sophisticated strategies to read the document selectively.

Higher level literacy strategies raised submission quality indicators. After we identified the specific strategies used by participants and understood their relationship to task time, we wanted to understand how these strategies affected participant responses (i.e., did faster task times result in poorer response?). To do this we plotted the complexity of participant

outlines as well as the length of their summaries (Figure 10 andFigure 11), again ordering participants by their Task Two completion times.

Both scatter plots have slightly downward trends, demonstrating that, in general, the longer a participant spent writing the outlines and the summaries, the shorter both of those responses actually were. While this finding might seem counter intuitive, it fits our understanding of highly effective reading, that is, focused and strategic reading does not reduce (and may even enhance) the quality of written material based on those documents. Furthermore, while these metrics are both indirect and do not definitively tell us which outlines and summaries were better than others, they do correlate strongly with each other, suggesting that, at least for this group, the strategies that resulted in dramatically shorter Task Two times also resulted in participant responses that were as good if not better than the strategies that involved less focused reading of the document.

Breakdown analysis. Both subgroups encountered common breakdowns related to navigation that made the kind of non-linear reading which characterized the strategy of the first subgroup difficult. In particular, most participants had difficulty navigating between pages.

Participants expected Kurzweil 3000 to allow for continuous scrolling between pages (a standard feature of document reading and writing software), however to advance between pages users must either allow the text-to-speech feature to auto-advance them, or use the page navigation buttons found at the top of the page. This led many of the participants, even ones with the most experience using Kurzweil 3000, to have difficulty determining whether the document contained more than one page. Most participants eventually found the page navigation buttons, but some participants resorted to work-arounds like using the forward button (a button located in the top menu designed to allow users to advance within the document one sentence at a time) to

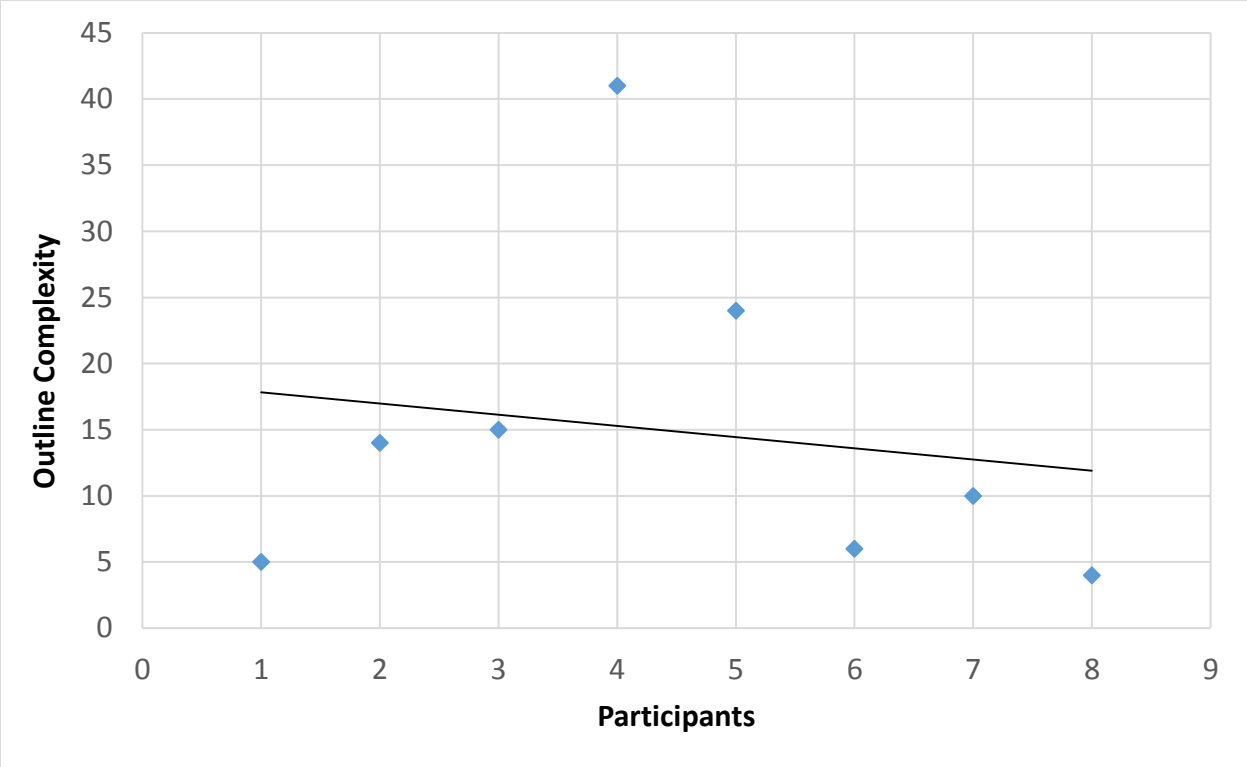

Figure 10. Group One outline complexity scatter plot.

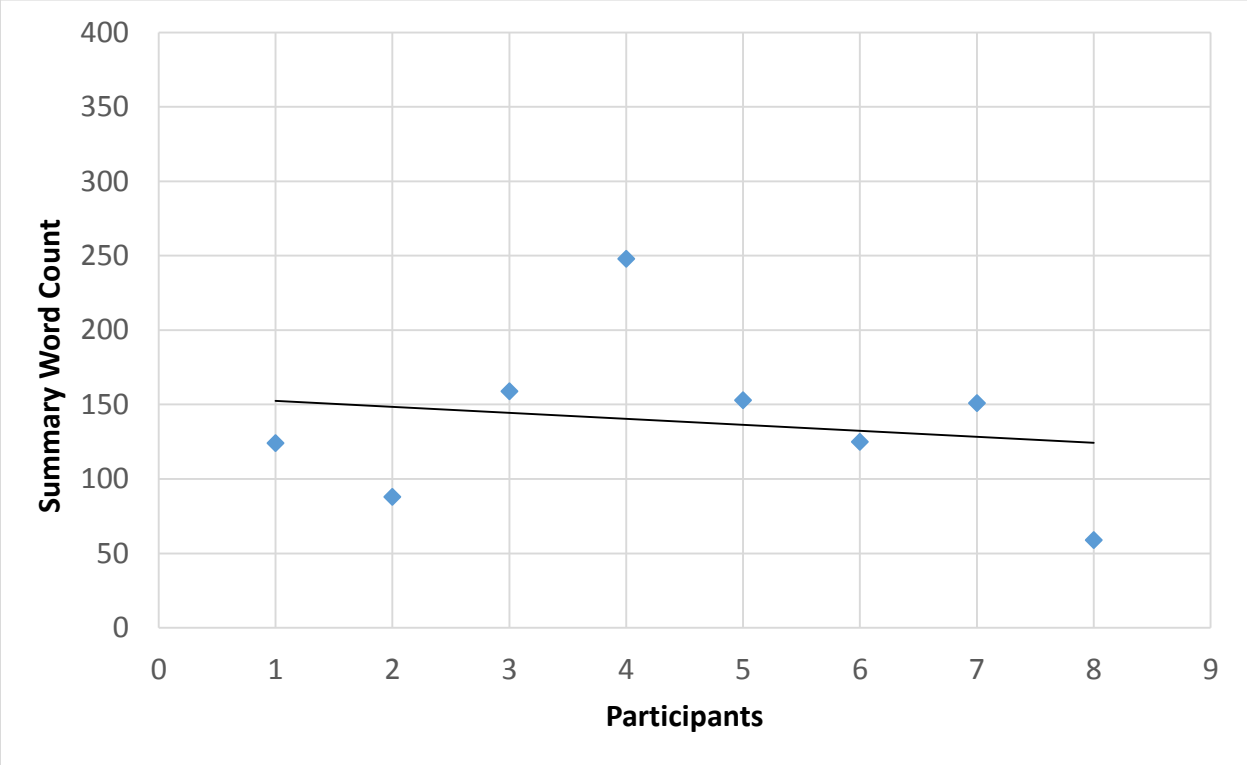

Figure 11. Group One word count scatter plot.

advance the text-to-speech feature to the next page, or in extreme cases selecting the last few words of a page, starting up the text-speech feature, allowing it to advance them, then stopping the feature so they could examine the page on their own.[8]

In addition to page navigation issues, Kurzweil 3000 further complicated navigation within the document by directing focus when users wanted to split focus. For instance, many participants tried to examine figures while the program's text-to-speech feature read the passages that referred to them, but Kurzweil 3000 directs the focus to the sentence being read, making scrolling to different sections while it reads impossible. One participant in particular commented that they liked to allow the program to "read to me while I'm thinking of stuff to type," indicating the split focus could be an effective component of individual strategy. Difficulty controlling focus, as well as difficulty navigating within the document, also made it more difficult for participants to quickly find and refer to figures within the document.

Additional Groups

Task time data comparable with Group One. Because the central role of the two additional groups (dyslexic participants using paper, and non-dyslexic participants using paper) was to provide comparison data both with the original group as well as each other, we created task time scatter plots (Figure 12 and Figure 13) using the same parameters for the first group.

When the data for non-dyslexic participants is compared to the dyslexic paper group (as well as to all the dyslexic participants), it becomes clear that while there are some important differences between the two groups (particularly on Task Two times) each group presented highly similar trends. In particular, just like Group One, Groups Two (dyslexics using paper) and

[8] This tedious work-around does not allow participants to return to previous pages, meaning that while participants who used it were able to move forward in the document, they were not able to navigate backward unless they also found the navigation arrows.

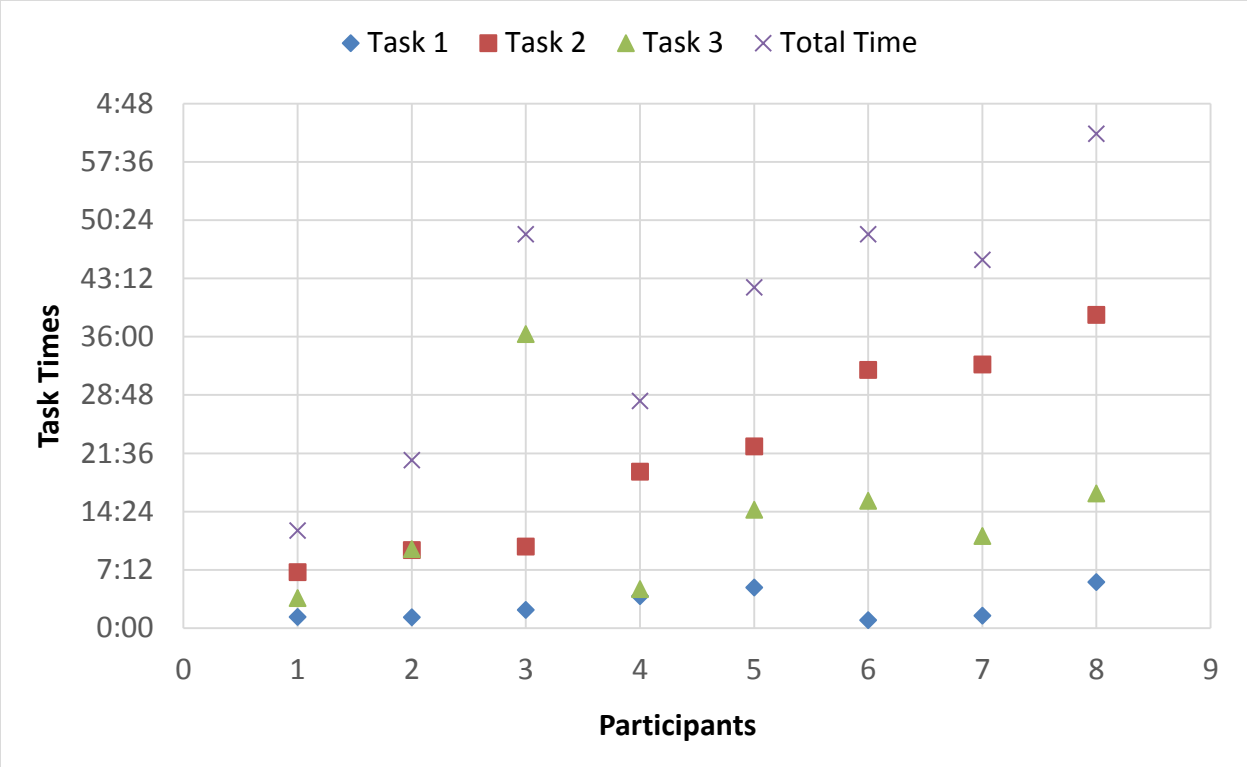

Figure 12. Task time scatter plot for Group Two (dyslexic participants using paper).

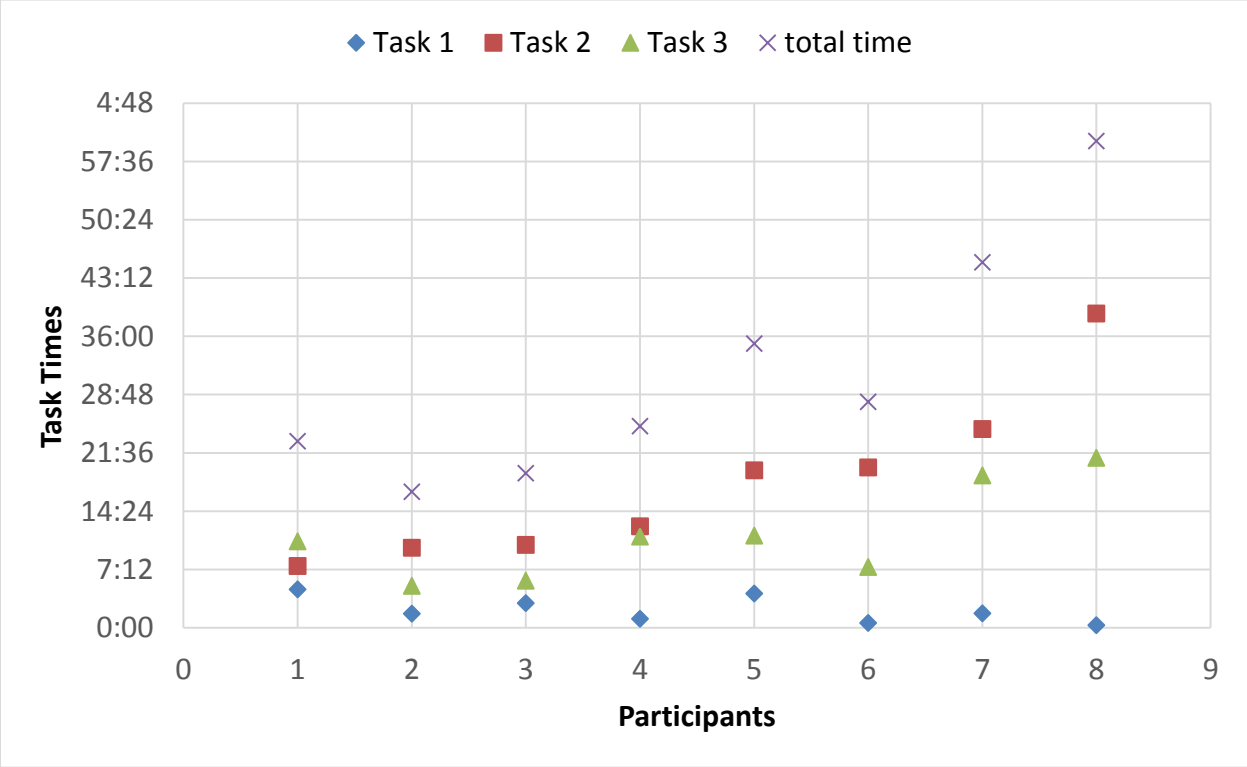

Figure 13. Task time scatter plot for Group Three (non-dyslexic participants using paper).

Three (non-dyslexics using paper) both had a subgroup of three or four participants who performed much faster than other participants in their group on Task Two. In addition to this, Task Two time performance of these subgroups was consistent across groups (roughly between seven and fifteen minutes) regardless of what technology they used or whether or not they had dyslexia. Furthermore, when all task times are combined dyslexic and non-dyslexic participants are distributed across the participants, and the fastest Task Two time was achieved by a dyslexic participant and the slowest by a non-dyslexic participant. All of these data indicates both that strategy played a similar role in the two additional groups as it did in the first, and that individuals with dyslexia are just as likely to use high level strategies as their non-dyslexic counterparts.

While the first subgroup (participants with faster Task Two times) were consistent across groups, there were important differences when comparing the second subgroup (participants who had longer Task Two times) across participant groups. Specifically the second subgroup for Group Three (non-dyslexic participants who spent more time on Task Two than other participants in their group) generally had faster Task Two times than participants in the same subgroup for both of the other groups, resulting in a shallower curve on the Task Two time plots for Group Three (though Task Three and total task times varied significantly in this subgroup).

Strategy analysis. ***Dyslexic and non-dyslexic participants just as likely to utilize higher level literacy strategies.*** Due to time limitations, as well as data quality, we preformed less extensive qualitative analysis of the two additional groups. However, reviewing our observations of participant sessions and post session interviews indicated that participants in both of these groups utilized strategies and practices that were also observed in Sellen and Harper's laboratory study (2002) including laying the pages out on the work space in order to more effectively and

efficiently navigate between them. One participant from Group Two commented that they would have spread the pages out further if we had provided a larger workspace, and they often lay printed documents out on the floor. Participants in both of these groups also used other strategies and practices that were indicative of higher level literacy including skimming, focusing on some sections more than others, or skimming the headings first to get a feel of the document before reading the main body. One participant in Group Three even stated that they "had a method" to reading, where they would skim by reading the first and last sentences of paragraphs before deciding which paragraph to read in full.

The fact that participants in both of these groups utilized these strategies and practices in roughly the same number as was observed in Group One, confirms the observations made from comparing task times and indicates that individuals with dyslexia are just as capable of developing higher level literacy skills as their non-dyslexic counterparts (this is at least true of dyslexics who attend college).

Dyslexic participants utilize non-textual techniques to aid in higher level literacy strategies. In addition to reporting skills traditionally associated with higher level literacy strategies, many participants in Group Two (dyslexic participants using paper) also discussed sophisticated and sometimes novel study strategies and memory techniques including constructing visual artifacts (either drawings or mental images of processes or ideas represented in text) or "reading" the images in documents first, then applying that knowledge to understanding the text, as well as developing color code notecard systems. In order to help them spell, one participant even used their fingers for letter "counters" by holding their hand out horizontally then lowering the finger which corresponded to which letter they were thinking about.

While these strategies were not specifically discussed in the previously cited literature on high level literacy, many of them were focused on the same aims. For instance consuming information from images first is very similar to skimming the headings to get a feel for a document and attempts to visualize the ideas represented in a text is essentially a means to developing a synthesized abstract understanding. What is novel about these strategies is that they emphasize non-textual and non-verbal ways of interpreting and understanding written text. For instance many participant strategies focused on visualization, and the use of fingers as counters for letters in words is essentially a way to draw upon kinesthetic resources to aid in the interpretation and production of written material. Nothing precluded non-dyslexic participants from utilizing similar strategies (in fact one participant from Group Three did mention that they usually look at pictures first), but these participants were less likely to emphasize such strategies during their interviews.

Kurzweil 3000 had a negative impact on submission quality metrics. Analysis of both outline complexity and word count of the two additional groups, revealed considerable differences between Group One and Groups Two and Three (see Figure 14 through Figure 17). Specifically, while the first group had slightly negative trends for both of the metrics when participants were plotted based on their Task Two time, these same trends were strongly positive for all metrics for both additional groups (particularly for Group Two's outline complexity). This was surprising given that the strong similarities between all groups regarding the plots for task times would have suggested similar trends in these plots as well. While these additional data complicate our understanding of participant strategies (unlike in Group One, in both of these groups participants who took longer on Task Two actually did make more complex outlines and longer summaries), these data are particularly useful in helping us understand how technology

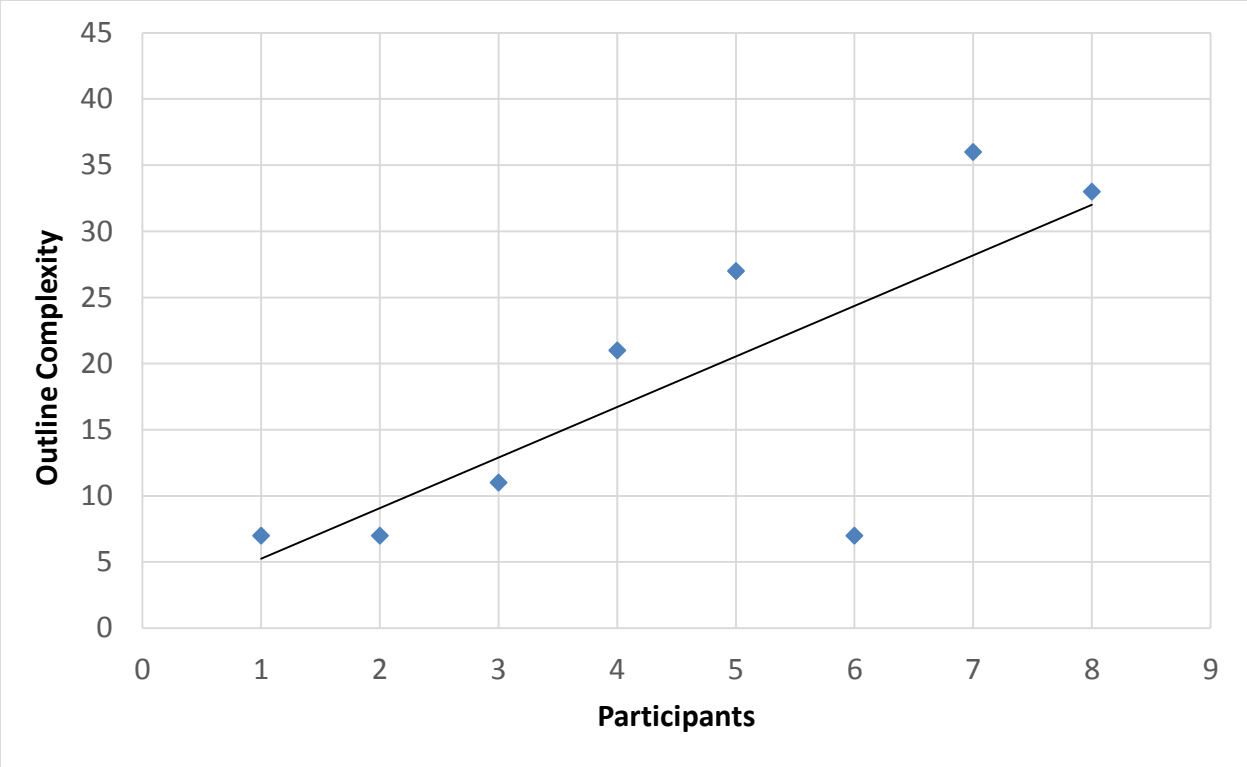

Figure 14. Outline complexity results for Group Two

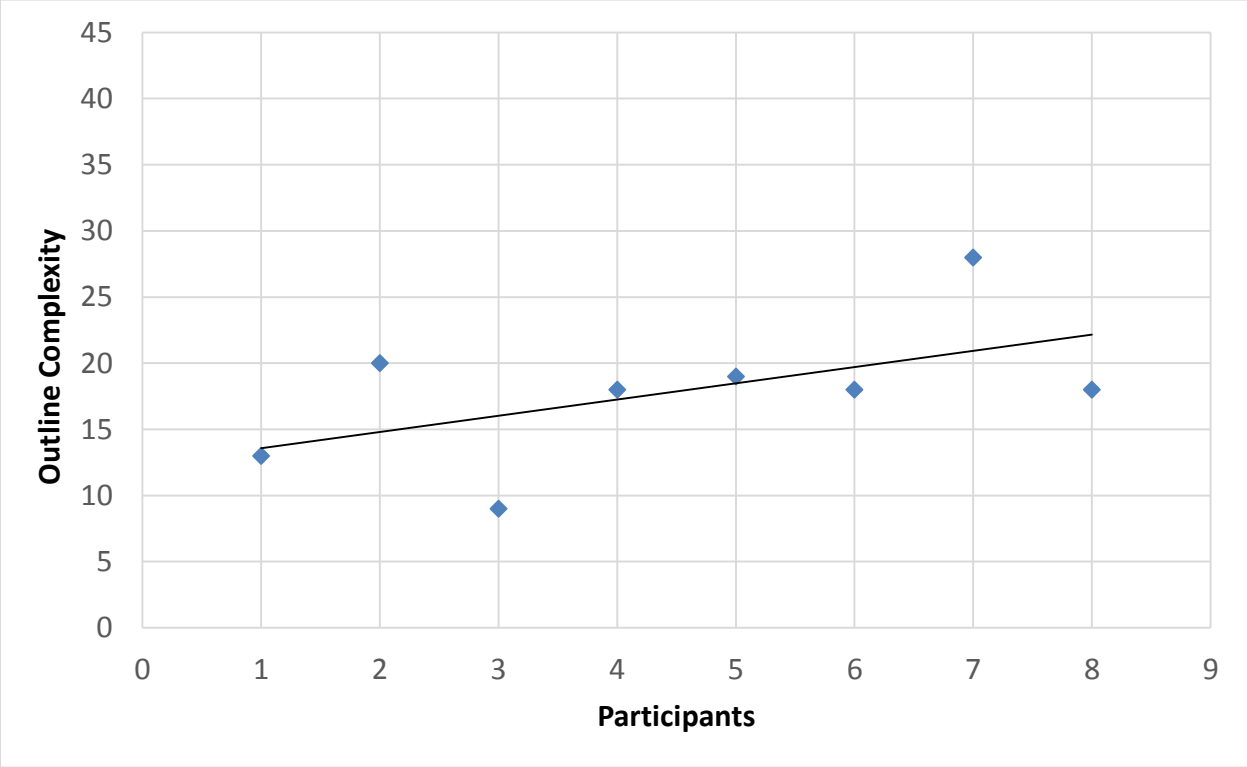

Figure 15. Outline complexity results for Group Three

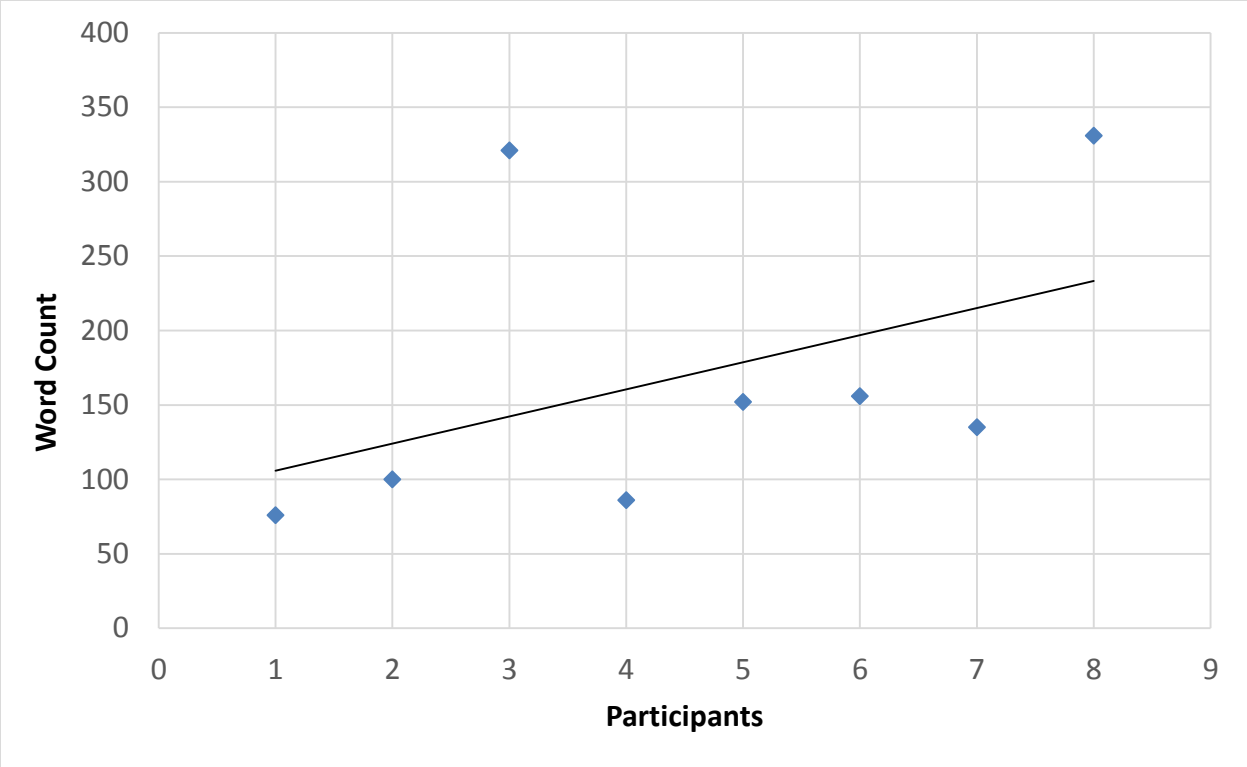

Figure 16. Summary word count results for Group Two

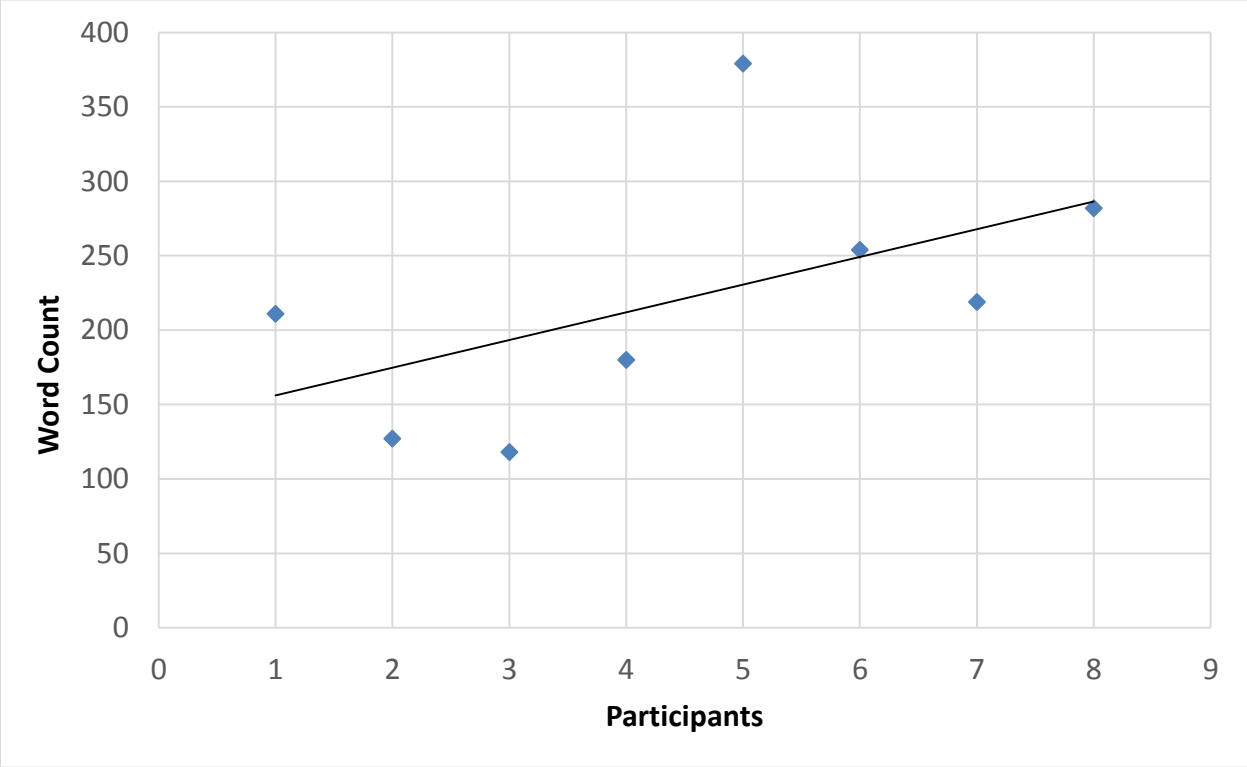

Figure 17. Summary word count results for Group Three

affected task time, strongly indicating that Kurzweil 3000 has a negative impact on the quality of participant submission (at least for participants who spent more time on Task Two). These data are also corroborated by descriptive statistical analysis of these two metrics, which reveals that for both metrics Group One had the lowest means and medians (see Tables 4 and 5 in Appendix G) indicating that as a whole Group One's outlines and summaries were less complex and shorter than either of the other groups.

A possible explanation for this, especially given the high number of breakdowns related to navigation within the document experienced by Group One, is that participants using paper (both dyslexic and non-dyslexic) had more freedom to devote the time they spent on Task Two to creating more detailed outlines and longer summaries, rather than trying to interface with the document itself. It is also likely that strategy might not be as clearly separable in the additional groups (task time may vary based on how thoroughly participants wanted to complete Tasks Two and Three as well as what strategies they used to do so). In addition, the very strong positive trend for outline complexity in Group Two (dyslexic participants using paper) is also consistent with many of the stories participants from both dyslexic groups told us regarding note taking and study practices. One participant in particular talked in great length about creating highly detailed notes for every reading assignment then referring back to the notes rather than the original text, and other participants in both dyslexic groups told similar stories about the importance of creating detailed outlines. This indicates that, particularly for Group Two, many participants took longer on Task Two because their standard note taking practices were in general more thorough than non-dyslexic participants. All of these data demonstrate that further qualitative analysis of the two additional groups could help to provide a clearer picture of how strategy played out within them.

The Role and Importance of Higher Level Literacy Strategies

Overall one of the most significant findings from this study is the role that strategy plays in effective reading, but more importantly, these findings demonstrate the value of strategy for individuals with dyslexia. In most cases, strategy was the dominant factor in determining task time, and for participants with dyslexia, it was even more of a determining factor than whether participants were using Kurzweil 3000 or paper. Overall, participants who skimmed sections then did focused readings (whether this meant using the text-to-speech feature of Kurzweil 3000 or not) completed the tasks far more efficiently than those who read using strategies that emphasized print level literacy.

Strategy and technology. Understanding the importance of strategy also helps us to better understand the role technology (assistive or otherwise) plays in reading. Because technology itself was not found to have a strong effect on task times and effective strategy reduced task times for all groups, this study suggests that the optimal role for technology is to support and even foster effective strategy, and for college level students that means higher level literacy strategies including skimming, cross-referencing, and skipping sections not relevant to the reader's current task. This understanding also helps explain some of the key differences between the Kurzweil 3000 group and the other groups, regarding outline complexity and summary word count, especially the reduced outline complexity and summary length for Kurzweil 3000 users (Kurzweil 3000 users had the lowest means and medians for both of these metrics, and spent more time on Task Two actually reduced both of these metrics for this group). As stated earlier by limiting the ability of participants to navigate within the document, Kurzweil 3000 introduced complications for participants trying to use higher level literacy strategies. While there were some participants who were able to integrate higher level literacy strategies

with Kurzweil 3000 (most notably the three participants in this group with the fastest Task Two time), even for these participants the unintuitive navigational controls made this difficult and as a result, overall Kurzweil 3000 did not support efficient or effective completion of the tasks (particularly Task Two).

Higher level literacy strategies and dyslexia. These findings have also allowed us to better understand both the role that higher level literacy strategies play in the literate practices of college students with dyslexia, and more importantly what affect dyslexia itself has on these strategies. Given that the tasks we designed emphasize higher level literacy, particularly quickly and effectively developing and then deploying a complex understanding of the document, the fact that when all participants are compared across groups, dyslexic participants are distributed across the Task Two data and the scatter plots for each individual group are highly comparable, strongly suggests that dyslexia does *not* result in an impairment in higher level literacy skills. Furthermore, because dyslexic participants were just as likely to both demonstrate strategies consistent with higher level literacy during the session and discuss the importance of these strategies to their work practices during the interviews, this interpretation is also strongly supported by the qualitative data as well.

This finding is still limited because, like Fink's study of highly successful dyslexics (1998), this study focused on a relatively successful group (college students with dyslexia), leaving open the possibility that dyslexia does affect the development of higher level literacy skills in at least a subgroup of individuals with dyslexia. However, now that the same result (no impairment in higher level literacy) has been found in two studies and a third paper detailing real-world experience—which together have sampled a large proportion of the dyslexic population, including highly successful dyslexics (a Nobel laureate, and a large number of

participants with post-secondary degrees) (Fink 1998), college students more broadly (the current study), and dyslexics enrolled in adult literacy classes at The Harvard Adult Literacy Center (Chall 1994)—it seems reasonable that the burden of proof should be shifted to those who would assume that such an impairment *does* exist.

Furthermore, these data from the current study also suggest that dyslexic participants have far more to gain from higher level literacy than their non-dyslexic peers. In particular, Group Three's shallower Task Two curve relative to Group Two, indicates that the non-dyslexic participants were more able to recover from less efficient strategies (ineffective strategies resulted in less dramatic increases in task time), whereas when using these strategies individuals with dyslexia perform in a way that is highly comparable to their non-dyslexic peers. Though additional analysis of the qualitative data would be needed to more thoroughly confirm this interpretation, like Sylvia Law's previously cited testimony (Fink 1998, p. 327), these data suggests that higher level literacy strategies can be an important way to mitigate continued impairments in print level literacy.

Implications

Research

Much current dyslexia research is focused on trying to identify a root physiological cause for dyslexia (currently there are three leading theories), usually through identifying specific impairments. This research focus has resulted in both an overemphasis on the cognitive processes that underlie tasks such as letter recognition or word decoding (effectively, print level literacy skills), as well as impairments as opposed to strengths. One study form the Journal *Brain* demonstrates both of these emphases (Franck et. al., 2002), which sought to resolve the controversy regarding the root cause of dyslexia by testing for a variety of impairments. But what is most interesting about this study is that it actually discovered that dyslexic participants scored higher than controls on the WAIS picture completion subtest (which tests the ability to quickly perceive visual details) (p. 851), yet this finding, although significant, was virtually ignored in the paper, likely because it did not fit into the current agenda of dyslexia research.

While these studies provide valuable insight, from both an information design and particularly a user-centered design stand point, as well as a research standpoint that focuses on the implications that dyslexia has on how individuals approach and accomplish knowledge work, these studies are incomplete and can even lead designers, policy makers, educators, and advocates for individuals with dyslexia to make assumptions about how print level impairments can affect high level tasks.

To information designers, this is a familiar problem described by Clay Spinnuzi as the problem of unintegrated scope (2003, chapter 2). In this scenario, information designers utilize a research technique that focuses on one level of scope (either macro, messo, or micro) and as a result they identify solutions to design problems that fail to take into account either the

complexities of the other levels or the interconnectedness of all the levels, usually by identifying a crux to the problem focused on the level of study. In this instance, research that focuses on the cognitive processes that underlie print level literacy (something on the micro level of scope) has tended to treat impairments on this level as cruxes to issues of literacy in general.

The solution to this problem is to utilize an integrated scope perspective by collecting data and developing methodologies that are not dependent on a single level of scope.[9] While our study is limited, it sought to approach both dyslexia and reading utilizing an integrated scope, both through consulting a variety of previous research and theory (which greatly shaped our methodology, especially what tasks we used and which aspects of literacy we paid closest attention to) and collecting data relevant to different levels of scope. For instance reviewing the recordings of participant tapes allowed us to directly observe micro level actions (a participant skims the headings of the document), while the post session interviews allowed us to both better understand the meso-level reasoning behind those actions (the participant wants to get a better sense of the whole document before deciding how to approach it more carefully), and also ask questions about how those actions fit into macro-level practices (i.e., how typical were specific actions, and in what context would participants use them).

This methodology allowed us to better understand the role that both dyslexia and assistive reading technologies play in knowledge work and literacy far more broadly than most previous research and also allowed us to better understand the role participant strengths play in those work and literacy practices. For instance, the finding that college level students are not impaired in higher level literacy skills indicates that while print level impairments likely still

[9] In his book, Spinuzzi (2003) outlines an integrated scope methodology called genre tracing.

exist for these individuals (localized to the micro level), these impairments, in and of themselves, do not create an impairment in higher level literacy skills such as skimming, evaluating documents for specific uses, or synthesizing together ideas from multiple documents (all localized to the messo and macro levels), even if lower level skills are involved in these tasks.

As the current study demonstrates, future research which emphasizes an integrated scope can allow us to better understand how specific impairments, but also strengths, affect the lives of individuals with dyslexia and the activities that they are a part of and design better technological and social interventions. Potential avenues for this research would include, ethnographic or qualitative studies of dyslexic writing and reading practices.

Pedagogy

As detailed in an article in the journal *Science* (Gabrieli 2009, p. 282), traditional childhood dyslexia educational interventions, which usually emphasize intensive phonics instruction, are extremely resource intensive (100 minutes per day for eight weeks, and involving a teacher to student ratio of about two to one), have not been shown to benefit all students, and rarely mean that students "catch up" with their peers. Furthermore, only half of students maintain the benefits of these programs after two years, and even then, these benefits are more likely to be centered on decoding accuracy rather than overall fluency (which is arguably far more important to real-world applications and higher level literacy).

Over an hour and a half of intensive instruction a day must take a toll on students especially when this time is spent on skills that are innately difficult for the student to develop, and when they involve removing students from traditional classes, an experience that is both potentially stigmatizing and which means students miss out on the opportunities to be exposed to

content knowledge and critical thinking from non-textual sources presented by good classroom instruction.

In light of the finding that individuals with dyslexia likely do not have an impairment in higher level literacy skills, it would seem prudent to rethink this "back to basics" approach. By focusing on systematic phonics instruction, these remedial approaches focus on the skills for which individuals with dyslexia are impaired, and divert school resources, as well as student time and energy away from talents and skills for which they are unimpaired. Teaching strategies that emphasize developing higher level literacy skills, on the other hand, would allow students to build on and utilize skills that they are not only unimpaired in, but that are valuable for all students.

Higher level literacy skills and the specific practices that go along with them, including skimming and drawing connections between different texts, also promote schema knowledge (an understanding of how information is generally presented and logically structured within a field or discourse) which in turn promotes further literacy development (Anderson 1983, as cited in Fink, 1998, p. 324). Schema knowledge both makes it easier to understand a document, and apply strategies like reading from context—a method used by many individuals with dyslexia (Shaywitz, 2008) including many of the successful individuals in Fink's study (1998, p. 325). Fink also identified "deep schema knowledge" as critical to the success of the majority of the participants in her study (p. 324), allowing them to read material about subject matters they were already familiar with more easily, further expanding their knowledge on that topic and developing their literacy skills (print as well as higher level).

Because print level literacy skills are generally seen as necessary for the development of higher level skills, this may mean developing new teaching strategies, and rethinking existing

models. For instance, the traditional educational model introduces students to content, predominantly through print, before introducing them to the logic that organizes that content or often leaves students to discern this for themselves. In most college level classrooms this model leads to a pattern of "read, write, discuss," where students are given a text, often with no background on it other than their general topic, expected to consume that text as content, then expected to reflect on that text in writing, before being given the opportunity to discuss the text in class. But Fink's study demonstrates that this is not necessarily the only path, and likely not the most efficient path for many with dyslexia, to developing higher level literacy skills. Specifically, many of her participants still had impairments in print level literacy in adulthood, but also had strong skills in higher level literacy (p. 328).

One possible method for improving access in the college level classroom and helping dyslexic students develop higher level literacy skills is to provide more non-textual ways to engage with content, particularly earlier in the typical unit or lesson. The essential problem with the "read, write, discuss" is that it means that students with dyslexia are required to engage with the material in the modality that is least accessible first, and by the time content is engaged in an accessible format (usually class discussion) students with dyslexia are already at a disadvantage in terms of being prepared to engage. The implication of this is that, in a sense, for students with dyslexia, understanding becomes a prerequisite to access, an inversion of the traditional path. Students with dyslexia, and perhaps other learning disabilities, would likely benefit if this model were flipped, or more accurately if it were complicated by providing additional avenues of engagement, especially if this early non-textual engagement focuses on developing schema knowledge (e.g., explicitly discussing how the class readings, or readings in the field more generally, are organized, or discussing the general principles behind a text, or a group of texts,

before they are assigned).[10] This engagement will help students better focus their approach to the readings, allowing them to read more efficiently and even providing more time for them to explore additional ideas within the specific text, or link these texts to their personal academic interests. Potential avenues for this type of engagement can take the form of preliminary class discussion, office hours, or the inclusion of non-textual media in class assignments.

An important note to make is that none of this is to say that these students are less capable of discerning logical structures, only that discussion is a better modality with which to expose these students to them. We know that helping students develop schema knowledge, and as a result develop higher level literacy skills, actually makes reading easier, something that can be a benefit in the current class but also future classes, and other knowledge work situations. Explicit discussion of schema knowledge can also model for students (dyslexic and otherwise) how to develop this knowledge in other areas of their studies, and demonstrate its benefits, again something they can carry with them beyond the specific course.

Policy

Non-impairment in higher level literacy skills also has important implications for policy decisions regarding students with learning disabilities, especially considering that in this study these skills were more essential to effective and efficient task completion than assistive technology. While some participants were able to combine high level literacy strategies with Kurzweil 3000, they often had to employ workarounds, and generally work against the natural tendencies of the program to do so. For other students, presenting Kurzweil 3000 as the primary

[10] An accommodation I negotiated with one of my professors that was particularly helpful was allowing me to turn in my written response after the class discussion instead of before. This allowed me the opportunity to use class discussion to fill in gaps in my reading, as well as develop the schema knowledge necessary to return to sections of that reading more easily before finishing my written response.

means of accommodation, without also finding ways to encourage higher level literacy strategies, could send the message that the silent sustained model of literacy embedded in the program[11] is the only means to accomplish college level work. Use of the program itself may even limit the development of these skills by making them more difficult to utilize.

College and disability resource center policies that focus on developing (and perhaps even destigmatizing) higher level literacy skills and strategies (while still providing support for students who have already integrated assistive reading technologies into their work practices) not only have the potential to provide greater support for students, but also offer the potential of providing students with a greater degree of independence, both in college and beyond. For instance, the LearnStation version of Kurzweil 3000 which RCPD suggested I purchase does not support optical character recognition, or the conversion of file types like PDFs to the .kes file type (Kurzweil 3000's proprietary file type). This meant that I had to rely on RCPD to scan print materials and convert digital documents, something which represents a significant institutional infrastructure that will likely not be available to me after graduation or in the workforce. Even if I had invested in the full version as well as any scanning hardware it required, scanning documents would still have taken a significant amount of time, presenting another barrier to access. On the other hand, policies that focus on developing high level literacy skills would also have lasting benefits as adults with these skills can leverage them in virtually any situation (whether that is in the classroom, the workplace, or their daily life). This does not mean that accommodations should not be made for these individuals, or that print level literacy impairments would not affect how individuals with dyslexia would approach these tasks, but it does suggest that, like educational policy and accommodation, the nature of such

[11] In which, as quoted earlier in this paper, "good readers read every word. They do not skim or rely on context for decoding," (Kurzweil Education Systems, 2004, p. 3)

accommodations should be reconsidered: instead of focusing primarily on finding alternative means of delivering content (as Kurzweil 3000 does) their goal should be to support the practices and skills for which dyslexic individuals are not impaired, and help them find ways to utilize these skills to develop effective work practices.

Design

Above all, this study demonstrates the importance of incorporating an understanding of the complexities of literacy and how it is specifically affected by dyslexia into the implementation and design of technological interventions, in particular highlighting the need for additional research on the reading and writing practices of individuals with dyslexia. But this study also demonstrates the importance of valuing and understanding the abilities of individuals with dyslexia and learning disabilities when designing these interventions. In the end, Kurzweil 3000 did not show substantial benefits for college students doing high level literacy tasks in this study not only because it approached literacy from a limited perspective, as evidenced by its white paper (Kurzweil Education Systems, 2004), but also because it failed to account for and support the literate strengths of its users.

One potential avenue to incorporate these understandings, beyond additional research into the successful writing and reading practices of individuals with learning disabilities, is incorporating more user feedback in the design process, something that has long been seen as essential to the accessibility of information technology (Slatin and Rush, 2003, p. 143-146). Given the complexity of the activities these technologies attempt to intervene in, incorporating this type of involvement is likely necessary for designing information systems and practices that are truly accessible for individuals with learning disabilities. From a synthesis of Sellen and Harper (2002) and Chall (1983) we can see not only the diversity of writing practices,

but the essential importance of this diversity to participation within knowledge work. On a regular basis, individuals use workspaces to spatially organize documents; seamlessly move between printed pieces of paper, books, trade journals, magazines, websites, emails, and word processors; employ whatever tools and techniques are available for annotating, including folding back the corners of pages, bookmarking websites, and writing on documents and notepads; and most importantly interweave disparate texts together applying them to the specific task at hand. From a design standpoint, this complexity is truly daunting, and it is hard to imagine a single technological intervention replacing or even supporting all of these functions. But at the same time, as the resourcefulness of dyslexic participants in this study suggests, such an intervention is likely not necessary.

As Huatong Sun demonstrates in her study of the efforts users made to localize text messaging systems (2006), designing fully localized products is not possible (p. 478). Supplementing Robert Johnson's call for greater user involvement in the design process (1997), Sun argues that the design processes should be extended, allowing users to "complete the design" after the product has been shipped, through developing and determining how a product is used within a particular social context (p. 477). Despite the fact that designers did very little to localize SMS and didn't anticipate the myriad of uses the technology would ultimately be applied to, users were able to overcome a cumbersome interface to adapt the technology to fit within their lives (p. 475), demonstrating that user feedback can be a powerful resource for designers. In the context of this study, the efforts of users to integrate high level literacy strategies with Kurzweil 3000, including developing navigational workarounds, as well as the highly sophisticated study strategies participants discussed in the post session interviews, which included among other things constructing visual artifacts, making detailed notes, consulting non-

textual sources, and engaging peers in discussion of topics, can all be seen as attempts at user localization of print technology and present avenues for designers to better understand how individuals with dyslexia accomplish knowledge work and support those practices. Furthermore, because existing guidelines for accommodating dyslexic users closely parallel recommendations for other disability groups (Evett and Brown, 2005, as cited in McCarthy and Swierenga, 2010, p. 150) and improving site accessibility for low literacy and dyslexic users has been shown to improve user experience for all users (Nielsen, 2005; McCarthy and Swierenga, 2010, p. 147, 151) incorporating more user involvement of individuals with dyslexia within the design process can also have important benefits for non-dyslexic users as well.

Given the complexity of literacy, improving access will require more than the design of a single technological intervention, but the redesign of systems of practice, an activity that would be impractical and likely ineffective unless it is guided and undertaken, not only by designers, but by the individuals for whom those systems need to operate. What might eventually provide the best access for individuals with learning disabilities may not be a specialized tool, but a set of practices those individuals use to localize existing technologies. This is not to say that there is no room for assistive technologies, or that issues of accessibility should not be a conscious part of all design, only that user involvement is vital to its success, and the most effective role that rhetoricians, technical communicators, and user experience researchers can play is to facilitate that involvement. Finally, understanding the importance of user feedback and involvement in the design process also points to one of the roles that rhetoric and composition can play in what Clay Spinuzzi calls "an interdisciplinary effort to define and refine accessibility in multiple activities, to resolve its contradictions, and turn it into a more settled enterprise that concretely improves people's lives" (2007, p. 200), specifically, the role of user advocate.

APPENDICES

Appendix A

Sellen and Harper's ten categories of reading

Reading to identify Glancing at a document only in order to *identify* what a document is or what type of document it is.

Skimming Reading rapidly in order to establish a rough idea of what is written, to decide whether any of its contents might be useful, or whether anything needs to be read in more detail later.

Reading to remind Reading specifically in order to remind oneself of what to do next, e.g., a to-do list, shopping list, Post-it note.

Reading to search for answers to questions Reading to search for particular information: to answer a question, for reference, or to obtain information necessary to make a decision. This kind of reading is goal-directed ranging from very simple goals to complex decision-making or problem-solving tasks.

Reading to self-inform Reading for the purpose of furthering general knowledge without any specific goal to which the information will be applied.

Reading to learn Reading with the goal of being able to relate or apply information at a later date. Includes reading to review the basic concepts for discussion, or reading which is much more reflective in nature.

Reading for cross-referencing Reading across more than one document or more than one page in order to integrate information. This is often done for the purpose of writing, and may well include some editing activities.

Reading to edit or critically review text Reading in order to monitor what has been written in terms of content, style, grammar, syntax, and/or overall presentation. Includes editing one's own text, seeing how one's own text fits into a collaborative document, or the review of the text of others.

Reading to support listening Reading in order to support listening to someone else talk (e.g., following a presentation by looking at a series of slides).

Reading to support discussion Referring to a document during a discussion in order to establish a mutual frame of reference and focus for discussion. Usually takes place in a face-to-face meeting.

Figure 18. Sellen and Harper's ten categories of reading. Reprinted from the Myth of the Paperless Office, by Abigail Sellen and Richard H. R. Harper, published by The MIT Press (2002, p.83).

Appendix B

Demographic Questionnaire

Job Function/Title in Agency/Organization: _____

Students – Area of Study/College Major: _____

What is your current level of education? _____

Age: _____

Where do you live? _____

How often do you use the Internet as part of your job or education?

- ❑ Every day
- ❑ 2 – 5 times per week
- ❑ 1 – 2 times per week
- ❑ Less than once per week
- ❑ Never

Which web search engine do you use most often?

- ❑ Google
- ❑ MSN
- ❑ Yahoo
- ❑ Bing
- ❑ Other _____

What browser do you use most often?

- ❑ Internet Explorer
- ❑ Mozilla Firefox
- ❑ Google Chrome
- ❑ Safari
- ❑ Other _____

What software (assistive technology) do you usually use, if any?

- ❑ JAWS
- ❑ Window Eyes
- ❑ Zoomtext
- ❑ Kurzweil 3000
- ❑ Other _____

What platform do you usually use?

- ❑ PC (Windows)
- ❑ Mac

What are you typically looking for on the Internet?

_____

What types of activities do you perform using the Internet? (select all that apply)

- ❑ Check email
- ❑ Check weather
- ❑ Read news
- ❑ Chat/Instant Message
- ❑ Research
- ❑ Play games
- ❑ Plan a trip or find a map
- ❑ Shop on-line
- ❑ Other _____

What do you usually do when you visit a website? (select all that apply)

- ❑ Read all the navigation items then make a decision how to proceed
- ❑ Scan the headings to find relevant information
- ❑ Read the content on the homepage, then decide how to proceed
- ❑ Access the site map if one is available
- ❑ Immediately access the "search" and type in a keyword
- ❑ Other _____

What are the main issues you have when you visit web sites?

- ❑ Can't find what I'm looking for
- ❑ Too many graphics make it hard to read
- ❑ If there's no search box, I am lost
- ❑ I can't understand the information
- ❑ Other _____

In your opinion, how much reading do you do in conjunction with your work when compared with your coworkers or peers?

Above average Average Below Average
0 _____ 1 _____ 2 _____ 3 _____ 4

When reading, how often do you use context clues to understand word meaning?

Rarely Sometimes Often
0 _____ 1 _____ 2 _____ 3 _____ 4

What kind of technology do you prefer using to read?

- ❑ Computer printouts
- ❑ Bound texts such as books
- ❑ On the computer
- ❑ A device like an e-reader or tablet
- ❑ Other _____

Please explain why

_____
_____
_____
_____

Appendix C

Adult Reading History Questionaire

Please circle the number of the response that most nearly describes your attitude or experience for each of the following questions or statements. If you think your response would be between numbers, place and "**X**" where you think it should be.

1. Which of the following most nearly describes your attitude toward school when you were a child:

Loved school; favorite activity — **Hated school; tried to get out of going**

0 _____ 1 _____ 2 _____ 3 _____ 4

---

2. How much difficulty did you have *learning* to read in elementary school?

None — **A great deal**

0 _____ 1 _____ 2 _____ 3 _____ 4

---

3. How much extra help did you need when learning to read in elementary school?

Help from:

No help — **Friends** — **Teachers/ parents** — **Tutors or special class *1 year*** — **Tutors or special class *2 year***

0 _____ 1 _____ 2 _____ 3 _____ 4

---

4. Did you ever reverse the order of letters or numbers when you were a child?

No — **A great deal**

0 _____ 1 _____ 2 _____ 3 _____ 4

---

5. Did you have difficulty learning letters and/or color names when you were a child?

No — **A great deal**

0 _____ 1 _____ 2 _____ 3 _____ 4

---

6. How would you compare your reading skill to that of others in your elementary classes?

Above average — **Average** — **Below Average**

0 _____ 1 _____ 2 _____ 3 _____ 4

---

7. All students struggle from time to time in school. In comparison to other in your classes, how much did you struggle to complete your work?

Not at all	**Less than most**	**About the same**	**More than most**	**Much more than most**
0	1	2	3	4

---

8. Did you experience difficulty in high school or college English classes?

No; enjoyed and did well		**Some**		**A great deal; did poorly**
0	1	2	3	4

---

9. What is your current attitude toward reading?

Very positive				**Very negative**
0	1	2	3	4

---

10. How much reading do you do for pleasure?

A great deal		**Some**		**None**
0	1	2	3	4

---

11. How would you compare your current reading speed to that of others the same age and education?

Above average		**Average**		**Below Average**
0	1	2	3	4

---

12. How much reading do you do in conjunction with your work?

A great deal		**Some**		**None**
0	1	2	3	4

---

13. How much difficulty did you have *learning to spell* in elementary school?

None		**Some**		**A great deal**
0	1	2	3	4

---

14. How would you compare your current spelling to that of others of the same age and education?

Above average		**Average**		**Below Average**
0	1	2	3	4

---

15. Did your parents ever consider having you repeat any grades in school due to academic failure (not illness)?

No	Talked about it, but didn't do it	Repeated 1 grade	Repeated 2 grades	Dropped out
0	1	2	3	4

---

16. Do you ever have difficulty remembering people's names or names of places?

No				A great deal
0	1	2	3	4

---

17. Do you have difficulty remembering addresses, phone numbers, or dates?

No				A great deal
0	1	2	3	4

---

18. Do you have difficulty remembering complex verbal instructions?

No				A great deal
0	1	2	3	4

---

19. Do you *currently* reverse the order of letters or numbers when you read or write?

No				A great deal
0	1	2	3	4

---

20. How many books do you read for pleasure each year?

More then 10	6-10	2-5	1-2	None
0	1	2	3	4

---

21. How many magazines do you read for pleasure each month?

5 or more	3-4 regularly	1-2 regularly	1-2 Irregularly	None
0	1	2	3	4

---

22. Do you read daily (Monday-Friday) newspapers?

Everyday	Once a Week	Once in a while	Rarely	Never
0	1	2	3	4

---

23. Do you read a newspaper on Sunday?

Completely every Sunday	Scan each week	Once in a while	Rarely	Never
0	1	2	3	4

*****Please check the most appropriate answer for each of the following questions*****

24. To the best of your knowledge, did *your* parents ever report that either one of them had a problem with reading or spelling?

____ Yes

____ No

____ Not sure

If yes, please give details:_____

_____

_____

_____

_____

25. To the best of your knowledge, did *your* brothers and/or sisters ever have a problem with reading or spelling?

____ Yes

____ No

____ Not sure

---

26. What is the highest educational level that you have attained?

____ High school, did not graduate

____ High school graduate

____ Trade or business school

____ Some college, did not graduate

____ Junior college graduate, associate's degree (or equivalent)

____ College graduate, bachelor's degree (or equivalent)

____ Some postgraduate education, no advanced degrees

____ Attained 1 or more advanced degrees

Appendix D

Document sample pages

Cruel Pies:

The Inhumanity of Technical Illustrations

SAM DRAGGA AND DAN VOSS

Illustrations such as pie graphs, line graphs, bar graphs, diagrams, drawings, and photographs occur widely in technical publications. Virtually every teacher and textbook advises writers to incorporate such illustrations whenever possible. A rapid rise in the international distribution of information also encourages technical communicators to substitute pictures for words or at least to reinforce words with pictures. And more and more every day, technological innovations make doing so both quicker and easier.

The discussion of ethics in technical illustrations, however, focuses chiefly on issues of deception or distortion (that is, telling lies). This focus on graphic lies creates a limited understanding of the ethics of visual display. As a result, in certain rhetorical situations—especially in the reporting of human fatalities—conventional illustrations offer inhumanity as though it were objectivity.

This article will therefore address the following:

- Review the existing research to define the prevalent treatment of the ethics of visual communication in the field and determine where it may be lacking
- Explain the implications of introducing a broader, more humanistic view of ethical illustrations
- Demonstrate the need for this humanistic view by looking at a sampling of conventional graphic images
- Explore possible techniques for humanistic illustration

A LIMITED DEFINITION OF THE ETHICS OF VISUAL COMMUNICATION

In the existing research on the ethics of visual communication, the definition of ethics is almost always linked to distortion and deception. For example, in "Ethics and graphic design," TyAnna K. Herrington (1995), explains that "readers bring less sophistication, and thus less skepticism, to the comprehension of graphic representation" (p. 153), and are therefore especially susceptible to visual displays that mislead and manipulate readers by disguising "the whole truth" (p. 156).

Similarly, in "Ethics and visual rhetorics: Seeing's not believing anymore," Nancy Allen (1996) discusses the "visual trickery" available to technical communicators, citing such techniques as the suppression of the zero point in line graphs and the use of disproportional pictographs (pp. 90–92). Sam Dragga's (1996) U.S. survey on the ethics of information design offers seven brief scenarios for subjects to judge; however, each scenario focuses exclusively on issues of deception.

In *The visual display of quantitative information*, Edward R. Tufte (1983) declares "graphical excellence requires telling the truth" (p. 53). He offers a formula for calculating the "lie factor" (p. 57) and denounces "lying graphics" (p. 77). The remaining characteristics of graphical excellence, however, hinge exclusively on efficiency of communication. In both *Envisioning information* (1990) and *Visual explanations* (1997), Tufte further defines the ethics of visual communication, but the treatment is still limited to issues of accuracy and validity.

In *Elements of graph design*, Stephen M. Kosslyn (1994) addresses visual ethics by explaining and exemplifying 25 ways to avoid graphic distortions and deceptions (pp. 207–235).

In *Designer's guide to creating charts and diagrams*, Nigel Holmes (1984), a leading practitioner of the picto-

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Figure 19. Sample page for Group One (Kurzweil 3000 version). Figure is intended so show text formatting; the text itself is not intended to be readable.

Cruel Pies: The Inhumanity of Technical Illustrations

SAM DRAGGA AND DAN VOSS

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Figure 20. Sample page for Groups Two and Three (Paper version). Figure is intended so show text formatting; the text itself is not intended to be readable.

Appendix E

Post Session Questionnaires

Kurzweil 3000 version (Group One)

Please rate how strongly you agree or disagree with each of the following statements by circling the appropriate number.

	Strongly Disagree						Strongly Agree
Using Kurzweil 3000 in my academic work would enable me to accomplish tasks more quickly.	1	2	3	4	5	6	7
Using Kurzweil 3000 would improve my academic performance.	1	2	3	4	5	6	7
Using Kurzweil 3000 in my academic work would increase my productivity.	1	2	3	4	5	6	7
Using Kurzweil 3000 would enhance my effectiveness in my academic work.	1	2	3	4	5	6	7
Using Kurzweil 3000 would make it easier for me to do academic work.	1	2	3	4	5	6	7
I would find Kurzweil 3000 useful in my academic work.	1	2	3	4	5	6	7
Learning to use Kurzweil 3000 would be easy for me.	1	2	3	4	5	6	7

I would find it easy to get Kurzweil 3000 to do what I want to do.	1	2	3	4	5	6	7
My interaction with Kurzweil 3000 would be clear and understandable.	1	2	3	4	5	6	7
I would find Kurzweil 3000 flexible to interact with.	1	2	3	4	5	6	7
It would be easy for me to become skillful at using Kurzweil 3000.	1	2	3	4	5	6	7
I would find Kurzweil 3000 easy to use.	1	2	3	4	5	6	7

Paper version (Groups Two and Three)

Please rate how strongly you agree or disagree with each of the following statements by circling the appropriate number.

	Strongly Disagree						Strongly Agree
Reading articles on paper in my academic work would enable me to accomplish tasks more quickly.	1	2	3	4	5	6	7
Reading from paper would improve my academic performance.	1	2	3	4	5	6	7
Reading from paper in my academic work would increase my productivity.	1	2	3	4	5	6	7
Reading from paper would enhance my effectiveness in my academic work.	1	2	3	4	5	6	7
Reading from paper would make it easier for me to do academic work.	1	2	3	4	5	6	7
I would find reading from paper useful in my academic work.	1	2	3	4	5	6	7
Learning to read academic articles from paper would be easy for me.	1	2	3	4	5	6	7
I would find it easy to read a document the way that I want when reading from paper.	1	2	3	4	5	6	7

My use of paper for academic purposes would be clear and understandable.	1	2	3	4	5	6	7
I would find paper flexible to interact with.	1	2	3	4	5	6	7
It would be easy for me to become skillful at reading academic articles from paper.	1	2	3	4	5	6	7
I would find paper easy to use for academic purposes.	1	2	3	4	5	6	7

Appendix F

Post-session interview questions

Kurzweil 3000 version (Group One)

- Did anything feel unnatural or atypical about the reading or writing that you did during the observed session?
    - If so what?
- In the first task, what were the clues that you used to determine the document's genre?
- I noticed that you took notes, could you elaborate on how you used them to support the reading or writing you did?
- At one point you appeared to be skimming a section, is that the case?
- At times you seemed to be moving back and forth within the document, could you explain the thought process behind this?
- I noticed you made an effort to rearranged your workspace or make adjustments to your computer could you tell me why you did this?
- You seemed to have trouble with a particular feature of the software program, if so:
    - How did you expect this feature to operate?
    - How did this unexpected behavior affect your work flow?
    - How did you eventually solve this problem
        - Did you get the feature to work the way you wanted it to?
        - Did you find a way to get another feature to fulfill the functionality that you expected?
        - Did you give up on finding the functionality you wanted?
- When you have used Kruzweil 3000 in the past, what are the main things you use it for?
    - What kind of documents?
    - Under what conditions (more or less interest in the content, time constraints, etc.)?
- What do you use to read when you don't use Kruzweil 3000?
    - Why do you choose that particular way to read?
- Did you use the graphics to help understand the article?
- When you wrote the summary, did you rely more on your memory of the article, your outline, or referring back to the article itself?

Paper Version (Groups Two and Three)

- Did anything feel unnatural or atypical about the reading or writing that you did during the observed session?
    - If so what?
- In the first task, what were the clues that you used to determine the document's genre?
- I noticed that you took notes, could you elaborate on how you used them to support the reading or writing you did?
- Did you markup the document at all?
- At one point you appeared to be skimming a section, is that the case?
- At times you seemed to be moving back and forth within the document, could you explain the thought process behind this?
- I noticed you made an effort to rearranged your workspace or make adjustments to your computer could you tell me why you did this?
- What do you normally use to read?
    - Why do you make these choices?
- Did you use the graphics to help understand the article?
- When you wrote the summary, did you rely more on your memory of the article, your outline, or referring back to the article itself?

Appendix G

Full Data Tables

Table 1. Group One (participants using Kurzweil 3000).

Participant	Task 1	Task 2	Task 3	Total Time	Outline Complexity	Summary Word Count
1	4:35	7:18	9:01	20:54	5	124
2	5:16	8:29	5:27	19:12	14	88
3	3:14	15:09	14:18	32:41	15	159
4	1:53	24:21	16:02	42:16	41	248
5	5:01	28:27	10:38	44:06	24	153
6	3:04	28:54	9:59	41:57	6	125
7	6:08	30:38	10:57	47:43	10	151
8	0:02	37:10	3:30	40:42	4	59

Table 2. Group Two (dyslexic participants using paper).

Participant	Task 1	Task 2	Task 3	Total Time	Outline Complexity	Summary Word Count
1	1:23	6:56	3:44	12:03	7	76
2	1:20	9:38	9:47	20:45	7	100
3	2:16	10:04	36:19	48:39	11	321
4	3:57	19:19	4:49	28:05	21	86
5	5:02	22:27	14:38	42:07	27	152
6	1:00	31:54	15:45	48:39	7	156
7	1:32	32:34	11:23	45:29	36	135
8	5:41	38:43	16:39	1:01:03	33	331

Table 3. Group Three (non-dyslexic participants using paper).

Participant	Task 1	Task 2	Task 3	Total Time	Outline Complexity	Summary Word Count
1	4:45	7:39	10:40	23:04	13	211
2	1:45	9:54	5:10	16:49	20	127
3	3:02	10:15	5:48	19:05	9	118
4	1:07	12:31	11:17	24:55	18	180
5	4:15	19:27	11:23	35:05	19	379
6	0:35	19:49	7:30	27:54	18	254
7	1:48	24:33	18:48	45:09	28	219
8	0:19	38:48	20:59	1:00:06	18	282

Table 4. Descriptive statistics (outline complexity).

	Group One	Group Two	Group Three
Mean	14.875	18.625	17.875
Median	12	16	18
Range	37	29	19
Minimum	4	7	9
Maximum	41	36	28
Standard Error	4.401450654	4.325743	1.940522
Standard Deviation	12.44918242	12.23505	5.488625
Sample Variance	154.9821429	149.6964	30.125

Table 5. Descriptive statistics (summary word count).

	Group One	Group Two	Group Three
Mean	138.375	169.625	221.25
Median	138	143.5	215
Range	189	255	261
Minimum	59	76	118
Maximum	248	331	379
Standard Error	19.83858	35.67159	30.17908
Standard Deviation	56.11197	100.8945	85.35932
Sample Variance	3148.554	10179.7	7286.214

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