Technology and Disability: A Help or a Hindrance?

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Abstract

This paper explores the paradoxical nature of computer technology to both help and hinder people with disabilities (PWD). More specifically, it examines how assistive computer technology improves or alleviates disability and how standard computer technology produces or exacerbates disability. The study consists of 12 interviews with people who have a physical or mental disability that requires them to use assistive technology (AT) to access the computer or complete cognitive tasks. The study results investigate the complex mix of benefits and drawbacks experienced by AT users. The types of AT include screen magnifiers, screen readers, voice recognition systems (VRS) and two other devices that convert handwriting to text. The study demonstrates that while AT helps provide partial computer access to PWD, its many technical defects and social costs prevent it from solving the problem of computer access for PWD. The study also reveals that screen readers and VRS simultaneously help and hinder reading and writing. When PWD are denied full computer access, they are denied the same economic, educational and social opportunities afforded to those who are free of disability and this puts them at risk of becoming even more disadvantaged. This paper addresses the concern that the standard computer's restrictive interface may work to further the divide between the able and the disabled.

Key Words

computers, assistive technology (AT), disability, accessibility, obstacles, opportunities, limitations, restrictions, hardware/software design, internet.

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Introduction

Technology has a paradoxical power to both help and hinder people with disabilities (PWD). Computer technology in particular, can simultaneously produce and alleviate disabilities, serving as both the problem and the solution. For example, the standard computer, with its traditional keyboard, mouse and screen monitor, is not accessible to many people with physical or sensory impairments, however, it is often the addition of *more* computer technology, in the form of assistive devices, that enables PWD to access computers. This is the computer's double-sided capacity to oppress and liberate PWD physically, or in relation to the body.

Computer technology is also a benefit and a detriment to the mind. While assistive computer technology or the stand-alone computer by itself, can aid people with learning disabilities or cognitive challenges, the computer, including but not limited to the Internet, can also threaten important mental capabilities (Carr 55). For example, the computer's proficiency to convey information visually and aurally makes it an assistive instrument for people with reading, writing or mental processing difficulties. On the other hand, computers can harm intellectual skills and abilities. For instance, typing pushes aside the practice of handwriting and computer aided design replaces free-hand drawing. Moreover, it has been argued that the Internet is negatively affecting the way we read, write and think (Carr). As an interactive, non-linear medium among other qualities described later, the Internet has the potential to jeopardize vital cerebral faculties such as concentration and contemplation (Carr 55). This is the computer's contradictory capacity to assist and provoke disabilities mentally, or in relation to the brain.

The positive/negative balance of computer technology which presents both opportunities and obstacles for PWD is the subject of this paper. Although counter-intuitive, computers both mitigate and exacerbate disability. They simultaneously impose limitations and remove barriers.

In this way, the mysterious machines serve as both an asset and a liability, physically and mentally, to PWD.

Disability is defined as, “a physical or mental impairment that substantially limits one or more major life activities” (Mann 2). As computers increasingly become an integral part of our personal and professional lives, our use of them moves closer to being considered a major life activity in which people must engage to be fully functioning members in contemporary culture. This is problematic as those who cannot access computers at all, or without the aid of assistive technology, are at risk of becoming even more disadvantaged. Without the ability to use computers or the Internet, PWD are denied the same economic, educational and social opportunities afforded to those who can access computers. This works to increase the divide between the able and the disabled.

Alternatively, computer technology allows PWD to perform tasks and communicate in ways they otherwise would not be able to. In this sense, computers are an equalizing force that gives PWD a chance to compete with those who are free of disability. Seemingly incongruent and backward, computer technology impairs PWD while leveling the playing field for them.

Assistive Technology – Definition and Examples

Assistive technology (AT) is defined as “any item, piece of equipment, or product system, whether acquired commercially off-the-shelf, modified, or customized, that is used to increase, maintain, or improve functional capabilities of individuals with disabilities” (Copenhaver 2; DeWitt 315). This paper is about AT for computers or what is called assistive computer technology. For simplicity’s sake, the term AT is used throughout the paper to refer to assistive computer technology. Examples of assistive computer technology include the following: voice recognition systems, text-to-speech software such as screen readers, word prediction and brainstorming programs, screen magnification devices, augmentative, or speech-enhancing, tools and finally, descriptive video services that verbally describe scenes and/or stories in TV and film (Hasselbring and Glaser 107–117). These assistive technologies are rarely built-in to the basic computer but are extra "add-ons" that must be purchased separately and installed or attached to the standard operating system (DeRuyter et al. 259).

Motivation of Research

The author is interested in the field of technology and disability because she has an invisible, physical disability that requires the use of AT to access the computer. The author has a condition in her arms that prevents her from using the computer keyboard or mouse. Currently undiagnosed and described by one doctor as a "biological mystery", the author's symptoms are caused by typing and clicking. These small, repetitive movements irritate the author's arms making them heavy and weak so everyday activities like brushing teeth or washing hair become difficult to perform. Carpal tunnel syndrome and repetitive strain injury have both been eliminated as possible diagnoses. Also eliminated is the possibility of a muscle or nerve defect. In spite of the author's condition being hereditary as her father and his two sisters also have it, several neuromuscular skeletal experts remain perplexed by her case. Because the disability is invisible, it makes it difficult for people to believe, understand or diagnose.

The author uses the voice recognition system Dragon NaturallySpeaking (Dragon) to produce typed documents and navigate the Internet. While the author had much to learn about different types of AT prior to conducting this research, she has used Dragon for 15 years and is familiar with the program. As a result, the author draws on her own experience using Dragon throughout the paper. This paper was composed using Dragon. Ironically, computer technology is largely responsible for creating a disability in the author's arms, however, it also deserves credit for allowing her to partially overcome it.

Purpose of Study

The purpose of this study was to investigate the dual nature of computer technology to both help and hinder people with physical and mental disabilities. More specifically, its aim was to discover how assistive computer technology improves or alleviates disability and how standard computers create or intensify disability. Research participants included people who used some type of AT, either to access the computer due to a motor or sensory impairment, or to aid them in cognitive tasks such as reading or writing. The study took place in April and May of 2013 and consisted of 12, one-on-one interviews.

Potential Significance of Research

Researching how computer technology causes or aggravates disability may serve as a catalyst to modify and redesign computers to accommodate all users. In addition, researching how AT reduces or relieves disability may advance the future design of assistive devices. Studying the different ways in which computer technology both supports and harms PWD is critical to developing accessible computer technology for all people.

Literature Review

Much of the literature in the field of technology and disability recognizes that computer technology can both help and hinder PWD (Annable, Goggin and Stienstra 146; Cole 2; DeWitt 315–316; Fichten et al. 180; Hollier and Murray 124; Lupton and Seymour 1853; Moser 373; Pilling, Barrett and Floyd 1, 58; Ring 79). Due to its two-sided ability to both enable and disable, computer technology has been described as a "double-edged sword" for PWD (Hollier and Murray 124). In one study in which PWD discussed their experiences with technology, the researchers concluded that their relationship with technology was best described as a dichotomous one of "love/hate" (Lupton and Seymour 1860). They have experienced the promises and disappointments of computer technology. For PWD, computer technology can be both a crippling and emancipating mechanism – one that together, subjugates and frees them.

How Computer Technology Improves or Alleviates Disability

New media technologies have been described as a panacea or cure-all for PWD (Moser 375). Some claim that technology completely eradicates disability (Moser 374) while others argue that it merely lessens the effects of disability (Boonzier 10; Lupton and Seymour 1853; Mann 7). Computer technology is credited with helping balance the scales of power and opportunity between people with and without disability. It is charged with the task of narrowing the gap between the able and the disabled.

Hide or Mask Disability

Computer technology can hide or mask physical disability (Cole 15; Goggin and Newell 129; Pilling, Barrett and Floyd 42). For example, the Internet's simulated space allows for disembodied identities in which people can detach themselves from their disability (Cole 15). Unlike the real world where people cannot escape their identities, the Internet lets PWD float invisibly and anonymously in cyberspace (Goggin and Newell 129). The digital environment separates people from their disabilities, enabling them to produce and present themselves in a way not possible in real life (Cole 15). Essentially, the Internet's virtual arena permits PWD to temporarily abandon their disabilities and disguise themselves as non-disabled (Goggin and Newell 11). Goggin and Newell point out the possibility that online interactions may be the only interactions that PWD have that are not "mediated by the disability-related stigma" (130). Unfortunately, disabilities are stigmatic and are often met with fear and negativity.

Reading, Writing, Thinking and Memory

Assistive technology (AT) can help people with learning disabilities or other cognitive challenges. For example, screen readers can improve the skill of reading (Forgrave 123). Screen reading software reads aloud whatever text is on the computer screen. This device is used by people with low vision or people who have difficulty visually absorbing information or more precisely, reading. As the words are read aloud, they are highlighted on the screen. This provides a "bimodal condition" in which information is presented both visually and aurally (Forgrave 123). Hearing the words read aloud while looking at them on the screen teaches people new words and also helps them decode and pronounce words (Forgrave 123). Screen readers can also be an effective editing tool as users can have their written work read back to them which allows them to evaluate its flow and readability (Payne and Sachs 3).

AT can also improve writing (Forgrave 124). Take speech-to-text programs for example. These voice recognition systems (VRS) allow people to get their thoughts on paper without experiencing the challenges that can accompany handwriting or computer keyboarding such as letter drawing or "slow typing speed", respectively (Forgrave 124). Users of VRS are less likely to lose their train of thought because the program types their spoken words relatively quickly. Also, users can concentrate less on spelling because the program usually spells words correctly, provided they were pronounced correctly. Seeing the words spelled correctly reinforces their proper spelling and improves this skill in the user (Forgrave 123).

Furthermore, when users select a word in order to correct it because it was misinterpreted, VRS present a pop-up window with a list of possible word choices (Forgrave 124). Listing different word alternatives such as *site and sight* familiarizes users with words that sound the same but are spelled differently (Forgrave 124). Furthermore, VRS encourage the use of a wider, richer vocabulary because writers may use a word they would have previously avoided as a result of not knowing its correct spelling (Forgrave 123). Several studies have examined the effects of VRS on student writing (Forgrave 124). Results show that when students use VRS to compose their papers, they write longer and more detailed papers compared to previous papers written by the same students using handwriting or manual typing (Forgrave 124). For many PWD, typing tends to produce more volume than handwriting and VRS tend to produce even more volume than typing.

Finally, VRS have been found to improve working memory and promote “higher order thinking” (Forgrave 122–124). Forgrave suggests a possible reason for improved working memory. She explains that when using VRS, users must “simultaneously concentrate on what they are saying, remember what they have said, and compare it with what is appearing on the screen” (124). This keeps the user mentally engaged and in a continuous state of cognitive processing. Because users of both screen readers and VRS do not have to exert the same mental effort to decode or spell words like they have to with traditional reading and writing, their minds are “freed up” for higher thinking processes such as reflection and analysis (Forgrave 122). Evidently, AT helps PWD with reading, writing and other mental processing tasks.

Improve Opportunities and Quality of Life

AT improves the lives of PWD because it allows them to perform activities they otherwise would not be able to do (Lupton and Seymour 1853). For example, someone without the physical ability to type can still produce typed documents by using VRS such as Dragon NaturallySpeaking. Likewise, someone with low vision who cannot read a computer screen can make the text accessible by using screen magnification software such as Supernova. In this way, computer technology can lower economic and educational barriers for PWD, enabling employees and students with disability to thrive among their non-disabled colleagues (Lupton and Seymour 1853). Aside from work and school, AT can support PWD socially (DeWitt 327). For example, by using AT to access the Internet, PWD can participate on social networking sites such as Facebook and Twitter. When PWD were surveyed in America, 48% of them said that using the Internet "significantly increased their quality of life" (Pilling, Barrett and Floyd 6).

Assistive devices increase autonomy for PWD making them less dependent on their family and friends for assistance (Forgrave 123; Pilling, Barrett and Floyd 43). Moreover, when a visually-impaired research participant was asked how he previously accomplished the tasks he was now completing with the use of AT, he responded, "I didn't" (Pilling, Barrett and Floyd 43). While it does not entirely eliminate disability, AT does allow PWD to "transcend some aspects of their disabilities" (Lupton and Seymour 1851). AT helps PWD participate in society and this dramatically increases their quality of life (Fleischer and Zames 211).

Benefits Non-Disabled People

Both standard computer technology and AT can benefit people who are free of disability. DeWitt explains that technology specifically designed for the purpose of assisting PWD is often helpful for non-disabled people as well (322). When non-disabled people make use of devices intended for PWD, DeWitt refers to this use as "non-disability applications" (317). Some non-computer related examples of this include ramps, elevators, handrails and telephones with oversized buttons or adjustable volume (DeWitt 322–323). Some computer related examples include the following: touch-sensitive screens, voice-activated commands, the ability to manipulate font size and style to accommodate different learning preferences, screen readers that can be set to read extremely fast so large amounts of written material is delivered and received in less time than regular reading, word prediction software and lastly, basic features in Microsoft

Word such as the *spell check* and *cut-and-paste* tools. Computer technology, including AT, not only supports PWD but also aids non-disabled people.

Extension or Prosthesis

Technology has been described as an extension or prosthesis for its capacity to enable both people with and without disability (Goggin and Newell 112; Lupton and Seymour 1852; McLuhan 47; Stone 3). Media scholar Marshall McLuhan explains that every medium or tool is an extension of ourselves, usually an extension of one of our senses such as vision or hearing (47). For example, binoculars extend our eyes and telephones extend our ears. For PWD, the sensory or bodily extension supplied by technology is particularly significant because it extends or enhances the part of them that is damaged or deficient. As an extension of a “sense organ” (McLuhan 47) or body part, technology acts as an artificial limb for PWD. Serving as prosthesis, technology extends a part of our corporal and cognitive selves.

Technological prostheses blur the border between bodies and machines – the line where the human stops and the apparatus begins becomes increasingly obscured (Goggin and Newell 112). A present-day example of the wall between person and computer collapsing is disabled physicist Stephen Hawking who, unable to speak on his own, uses high-tech and sophisticated communication equipment to write books and give lectures (Stone 5). Allucquere Rosanna Stone explains the difficulty in making the distinction between Hawking and his AT (5). She is worth quoting at length: (please note that Stone was initially listening to Hawking speak over an outdoor PA system but then moved inside the building where Hawking was physically present).

> Exactly where, I say to myself, *is* Hawking? Am I any closer to him now than I was outside? Who is it doing the talking up there on stage? In an important sense, Hawking doesn’t stop being Hawking at the edge of his visible body. There is the obvious physical Hawking, vividly outlined by the way our social conditioning teaches us to see a person as a person. But a serious part of

> Hawking extends into the box in his lap. In mirror image, a serious part of that silicone and plastic assemblage in his lap extends into him as well…no box, no discourse; in the absence of the prosthetic, Hawking's intellect becomes a tree falling in the forest with nobody around to hear it. On the other hand, with the box his voice is auditory and simultaneously electric, in a radically different way from that of a person *speaking* into a microphone. Where *does* he stop? Where are his edges? The issues his person and his communication prostheses raise are boundary debates, borderland/*frontera* questions. (5 – emphasis original)

To separate Hawking from the technology that allows him to communicate is to alter his identity – it is to disrupt and distort the nature of his social self. In a very real sense, part of Hawking exists in and through his assistive devices because without them, he would be silenced, muted, dehumanized. Hawking's rare intellect would remain trapped inside him with no chance of escape.

Technology is an extension of ourselves, a prosthesis that projects and protrudes from us, stretching and spreading that which was once curtailed and contained. Writing about building a home-made radio, Stone states, "I was hooked. Hooked on technology. I could take a couple of coils of wire and a hunk of galena and send a whole part of myself out into the ether. An extension of my will, of my instrumentality…that's a prosthesis, all right" (3). Stone explains that it is not "just information" that travels through electrical wires – it is "*bodies*" (7 – emphasis original). In the synthetic sound waves delivered by radio, real people reside. Now referring to the computer, Stone states, "inside the little box are *other people*" (17 – emphasis original). Computer technology is vacant and void – entirely inanimate, spiritless – until someone interacts with it and injects it with mortal substance. The empty, faceless character of the cold machinery is infused with human qualities and values. People penetrate and permeate automated tools and a metaphorical but meaningful part of themselves lies within them.

How Computer Technology Produces or Exacerbates Disability

Amputation

Now for the reverse of extension – amputation. McLuhan asserts that when media extend one of our senses, that part of our central nervous system becomes numb. This is like a defense mechanism where we numb our sense organs to endure their extension (McLuhan 47). McLuhan describes this numbing of our extended senses as a form of "self-amputation" (42) and he demonstrates how our language expresses the self-amputations forced on us by the media (43). He writes, "we speak of 'wanting to jump out of my skin' or of 'going out of my mind'...or of 'flipping my lid'" (42).

When using electronic technology such as the computer, McLuhan thought we must cut off the extended part of our central nervous system in order to protect it (52). He claims that our extended senses no longer dwell inside us but live "outside us" in the electronic technology itself (52). "In the electric age", McLuhan asserts, "we wear all mankind as our skin" (43). Our skin is an exterior shell – something outside us or at least *on* the outside of us. Electric technology becomes a temporary home for our once internal parts. Our sensory organs transform into extraneous items, hailed into the computer and away from us. McLuhan explains, "electromagnetic technology requires other human docility and quiescence of meditation such as befits an organism that now *wears its brain outside its skull and its nerves outside its hide"* (57 – emphasis added). Our senses are extended to the point that we detach ourselves from them so they momentarily inhabit a space external to us. The over-extension of our senses results in their involuntary and unconscious severance and therefore, instead of working as a prosthetic, electric technology amputates part of us, disabling rather than enabling.

McLuhan's concept of amputation is perhaps difficult but there is a simpler type of amputation that occurs between PWD and computer technology. That is, the computer's interface can immobilize and paralyze the part of our bodies that cannot access it. For example, using the standard computer keyboard and mouse demands fine motor movements that are not easily performed by people with certain hand and arm conditions (Pilling, Barrett and Floyd 13). In this way, the computer symbolically cuts off or amputates its user's hands or arms. Unable to type or click, the user's upper appendages become useless when interacting with the computer.

Likewise, the computer screen that would typically extend its user's eyes or visual sense has the opposite effect on people with vision impairments. With its widely used 12-point font for word processing and its visually detailed web pages containing multiple links and difficult-to-find search bars (Pilling, Barrett and Floyd 34), the computer and Internet screen further disable the eyes of someone with low vision. Lacking an assistive device like screen magnification software, the user's eyes are rendered futile by the computer's platform. Whether physical or sensory, the computer can amputate PWD, severing the part of them that is already impaired.

The Physical

Arguably, the human body is not designed for the small, repetitive movements required to operate the computer keyboard or mouse (*Why Things Bite Back*, Tenner 173). As a result, computer use can lead to physical ailments such as carpal tunnel syndrome or repetitive strain injury. This is an example of how computers create disability. Computers can also exacerbate existing disabilities. For example, people with motor or sensory impairments are further disabled by the computer because they cannot access the resource like people who are free of disability. The telephone further disabled the hearing-impaired and the computer has further disabled the vision-impaired. Several authors have addressed the problem that people with physical disabilities cannot access the computer (Hwang et al. 141; Pilling, Barrett and Floyd 12–13; Light and Drager 210). Moreover, McNaughton and Bryen point out that most of today's computer technology depends on a "single input modality" in which people must use their hands to access the computer (226). This is a problem for many PWD.

In his book, *Why Things Bite Back: Technology and the Revenge of Unintended Consequences* (1996), Edward Tenner explains that technologies seek "revenge" on their users by "biting back" with negative repercussions (161). Tenner claims that physical injuries caused by computers have reached epidemic proportions (*Our Own Devices*, 207) and he argues that worker's compensation insurance has increased, not because of "fatal accidents" like in industrial times, but because of the "automation of office work" (165). Seemingly harmless activities such as sitting, typing and looking at screens can have debilitating effects (Tenner 180). Tenner describes how we have shifted from "hot sweat", or the hard manual labour of the past, to "cold sweat" that results from a new type of labour which appears innocent and risk-free but is in fact costly and precarious (173). Tenner speaks of the "hazards of software" (189) and suggests that the safe, comfortable indoor office has become a potentially "dangerous place" (182).

Like philosopher Michel Foucault who claims that enforcing good handwriting is a way to control the body (152), Tenner claims that typewriting or computer keyboarding is the result of a "social drive to discipline the body" (*Our Own Devices*, 192). Foucault observes that governments control bodies through institutions such as schools, hospitals, prisons and the military (138–140). These institutions manage and manipulate bodies by imposing upon them rigid eating and exercise schedules and by classifying and organizing bodies according to gender, number or disease (Foucault 205). What Foucault says about institutions regulating the body can also be said about computers. He writes, "exercising upon it (the body) a subtle coercion, of obtaining holds upon it at the level of the mechanism itself – movements, gestures, attitudes, rapidity" (137). The classical age, according to Foucault, witnessed an obsession with the body (136) and this fascination with and focus on the body has returned today as a result of computerization (*Why Things Bite Back*, Tenner 182).

Tenner points out the oddity in how using computers for "intellectual work" has drawn so much attention to the body (*Why Things Bite Back*, 182). While computer use appears to primarily involve mental tasks, it also requires a type of physical fitness. Computer users are expected to continuously improve by getting faster and making fewer errors. Physical speed and precision are taught, practiced and rewarded. The modern work office demands from its employees an "efficient method of text entry" (McNaughton and Bryen 220). Office workers must mold their bodies so they each become "an efficient machine" (Foucault 164). The computer has been described as a "kind of straitjacket into which the body must adapt itself" (Strong and Casement 150–151). Computer use is unnatural for the body and something to which it must adjust and conform.

The Mental

In addition to its negative physical effects, the computer can also have negative mental effects. Nicholas Carr argues that the Internet is harming our ability to read, write and think. First, the Internet does not allow its users to read carefully or critically but promotes "interruption of thought" (Carr 132) with its numerous links and pop-ups that disturb concentration (Carr 90). The Internet often supplies only small, fragmented pieces of information and rarely contains longer, complex writing that is grounded in context (Carr 91). Instead of focusing on a single piece of writing for any length of time, Internet users are encouraged to jump around and merely engage in "cursory reading" or "superficial learning" (Carr 16). Carr thinks the Internet is making people become "impatient" with books and he predicts that thick blocks of carefully constructed text will increasingly become less tolerated (111).

The Internet, according to Carr, is also having an adverse impact on writing. Online bloggers arguably do not take as much care crafting what they write as their words can easily be changed unlike words in a printed book (Carr 15). Instead of producing perfectly polished prose to be published in print, website building and Internet blogging do not foster such precision and finality (Carr 15). In fact, they do not permit it. Carr explains that we are no longer "composing sentences and paragraphs" the way we used to and he anticipates that people will start tailoring their writing so it will appear high up on search engine results and therefore be found and read first (120). Carr argues that online writing is changing the motivation of writers and negatively influencing the content they produce.

Lastly, Carr claims that the Internet is negatively affecting the way we think. Carr explains how the Internet has moved us from linear to sporadic thinking and he dedicates a chapter in his book to this phenomenon called "The Juggler's Brain" (Carr 115). The Internet encourages its users to be "shallower thinkers" and has taken them from the quiet deliberation and meditation that accompanies the printed word (Carr 55). Strong and Casement write about computers: "speed and control are emphasized at the expense of thoughtfulness and understanding" (15). Carr blames the Internet for impairing concentration and reducing attention spans. He claims that we are no longer thinking reflectively and contemplating deeply and for this cognitive loss, he holds the Internet responsible. Computers not only have detrimental physical effects but damaging mental effects as well.

Built-in Disability

It has been argued that like architecture, digital communication technologies have disability purposely built-in to them (Goggin and Newell xv-xvi; Moser 375). In other words, computers are designed to intentionally disable (Goggin and Newell xvii). Unlike Tenner who claims that technology's debilitating consequences are unintended, others claim that disabling features are knowingly inserted into technology (Goggin and Newell xvi-xvii; Moser 375). This happens from the very start, at the planning stage and at the manufacturer level (Goggin and Newell xvii). On the one hand, this sounds like a radical conspiracy theory and on the other, it is disturbingly probable. Take cellular phones for example. With their tiny buttons, cell phones are nearly impossible to use by people with low vision or by those who lack the physical ability to press the keys (Goggin and Newell 11).

The Internet also contains many obvious visual or auditory features that make it inaccessible to the vision or hearing-impaired. Annable, Goggin and Stienstra ask, "why are information technologies – often the newest heralded ones – still disabling?" (146). Given his observation that bodies are controlled by authority figures in institutions (Foucault 205), Foucault would likely agree that modern-day communication technologies are deliberately designed to restrict and restrain people. Goggin and Newell write:

> Just as the rise of the factory in Britain was more a managerial than a technical necessity, similarly the wheelchair, cochlear implant, and contemporary digital communications and media technologies are seen as forms of the management and regulation of people with disabilities, effectively controlling their aspirations, movements, and access to various parts of the social world. (10)

Similar to the way spaces are designed to guide movement or enclose people, computer technology is designed so the body must make specific movements. This body is an able body with the manual dexterity and high functioning senses required to operate the computer.

Computer technology is not impartial or unbiased – it is consciously constructed to exclude those who do not fit into the culturally manufactured, predetermined category of *normal*.

Problems with Assistive Computer Technology

While AT enables and empowers PWD, its many problems prevent it from being a perfect solution to providing full computer access to PWD. Cost and training are two major disadvantages of AT (Fichten et al. 182; Forgrave 125; Hasselbring and Glaser 118; McNaughton and Bryen 224; McNaughton et al. 49; Pilling, Barrett and Floyd 47; Scruggs 156). First, AT needs to be purchased by PWD and installed on their existing computers. PWD then must learn how to use the assistive software program, forcing them to acquire a skill beyond that of non-AT users (Goggin and Newell 117). AT can be very expensive and often frustrating and challenging to learn how to use. Voice recognition systems can be particularly difficult to master. Because assistive technologies are not nearly as common as regular computer software programs, fewer people know how to operate them. As a result, training and technical help can be hard to find or altogether unavailable. In addition to their scarcity, training and technical help often pose an additional cost for AT users. Training teachers how to use AT is especially important for students with disability who rely on it to complete work in the classroom (Williams, Krezman and McNaughton 197).

Furthermore, a lot of AT is lacking in interoperability (DeRuyter et al. 259). Interoperability refers to compatibility with other electronic devices or computer programs. More precisely, it means the ability to function alongside or in combination with various other technological tools. For example, all AT should easily attach to distinct and diverse interfaces and should work in different operating systems such as Macintosh and Windows. Unfortunately, this is not the case – some AT is still incompatible with certain hardware and software. When standard computers are built without consideration for interoperability, it deprives AT users of the same computer access as non-disabled people.

There are drawbacks to specific assistive technologies such as screen readers and voice recognition systems (VRS) and these drawbacks are apparent in the study results. For example, screen readers cannot interpret images (Pilling, Barrett and Floyd 13) and they can mispronounce words (Baxter et al. 121). Screen readers can also mis-read tables and charts as they read linearly, from top to bottom and left to right, and tables and charts need to be read according to columns and rows.

Compared to other types of AT, VRS seem to cause the most irritation for PWD. (Pilling, Barrett and Floyd 49). First, VRS must be trained to recognize its user's voice and even then, they often misinterpret spoken words. The primary contributors to misinterpreted words are accents and lack of "voice consistency" (Pilling, Barrett and Floyd 49, 62). Also, VRS are sensitive to sound and therefore pick up background noises or noises made by the user such as coughing, sneezing or laughing (Forgrave 125). This forces the user to go back and delete the unwanted words the system mistakenly typed on the screen.

Next, in order to operate VRS effectively, users must learn "special commands" (Forgrave 124). More specifically, users must memorize the precise language required to perform each and every voice command. For example, users need to learn commands such as *open new file, go to address bar, scroll down, page up, minimize window, press return, move down 20 lines* etc. In addition to learning the program's commands, users must teach the program words it does not know (Williams, Krezman and McNaughton 201). While professional versions of VRS exist such as medical and law versions that are programmed to know the language that belongs to those disciplines, regular versions have a limited vocabulary and therefore need to be trained to recognize certain names or discipline-specific words.

Furthermore, voice commands used to navigate the Internet often fail to work (Pilling, Barrett and Floyd 28). For example, VRS may fail to open links or move the cursor to the search bar (Pilling, Barrett and Floyd 35). Additionally, VRS can cause voice strain or general fatigue due to the amount of talking and enunciating required to operate them (*Why Things Bite Back*, Tenner 210). In one study, people described VRS as "tiring and wearying" (Pilling, Barrett and Floyd 28). Compensating for one disability can create another ailment or condition.

A common problem with AT in general is that it is often not portable and therefore, AT users are restricted to using their device in one location where it is set up and trained (Pilling, Barrett and Floyd 26). This is especially true for VRS. People who use VRS must create their own personal user profile that has been trained to understand their individual and unique voice. Unless users save their profiles on a disk or USB key and take it with them to a different computer, they must start the training process all over again and teach their voice to the new computer – provided the new computer has Dragon installed on it.

A major deficit of VRS is that the program's instructions are built into the software itself and are not available on paper (Pilling, Barrett and Floyd 28). Users of VRS often have motor impairments in their arms or hands and therefore, it is not helpful to put the program's instructions in electronic form that must be accessed through the computer. A paper, hardcopy instruction manual should be provided with the purchase of VRS. Finally, a significant drawback of student AT use such as using screen readers to read or VRS to write, is that teachers can feel that students are not exercising the skills of reading and writing as they have traditionally been practiced (Forgrave 123). Clearly, AT is not problem-free. AT users experience many obstacles when using the equipment they need to be high functioning.

Future Direction of Technology

The future design of both standard computers and AT is crucial to providing accessible computer technology for PWD. DeRuyter et al. outline six important qualities of "emerging information and communication technologies" (266). These include being unobtrusive, personalized, adaptive, anticipatory, easily usable and private (DeRuyter et al. 266). *Unobtrusive* means the technology will be integrated into the existing technological environment – it will not be feared or foreign but will become a natural part of our surroundings (DeRuyter et al. 266). *Personalized* means the technology recognizes its user and meets his unique needs (DeRuyter et al. 266). Examples of personalized AT include VRS that are trained to recognize individual voices and screen readers with voice options that are similar to the user's own voice. For instance, a young girl may prefer to hear another female child's voice instead of that of an elderly man (Light and Drager 211). Ring explains that when AT is personalized, it is more likely to be a good "match" with its user and this positive pairing between the user and device largely determines the success of the human/machine interaction (81). *Adaptive* means the technology responds appropriately to the user's physical actions or verbal commands (DeRuyter et al. 266).

Moreover, *anticipatory* means the technology predicts the user's needs (DeRuyter et al. 266). An example is Dragon anticipating the next action a user wants to make such as clicking a link or moving the cursor to its next logical place. *Easily usable* means the technology is simple to operate and does not demand extensive training or technological expertise (DeRuyter et al. 266). Lastly, technology must protect its user's *privacy*. A lot of AT use involves verbal input or auditory output and this production of sound sacrifices the user's privacy. Many AT users do not have the option of reading or writing in public spaces due to the oral (mouth) and aural (ear) nature of their devices. Solutions to protecting one's privacy when using these types of assistive technologies are not easily arrived at.

Furthermore, five principles have been identified to guide the future design of augmentative and alternative communication (AAC) technology (Williams, Krezman and McNaughton 195). AAC technology includes any equipment that helps a person communicate. Although AAC devices are not exactly like assistive computer technologies, they are very similar in many ways and therefore, these AAC principles can arguably be applied to AT. The five principles include the following: "the time for AAC is now" which means immediate action must be taken to develop new and improve existing assistive communication devices; "one is never enough" which refers to the need for multiple devices in case one fails; "my AAC must fit my life" which means it must be conducive to the user's environment and lifestyle; "AAC must support FULL participation in ALL aspects of 21st-century life" which means it should not just *improve* access for PWD but should grant them the *same* access as non-disabled people and finally, "nothing about me without me" which refers to the pivotal role PWD need to play in the research and development process of assistive communication technologies (Williams, Krezman and McNaughton 195 – emphasis original). This last principle echoes the sentiment of the International Year of Disabled People in 1981 in which the movement's slogan was "Nothing about Us without Us" (Goggin and Newell 20).

Furthermore, AT users would significantly benefit from open source AT software. Open source means the technology is free and available online. Also, open source software is "user-modifiable" allowing AT users to alter and adjust the technology to suit their individual needs

(DeRuyter et al. 267). Lysley et al. have an acronym for "Open Source Assistive Technology Software" – they call it OATS – and admit that it is "difficult to find on the internet" (n.pag).

In addition to improving standard computer technology and AT, much can be done to make the Internet more accessible for PWD. For example, PWD have expressed the desire for websites to include "simplified content" (Nicolle et al. 73). The more complex and detailed websites are, the more AT users struggle to efficiently navigate the site (Nicolle et al. 78). Eliminating unnecessary text and graphics, and minimizing the number of tabs and links, greatly increases AT user's ability to access websites. PWD have also indicated the desire to change the size and colour of text on a website as well as have the option of fast forwarding or rewinding their website navigation instead of repeatedly clicking the forward and back icons (Nicolle et al. 77). Building accessibility into the computer and the Internet from the start places the technology within the timely reach of PWD.

Designing technology to fit the needs of as many people as possible is the essence of Universal Design or "the design of all products and environments to be usable by people of all ages and abilities to the greatest extent possible" (D'Souza 3). Universal Design allows most people to access the same things and this engenders a "culture of inclusion" (Goggin and Newell 150). One of the major principles of Universal Design is that products should not have to be "modified or adapted" in any way – they should be readily accessible from the outset (Seale 4). The concept of Universal Design was introduced about 30 years ago and while it initially only applied to architecture, the last 10 years has witnessed its extension to include technology (Boonzier 12). Creating computer technology so it is easily used by people with a wide range of communication needs is a step toward giving PWD an equal chance to succeed.

Laws and Organizations

Over the last few decades, laws and organizations have been developed to promote the equal participation of PWD both in and outside of the workforce. First, the Americans with Disabilities Act (ADA) of 1990 prohibits discrimination against PWD in all areas of employment and education (American Council on Education 4). Furthermore, the Act states that PWD must be able to access "all private and public schools, libraries, businesses and facilities" (American Council on Education, 4). These services must provide accommodations such as wheelchair washrooms, automatic door openers and an alternative to stairs. The ADA makes specific reference to the "modification of office equipment" (American Council on Education 4) which illustrates that standard computer technology is not accessible to all people. At one time, advocacy groups fought to get the rules of the ADA applied to the Internet but they were unsuccessful (Goggin and Newell 119). It was argued that the "one-size-fits-all" philosophy could not be applied to the Internet because it is "an evolving media, not a physical structure" (Goggin and Newell 119). Moreover, a U.S. federal court ruled "that a commercial website was not 'a place of public accommodation' and was therefore not covered by the ADA" (Pilling, Barrett and Floyd 19).

Another major law was passed in 1988 and revised in 1994 – this is the Technology-Related Assistance Act or Tech Act for short (Behrmann 9; Forgrave 124; Shepherd et al. n.pag). Like the ADA, the Tech Act requires "equal access to goods and services, including libraries, public buildings, education, including all government agencies as employees or disabled people – **within reason**" (Boonzier 11 – emphasis original). The *within reason* part is included in the Tech Act because it is "not always possible to accommodate everyone in the same way and to the same extent" (Boonzier 11). Another element of the Tech Act involves U.S. federal funding to individual states to help them create AT programs and services (American Council on Education 4; Forgrave 125). Here the Tech Act addresses the specific technological needs of PWD.

Two other laws include the Individual with Disabilities Education Act or IDEA that mandated in 1975 that “children with disabilities receive a free, public education in the least restrictive environment” (Fleischer and Zames 209) and the Rehabilitation Act of 1973 that “granted civil rights to people with disabilities in programs receiving federal funds” (Fleischer and Zames 209). In other words, if PWD are registered in a program that is financially supported by the federal government, they shall not be discriminated against on the “basis of disability” (American Council on Education 4).

Formed in October 1994, the World Wide Web consortium or W3C is an international organization that produces and promotes web accessibility standards (Wikipedia). The organization’s main purpose is to develop a web that is accessible to everyone and its mission statement is as follows:

> The social value of the web is that it enables human communication, commerce, and opportunities to share knowledge. One of W3C’s primary goals is to make these benefits available to all people, whatever their hardware, software, network infrastructure, native language, culture, geographical location, or physical or mental ability. (www.W3.org)

In 1996, the W3C created the Web Accessibility Initiative or WAI which conducts research and development and establishes guidelines to improve web accessibility (Guillou et al. 168). These guidelines encourage web designers to include accessible features on their websites such as “equivalent alternatives to auditory and visual content”, “context and orientation information” and “clear navigation mechanisms” (Pilling, Barrett and Floyd 14). In April 2013, the WC3 consisted of 379 members who collaboratively work towards making the World Wide Web accessible to everyone (Wikipedia).

Digital Divide

While AT helps bridge the gap of unequal access to computers, there remains concern that computer technology will continue to further the divide between the able and the disabled (Cole 2; DeRuyter et al. 260–268; Fichten et al. 180–181). As governments, businesses and schools increasingly move their services online and gradually phase out their traditional ways of servicing the public, PWD are at risk of becoming excluded from important and necessary life activities (Pilling, Barrett and Floyd 9). Statistics have shown that PWD are "far less likely" than people without disabilities to own computers or have Internet access (Schartz, O'Day and Blanck 1). This is often because they cannot afford or access the technology. When it comes to designing computer technology, PWD are often an "afterthought" (Goggin and Newell xiii). First and foremost, computers are designed for able bodies. It is only later, about 6 to 12 months after a new technology is introduced, that computer manufacturers and developers scramble to create access solutions for PWD (DeRuyter et al. 262; Goggin and Newell 110). Unfortunately, many PWD continue to be victims of "exclusion through design" (Newell et al. 171).

Methodology

Recruitment

The author sought to recruit research participants whose disabilities require them to use some form of AT. 10 out of the 12 research participants had some type of disability that caused them to use assistive computer devices. The remaining two research participants included an assistive technologist who teaches people how to use AT and a student who does not use AT but considers the standard computer a type of AT in itself.

Research participants were primarily recruited in two different ways. First, over 100 recruitment flyers were posted around the McMaster University campus in Hamilton, Ontario, Canada. The flyers asked for volunteers who used assistive computer technology to participate in a one-hour long interview. The flyers stated that the researcher was a Master's student in the Communication and Multimedia Department who was studying alternative computer interfaces used by people with disabilities. Contact information was provided along with the declaration that the study had been cleared by the McMaster University Research Ethics Board (MREB). Please see Appendix A for a copy of the recruitment flyer.

The second major method of recruitment was more effective than the first as indicated by the number of responses received. It involved mass e-mailing students with disabilities who belonged to the Student Accessibility Department at two universities – McMaster University and Wilfrid Laurier University in Waterloo, Ontario, Canada. Student Accessibility departments provide support services for students whose disabilities require academic accommodations such as separate rooms for exam writing or scribes who write or type the student's oral exam answers. E-mailing students who belonged to their University's Student Accessibility Department specifically targeted people with disabilities and therefore, this method of recruitment was more effective than the flyers in obtaining qualified research participants. Please see Appendix B for a copy of the recruitment e-mail script that was sent to the students with disabilities in the Student Accessibility departments at both universities.

The third method of recruitment simply involved networking or talking to people who could be potential research candidates. Only two research participants were recruited using this third method.

Research Participant Demographics

Most of the research participants – 8 out of 12 – were either McMaster or Wilfrid Laurier University students. The remaining four research participants were not university students, however, two of them were employed in the Student Accessibility Services Department at McMaster University. These included Clark Cipryk, the assistive technologist and Tim Nolan, the manager of disability services and university advisor on disability issues. Moreover, the two non-student research participants were acquaintances of the author who were recruited using the networking method of recruitment. With the exception of Clark Cipryk and Tim Nolan who both gave written consent to use their real identities in this paper, this study is completely anonymous. Fictitious names are used in the study results to avoid identifying the study participants.

Out of the 12 research participants, eight were male and four were female. Their ages ranged from approximately 20 to 70 years old. The research participants had a variety of disabilities including autism, Asperger's syndrome, multiple sclerosis, low vision, dyslexia, attention deficit hyperactivity disorder (ADHD) and other learning challenges such as visual or auditory processing problems.

Interview Procedures

The interviews were audio recorded with the research participant's permission and later transcribed by the author. The interviews ranged in length from 50 to 100 minutes. Please note that the author gave the participant the option of stopping the interview at the one-hour mark. Most research participants brought their AT with them to the interview so they could demonstrate how it worked. Some interview questions included the following:

- What type of assistive computer technology do you use and why?
- What is difficult to use about the assistive technology? Is technical help available?
- Would non-disabled people benefit from using the assistive technology? How?

- What part of the computer is inaccessible to you? (keyboard, mouse, screen, speakers)
- What physical, social, economic or educational barriers do computers create for you?
- How would you describe your relationship with computer technology? (love/hate)
- What part of your body, senses or mind do standard computers amputate and what part does your assistive computer technology extend?
- How would you feel without the assistive technology?

Please see Appendix C for a copy of the interview consent form that was signed by all the research participants prior to being interviewed with the exception of Tim Nolan and Clark Cipryk who signed a different form waiving their confidentiality.

Study Limitations

Like all research, this study has limitations. First, the study does not include every type of AT. For example, screen readers, screen magnifiers and voice recognition systems are prevalent throughout the study while other forms of AT such as descriptive video services or word prediction software are missing. Secondly, the study does not include every type of disability. For example, people with low vision, motor challenges or learning disabilities are featured in the study while other disabilities such as hearing impairments are absent. Lastly, the sample of study participants is not diverse but fairly heterogeneous. For example, 66.7% of the research respondents are university students. While study participants include both males and females with a wide range of ages, the majority of them (all but two) are university affiliates – they are either students or employees at one of two universities in southern Ontario. The results of this study reflect the unique experiences and individual opinions of the research participants. They include personal accounts that cannot necessarily be generalized to a larger population.

Study Results

The Standard Computer

As previously mentioned, the standard computer interface is not accessible to many people with motor or sensory impairments. Tim and Pat are visually-impaired research participants who modified their basic computers to make them more accessible. For example, Tim uses a bright yellow keyboard cover with big black letters and symbols on it. This cover is a perfect model of the computer keyboard and is placed over it to enlarge and enhance the standard computer keys. This product is advertised on TV and targets the elderly who may have difficulty seeing the standard computer keyboard. Tim eventually stopped using the keyboard cover as he has memorized the location of the computer keys after many years of practice touch typing and using keystroke commands.

The raised divots on the *F* and *J* keys of the standard computer are critical to helping Tim place his hands in the proper typing position and subsequently navigate the keyboard. These divots give Tim his foundation, his grounding and his starting point. These keyboard markers are an example of a helpful feature that is built into the basic computer from the start. Pat also finds the raised divots useful and has exaggerated them by gluing tiny pieces of rubber on them. By reinforcing the divots, Pat can quickly orient himself and effectively move his way around the keyboard.

The standard computer keyboard is inaccessible to Amar, a research participant with autism that negatively affects his motor skills. Amar has difficulty both writing and typing and pain prevents him from typing for more than 30 minutes. Amar lacks muscle memory and therefore cannot learn to type effectively – his brain and body struggle to remember the location of the keys. Deep, as opposed to shallow computer keys, are particularly difficult for Amar and he wishes he could wear magical gloves that would allow him to repeatedly pound the keys. The QWERTY keyboard found on most computers is designed so the strongest fingers do the most work. For example, the most commonly used letters are pressed with the thumbs and the middle and index fingers – the baby finger rarely extends out to hit the *q* or *z* key. This is in contrast to the Dvorak keyboard that places the most commonly used letters in the home row to minimize finger movement, reduce errors and increase typing speed (Wikipedia). Regardless of the type of keyboard, it remains inaccessible to many people with disabilities.

Repeatedly clicking the computer mouse can fatigue or injure even a non-disabled person's arms, wrists or hands. Low-vision Pat has multiple sclerosis (MS) and uses a wheelchair most of the time which is hard on his arms. Using a computer mouse further strains Pat's arms and he cannot use a mouse for more than two hours at a time. To give his right hand a rest, Pat started using the computer mouse with his left hand. In order to use the mouse with his left hand, Pat had to move it from the right to the left side of his computer. When this happens, the index and middle fingers no longer fall in the same spot on the mouse – the index finger now touches the right click button and the middle finger now touches the left click button instead of the other way around. This is disorienting and makes using the mouse awkward. To solve this, Pat reversed the right and left click buttons on his mouse so his index and middle finger now touch the left and right click buttons, respectively, like they did before. Despite this modification, Pat still finds it challenging to operate the mouse with his left hand and as a result, he uses the computer less than he otherwise would.

Screen Magnifiers

Both Tim and Pat use screen magnification software as their low vision prevents them from seeing the computer screen. The program they use is called ZoomText which includes both a screen magnifier and a screen reader. This section, however, deals only with the screen magnifier. Screen magnifiers can be considered *enhanced* AT because they enhance the basic computer screen by magnifying it. This is in contrast to *alternate* AT such as screen readers and voice recognition systems that provide alternative ways of accessing the computer, primarily verbal instead of manual input and output methods. While the *same* type of AT is used by people with *different* disabilities – for example, screen readers are used by both the vision-impaired and people who have difficulty reading – screen magnifiers are typically used by people with low vision.

Although Tim and Pat are able to see the computer screen with their magnifying software, they can only see a very small portion of the screen at a time. Having to enlarge the screen at least six times its normal size, Tim and Pat are left with only about one thirtieth of the available screen. Picture a square box two inches by two inches – this is the only area of the screen they can view at one time. Needless to say, this makes using the computer and especially the Internet extremely laborious and time-consuming. Referring to the magnified square portion of the screen, Pat states, “if it gets too big, it gets hard to navigate”. Pat estimates that it takes him four or five times longer to view a single webpage than a sighted person who can see the entire screen all at once. It would be helpful, explains Pat, to have a map on the website’s homepage that outlines where on the screen the main tabs or links are located. Providing a mini tour of the website that familiarizes users with the webpage’s layout would significantly improve their ability to navigate the Internet. If a sighted person is available, Pat will ask him to point out where on the screen the major icons reside so he can find and enlarge them later when he is alone.

Because Tim and Pat are only exposed to a tiny window each time they view the computer screen, they must move the mouse around a lot in order to view the entire screen. To clarify, they must move the magnified box over each area of the screen and view it square portion by square portion. “You’re moving the mouse around all the time”, states Pat. This extra mouse movement has caused repetitive strain injury in Tim’s arms and although he wears braces on them, they do not alleviate the pain. Referring to the excessive amount of mouse movement he performs, Tim quips, “if you were to put an odometer on my mouse, I’d probably have made about five or six tours around the world”. Compensating for one disability can often create another disability. Tim’s lack of eyesight has created a problem in his arms. His primary disability of low vision has produced his secondary disability of repetitive strain injury.

When asked about secondary disabilities, the assistive technologist Clark responds, “the first thing that comes to mind is posture”. Clark explains that poor posture often results from vision impairment as the person stretches and strains his body and neck trying to see the computer screen. Because he teaches others how to use AT, Clark has an oversized computer screen on a swivel arm so the screen can be completely turned around to face the student. It is very much like a flexible big-screen TV. With a large range of motion up and down and back and forth, Clark can bring the computer screen within six inches of his face without moving his chair forward at all. Clark thinks that proper ergonomics can often prevent or solve the secondary condition of poor posture.

Pat says ZoomText is better than the magnifying feature built into Microsoft Office. ZoomText is superior because of the way it magnifies the screen. Unlike Microsoft Office’s magnifier that only enlarges the area of the screen that is currently under the square viewing window, ZoomText blows up the entire screen so Pat can simply move the window over the enlarged screen one area at a time.

“Good” is the word Pat uses to describe his relationship with computer technology. Without the screen magnifier, Pat says accessing the computer would be “impossible”. “It kept me high functioning at work for nine years”, states Pat about ZoomText. As a result of his physical limitations including restricted mobility, Pat feels the computer, and particularly the Internet, keeps him “active in society”. It enables him to connect with others and stay informed. Pat states, “with the programming and the technology, it lets me do what everyone else does on the computer. It keeps me doing normal things that normal people do”. Due to Pat’s mobility issues, he does a lot of his banking and shopping online. Pat largely limits his Internet use to these necessary life activities and rarely uses the Internet for leisure or entertainment. It is not worth the time and effort.

Screen Readers

Used by visually-impaired people and those who have trouble reading, screen readers read aloud the text on the computer screen. They can either read all the text on the screen or only the text that is selected. More precisely, screen readers can be set to read every single word of a document or webpage or they can be set to read only those words that are clicked on with the mouse. The most common type of screen reading software is a program called Kurzweil that costs approximately $1500 CAN with updates costing approximately $400 CAN.

A major drawback of Kurzweil and screen readers in general is the amount of time and effort it takes to prepare the documents to be read. First, electronic documents must be obtained from the publisher so they can be scanned into the program. This is not always easy. One Kurzweil user named Bob, who is completing his third Master’s degree, says the electronic documents must be requested from the publisher not weeks but months in advance of needing them. Many student Kurzweil users must request their electronic textbooks for the fall term as early as the spring or summer. Nisha, who also uses Kurzweil, explains that the length of time it takes to get the publisher's electronic documents becomes an issue if she switches courses at the beginning of a school term because she is then left waiting for the materials she needs for her newly-added courses. Moreover, in order to release the electronic version of a work, the publisher requires that a hard copy of the work be purchased first. Dave, a PhD student who uses Kurzweil, explains that he has to provide the publisher with proof of purchasing a hardcopy version, in his case, a school textbook. Even then, Dave has still had publishers reluctant to provide him with the electronic documents he needs.

Kurzweil users must get the publisher's electronic version of a book instead of the regular electronic or e-book as Kurzweil cannot read e-books. This is due to the protective devices built into e-books to protect intellectual property rights and conform to copyright law. The publisher is the only source who can supply electronic versions of a work that are free of these security restrictions or "digital locks" as Dave calls them. Digital Rights Management or DRM is the term used to describe the practice of protecting electronic documents from being reproduced in any form including spoken form as is the case with Kurzweil.

Once the electronic documents are received from the publisher, they have to be scanned into the program. This takes more time. Another Kurzweil user named Tyrell explains that he only scans part of a textbook at a time because otherwise, he must delay listening to one section or chapter until the entire textbook is scanned. Bob explains that Kurzweil's scanning speed has improved over time and he estimates that it takes five minutes to scan an average length chapter. Nisha claims the program has a tendency to "freeze" when scanning documents. She mainly experienced this when using Kurzweil for Windows. Now that Nisha uses the Macintosh version of Kurzweil, her freezing problem has largely disappeared.

After the documents have been scanned into Kurzweil, both Dave and Tyrell spend some time further preparing the documents to be read. As previously mentioned, screen readers read every single character on the screen. To prevent this, users can highlight the parts of the screen they do not want read. For example, Dave and Tyrell highlight the page number on every page, titles and subtitles, and other information such as the author's name and date of publication. Dave and Tyrell feel this initial document preparation is worth the work as it makes the document faster and easier to listen to.

Dave and Tyrell are not vision-impaired but use Kurzweil so they can absorb their readings aurally instead of visually. When Kurzweil reads aloud, it automatically highlights both the word and the sentence that is currently being read. For example, the sentence may be highlighted in yellow and the word may be highlighted in green. Tyrell looks at the screen while it is reading whereas Dave does not. Tyrell finds helpful the added visual stimulation of looking at the words as they are spoken. Dave, on the other hand, opts to listen only as reducing visual stimulation helps him concentrate on what he is hearing. Dave states, "you're forcing your other cognitive faculties into low gear so all the energy can go to the auditory and the memory".

While screen readers supply an alternative to traditional reading, they usually slow down the reading process. Dave explains that the average person silently reads to himself at about 250 to 300 words per minute. Dave sets Kurzweil to read to him at 150 words per minute. This is the best speed for Dave. Kate is another respondent who uses Kurzweil. Kate says she struggles to find a comfortable speed at which the program can read to her. She feels the speed settings are either too fast or too slow. Tim would like to preprogram his ZoomText screen reader to automatically read different documents at different speeds but it will not let him do this. For example, Tim would like e-mails to be read faster than websites. While the program allows Tim to adjust the reading speed for different types of documents, he must readjust the speed every time he switches from one document type to another. Ideally, Tim could preset the screen reader to always read e-mails at speed *x* and always read websites at speed *y*. This would prevent him from frequently readjusting the speed in order to maximize his productivity when working on the computer. Furthermore, Voice Ware Julie and Voice Ware Paul are Dave's favourite screen-reading voices because they sound the most "life-like" or non-robotic. Kate prefers a female voice and also mentions Voice Ware Julie as the voice she most often uses.

Screen readers have several weaknesses or shortcomings. For example, they can mispronounce words and misinterpret fonts. When a word is mispronounced, a pop-up window allows the user to type the word the way he wants it to be pronounced. The word, however, must be spelled phonetically for the program to pronounce it properly. Dave gives the example of the word *implecature* which he must spell *im-pli-catch-er* in order for Kurzweil to correctly pronounce it. Kurzweil can also misinterpret certain fonts. Dave explains that the program has difficulty reading italics or fancier fonts often found in older books. Kurzweil performs best when reading standard fonts such as Arial or Times New Roman. Optical Character Recognition or OCR is the term for software's ability to visually recognize individual letters, numbers and symbols. Dave says the program will "run a probability algorithm" to determine which character it most resembles. The more the character's appearance deviates from the standard character that is preprogrammed into the software, the more Kurzweil struggles to read it.

Clark explains that there are fonts purposely designed so that no character looks the same rotated or otherwise. For example, with the exception of the *q* that has an extra marking in the form of a tick or tail if you will, the lowercase letters *b, d, p* and *q* all consist of a stick and a ball that only need rotating or reversing to become a different letter. The special fonts to which Clark refers maintain their unique appearance in spite of being turned sideways, backwards or upside down. This special font would reduce Kurzweil's likelihood of misrecognizing characters. Screen readers can also misrecognize extra markings on a document. Take photocopies for example that often have unwanted black lines or distorted text. Kurzweil attempts to translate these ink spots or blemishes and fights to interpret the warped words. Tyrell states, "it's just painful to listen to Kurzweil butcher and skip words". Course packages, or a compilation of photocopied articles assembled by the professor, are often used in universities. These photocopied class readings pose a challenge for students who use screen readers.

Another limitation of screen readers is that they do not consistently interpret abbreviations or symbols correctly. This creates an obstacle for Tim when he wants to find out the sports scores on the Internet. An example will explain. If the abbreviation has a phonetic equivalent such as LAD for Los Angeles Dodgers, then the screen reader will pronounce the word phonetically and read *lad* as in a young boy. If there is no phonetic equivalent to the abbreviation such as SDP for San Diego Padres, then the screen reader will simply read the letters *SDP*. This inconsistency makes it difficult to follow what the program is saying. It sounds like a series of random, senseless noises – gibberish really. Tim explains that it takes extra effort and concentration to decipher what the screen reader says because he has to infer a lot of short forms. This increases his cognitive load.

Furthermore, screen readers are not effective at reading charts and Tim's sports scores are presented in chart form. Most screen readers are designed to translate information that is presented in fully written-out sentences. They are ill-equipped to deal with data presented in charts or graphs. Naturally reading the chart's columns and rows from top to bottom and left to right, the screen reader conveys information in the wrong order because charts are not intended to be read that way. "I hate websites", declares Tim. Under his circumstances, one can see why.

In addition, Tim explains that the ZoomText screen reader is compatible with text-based documents but incompatible with image-based documents. Tim laments that he is often sent e-mails containing PDF attachments that are image-based instead of text-based. His screen reader cannot read them. Tim must e-mail the person back and request that the attachments be sent again, this time in a way that is compatible with his assistive technology. Talking about these useless PDF attachments Tim is regularly sent triggers him to discuss people's expectations of him with regards to computer technology. While Tim does not feel the computer has necessarily created barriers for him, he explains that it has created "an expectation that can't be met". Here he gives the example of the PDF attachments that people expect him to be able to open and read. Tim states about the computer: "it's given me access to things that I didn't have access to before but on the flipside, it does not give me access to things that other people would expect I have access to". This demonstrates the widely held misperception that the computer is accessible to all people.

While screen readers are effective at reading standard text, they do not translate all texts and they cannot interpret images. Pat explains that his ZoomText screen reader will not read certain text on people's Facebook profiles. More specifically, it will not read the text surrounding the status box of Facebook users. ZoomText also fails to communicate the Facebook's *thumbs-up* sign. When documents or websites are littered with pictures and graphics, they are less accessible to the visually-impaired using screen readers. Minimizing superfluous or decorative images on the Internet makes information more accessible to some PWD. Prior to using

ZoomText, Tim used a similar program called Vista or Super Vista. Tim explains that Vista was superior to ZoomText because it enlarged everything on the screen while ZoomText fails to enlarge certain graphics. Tim no longer uses Vista because it is not compatible with present-day computers. Surprisingly, assistive technologies do not always improve in every area over time. Parts of a newer version of an assistive software program can be inferior to those same parts in previous versions. The most recent and up-to-date AT is not always better than the existing AT.

Simultaneously pressing *control*, *alt* and the letter *a* on the computer keyboard triggers ZoomText to start reading aloud. When Pat looks at and listens to websites, he finds it annoying that his screen reader reads every single word on the screen because he is not interested in all the content. Regardless, his screen reader reads it all to him. At any point during the reading, Pat can click on the screen and it will stop talking. Nisha complains that Kurzweil will not stop reading even when she pushes the button that is supposed to make it stop. She says she has to push the button multiple times before it registers the command and goes silent.

Screen readers can threaten their user’s privacy because they produce sound that may be heard by people within earshot. Tim admits that he has probably had an e-mail read aloud before that was overheard by someone he would have preferred not to have heard it. AT jeopardized Tim’s privacy. Dave wears headphones to protect his privacy when he uses his screen reader in the presence of others. A final and significant disadvantage of screen readers is that they are viewed by some people as a type of cognitive shortcut or form of cheating in that the activity of reading is not practiced in the traditional way. Teachers may especially feel that students who use screen readers are not exercising the skill of reading as it has conventionally been taught.

In addition to supplying a substitute to standard reading, screen readers provide other benefits as well. Take editing one’s own work for example. Both Nisha and Kate scan their own electronically-formatted essays into Kurzweil and hear them read back to them. This helps them identify problems with their writing such as run-on sentences or poor sentence structure. Hearing their own writing read aloud distances Nisha and Kate from it and gives them the necessary objectivity to improve their work. Although not its intended use, Kurzweil can be an effective editing tool. Kurzweil can also be an effective note-taking tool. For example, users can highlight a portion of the text and move it into the margin. Tyrell does this and then he cuts and pastes these margin notes into a Word document from which he studies.

Moreover, Bob audio records Kurzweil as it reads a document and then he converts the recorded document to his MP3 player so he can listen to it while walking or driving. In this way, Kurzweil helps its users multitask. When people read silently to themselves, the task demands their complete concentration so they cannot accomplish much else. Kurzweil allows people to aurally absorb information while engaged in another activity. Absorbing information aurally instead of visually impacts how it is mentally received and processed. Tim explains that what he may have missed while silently reading, he "picks up" when he hears the material read aloud. Perhaps this is because Tim's low vision has sharpened his hearing. Often a deficiency in one sense such as vision can lead to the improvement or enhancement of another sense such as hearing. Since his eyes are denied visual stimulation, Tim's ears are hypersensitive to auditory stimulation.

Regardless of the reason why, the fact that Tim processes more information when he hears it instead of sees it, indicates that screen readers have the potential to benefit the non-disabled. Some people digest material more thoroughly when it is presented in a way that caters to their hearing, not sight. Tim points out how the popular TV show *Star Trek* had talking computers in which two-way dialogue took place between people and machines. Free of disability, the TV characters chose to interact with computers the same way as many people with disabilities – sound input and output. When asked if screen readers could benefit people without any type of disability, Tyrell answers, “oh absolutely”. Tyrell gives the example of his non-disabled brother who once used Kurzweil to “rifle through” a large amount of material in a short period of time. As was evident with Dave, screen readers can slow down reading but they can also speed it up. Screen readers appear to have both positive and negative effects on reading. While they provide an alternative to standard reading, screen readers disrupt the reading process by presenting numerous obstacles. For the research participants who use screen readers including Tim, Pat, Bob, Dave, Tyrell, Nisha and Kate, the assistive technology is essential to their employment or education.

Voice Recognition Systems (VRS)

VRS convert speech to text and are used by people who have difficulty physically typing or by people who have mental difficulty forming sentences using a pen or computer keyboard. This second type of user writes more effectively by speaking the words instead of manually writing or typing them. Dragon, made by the company Nuance, is the most popular voice recognition software in North America. Dragon NaturallySpeaking is the program for computers with a Windows operating system and DragonDictate is the program for computers with a Macintosh operating system. All the research participants who used a voice recognition system used one of these two Dragon programs.

Dragon and VRS in general have made the computer keyboard accessible to many people who otherwise would be unable to access it. Dragon provides an alternative to conventional keyboarding by allowing users to produce typed documents on the computer by talking instead of typing. The *Premium* version of Dragon also allows users to navigate the Internet by using voice commands instead of clicking the computer mouse. For many people with fine motor problems or other manual dexterity issues, Dragon is critical to computer access.

The advantages of Dragon are described first. While Dragon's main benefit is that it helps provide computer access to people with physical disabilities, it has other positive effects as well. For example, Dragon can improve writing. In addition to a screen reader, Dave also uses Dragon because he can think quicker than he can write or type. Dave loses his thought if he does not get it out right away. Dragon gives Dave the immediate speech-to-text translation he needs to effectively compose sentences and write essays. The program allows users to get their thoughts on paper, or more accurately, on the screen, faster than they would be able to type them. Dave finds that he writes longer, higher quality essays when using Dragon compared to regular typing.

Amar, who cannot write or type because his autism negatively affects his motor skills, is dependent on Dragon to produce typed documents. Amar's spelling is so poor and his handwriting is so illegible that he must rely on computers to communicate in written form. Before using Dragon, Amar avoided using certain words in his writing because he could not spell them. Now that Amar can speak instead of write the words, he uses words he otherwise would not use. Dragon has allowed Amar to reclaim some of the words in his extensive vocabulary. Additionally, Dragon enables Amar to make a large volume of notes in a short period of time. Instead of writing or typing notes from a book, Amar can efficiently pull information out of a source by speaking the material to Dragon. The program permits the rapid transfer of information from hardcopy to electronic form. Amar admits that without Dragon, he would be at a "huge disadvantage" because of his poor typing ability. Amar states, "if I were to just use the keyboard solely alone, I could never finish projects on time". Amar credits Dragon with enabling him to get an education.

Furthermore, Dragon allows for higher-order thinking. Because the material is spoken and not written, users do not need to concentrate as much on the rules of language, namely spelling and grammar. Instead, they can focus on the content, depth and flow of their writing. Many people with learning disabilities struggle to manually form letters or write efficiently. Focused on the techniques of writing, their minds are less free to delve into complex concepts or communicate intricate arguments. Dragon helps eliminate some of the difficulties experienced by people when writing. Tyrell supervises students with handwriting or typing difficulties who use Dragon to compose documents for school. When using Dragon with his students, Tyrell explains that "it takes care of basic things to allow us to get to more complex things". Tyrell believes Dragon helps his students move closer to their full potential. Not preoccupied with spelling or grammar, or distracted by the task of having to physically compose letters or swiftly hit computer keys, Tyrell's students are able to think and write more effectively when using Dragon.

Dragon's disadvantages are described next. First, the basic version of Dragon has a limited vocabulary. While Dragon is preprogrammed with a surprising amount and variety of words including names and places, it does not know a lot of scientific or medical jargon. There are advanced versions of Dragon that include the sophisticated vocabulary that belongs to specific disciplines such as science and medicine, however, these programs are expensive and less available than Dragon's standard version. Because the basic Dragon fails to recognize many scientific terms, Dave does not use the program when composing science-based essays. Dave feels it is counterproductive to use Dragon for this type of essay and therefore, he limits his Dragon use to essays that do not require a lot of words outside its vocabulary. Dragon users can build the program's vocabulary by teaching it new words but they may have to spell the misinterpreted word several times before the program starts to recognize it properly. For example, the name *Hranka*, pronounced *Ranka* with a silent *H*, had to be corrected more than 20 times before Dragon started to translate it correctly. Easier words without a silent letter are learned more quickly by the program.

Amar is a science student whose discipline requires that he create a lot of tables and diagrams using the computer. Dragon is not conducive to this. While there is likely a number of precise verbal commands that can be said in a specific order for Dragon to create a table with columns and rows or various graphs like pie charts, Amar finds it too tiring and burdensome to bother. Unable to draw these diagrams by hand, Amar must manually produce them using the computer mouse. This is time-consuming and painful for Amar.

In addition to not recognizing certain words, Dragon fails to recognize certain accents. While there are versions of Dragon designed to interpret different accents, they are difficult to find in Canada and the United States. The standard version of Dragon in these North American countries is designed to recognize Canadian or American accents that although not exactly the same, sound fairly similar. Dragon's inability to recognize certain accents was noted by June, a former Dragon user with an English accent. June found Dragon to be exhausting and useless because it did not recognize what she said. Referring to using Dragon, June states, "it was the first time I laughed in like 10 years because the things it wrote were so outrageous". June spent hours training Dragon and she promised herself that it would not "beat her" but in the end, "it did" confesses June. After contacting Dragon's manufacturer, June learned that her version of Dragon was incompatible with her accent and she was advised to purchase the version that would understand her. At that point, June abandon Dragon and never returned to it. In a similar vein, Dave explains that while Dragon allows him to choose American or British English, there is no option for Canadian English. For example, the program does not put the letter *u* in the words *colour*, *favourite* or *neighbour*. If the user, however, corrects the word to include the letter *u*, then Dragon asks the user if he always wants the program to spell the word that way.

Furthermore, several Dragon users complained about its general lack of accuracy in recognizing regular words. While it depends on how well the program has been trained to recognize its user's voice and how well the user dictates, Dragon frequently misinterprets common words, especially words that sound the same such as *than* and *then* or *in* and *and*. When words are misinterpreted, Dragon users correct them by saying *select* followed by the misinterpreted word. For example, if the word *accent* is misinterpreted as *accident*, the user says *select accident* at which time the word *accident* is highlighted and a pop-up window appears that lists possible word alternatives. A list of similar sounding words is presented often containing the word the user intended. In fact, Dragon users can preset the number of word choices offered. If the correct word is in the pop-up window, then the user simply says *choose one* or *choose two* as each of the words are labeled with a corresponding number. If the correct word is not in the pop-up window, then the user can opt to manually or orally spell the word letter by letter in a spelling window. Referring to spelling words orally, Amar states, "this is a painful way to spell". Amar's spelling is so poor that he is rarely able to spell the misinterpreted word and this prevents him from improving Dragon's vocabulary.

Orally spelling out a word letter by letter in the spelling window creates more obstacles as Dragon frequently misinterprets letters that sound similar. For example, *m* sounds like *n* and *b*, *d*, *e* and *p* all sound alike. Letters that are individually dictated are also misinterpreted because they lack context. When translating a sentence, Dragon interprets a word based on the other words surrounding it but when translating letters, Dragon does not seem to have this type of judgment and perception. To clarify, Dragon does not use the letters that have already been spelled by the user to make an informed decision or educated guess about what the next ambiguous sounding letter might be. That noted, Dragon does start predicting the word as the user starts typing or dictating its letters. For example, if the user starts spelling the letters *wav*, Dragon starts offering the words *wave*, *waving*, *wavering* etc.

The following are examples of how Dragon understands the context of words. Dragon types the words *read aloud* instead of *read allowed*, the *colour red* instead of the *colour read* and *human rights* instead of *human writes* because it somehow knows that these are correct. The program, however, does not always properly interpret word combinations. For example, it has written *Mary Christmas* instead of *Merry Christmas*. Moreover, while Dragon usually knows proper grammar, it occasionally makes a grammatical error such as typing *there* instead of *their*. Finally, if a user dictates the word *to*, Dragon usually types the spelling, *to*, but if a user dictates the words *too much*, Dragon includes the second *o* in the word *to* because it knows this is the correct word sequence. The program appears to have a mild degree of intuition. It must be preprogrammed to accept or reject certain word combinations.

Although it is never mentioned during the interview, it is obvious that Amar has a stutter. This creates an obstacle when using Dragon as the program works best when words are strung together and spoken like a natural sentence. By pausing in between each word as Amar often does, Dragon is not given the context it needs to properly interpret a sentence. Users must be careful, however, not to string their words together too quickly because then mistakes happen – for example, the words, *anticipate it*, may be interpreted as *anticipated*. Another example is *so does* being misrecognized as *sodas*. Dragon has difficulty understanding Amar. For instance, the program does not recognize the way he says the word *a*. This would be troublesome since it is a frequently used word. Amar does not elaborate on how Dragon misinterprets this word but he does give another example of a word the program simply will not learn – this is *Cootes* as in *Cootes Paradise*, a Hamilton city beach. Despite teaching Dragon this word numerous times, it continues to misinterpret it. *Perceive* is another "problem word" for Amar as Dragon keeps picking it up as *preserve* instead.

Dave finds it "very frustrating" when Dragon misinterprets his words. Having to frequently correct mistakes as he writes defeats the technology's purpose to increase efficiency, observes Dave. Nisha, a former Dragon user who abandoned the program out of frustration like June, explains that when Dragon makes mistakes, she feels the need to correct them right away. Nisha often stops halfway through a spoken sentence to go back and fix an error in the first part of the sentence. This causes her to lose her thought. After correcting a mistake which could take up to 30 seconds if she has to orally spell the word, Nisha no longer remembers what she was going to say. In contrast to Dave who feels Dragon allows him to communicate his thoughts effectively, Nisha feels the program hinders her self-expression. Nisha euphemistically describes herself as "not a fan" of Dragon and then she bluntly states, "I despise that program, I'm not going to lie". Nisha continues about Dragon: "it was more obnoxious than it was actually useful". This indicates how difficult and challenging the program can be.

In addition to supervising students who use Dragon, Tyrell uses Dragon himself. Rather than directly dictating his essays to the program, however, Tyrell hand writes his essays first and then reads them aloud to Dragon. Tyrell does it this way because he writes better with paper and pencil but his essays need to be typed for school. Tyrell states, "I really find the word process flows a lot better for me using pencil". For Tyrell, Dragon is more cognitively demanding than handwriting because it requires him to completely formulate a thought and translate it to a sentence structure all at once. Tyrell explains, "because you're dictating, internally there's a thought of what it is I'm going to say, I formulate in my mind and then I speak it, so I feel as if I need to be more polished. I need to be closer to the final product when I finally speak it rather than just writing free, letting the ideas flow". Although Tyrell can pause between words to gather his thoughts, this jeopardizes the accuracy of the translation as the program understands full sentences better than individual words. Like Nisha, Tyrell feels Dragon restricts his writing.

Tyrell explains that many of his student Dragon users cover the computer screen when dictating so they will not get discouraged by its multiple mistakes. Tyrell points out that children are not as good as adults at clearly articulating words and therefore, Dragon poses an even greater challenge for them. Once Tyrell's students finish dictating, they then go back and correct the errors. If Dragon interpreted a sentence so poorly that the students cannot decipher what it was supposed to type, they then utilize Dragon's playback option in which the program reads back not what is on the computer screen but what was originally spoken to the program.

Moreover, when a user selects a word for correction, Dragon does not always select the word the user wanted. It may select a similar sounding word instead. As a result, Dragon's training guide instructs users to select not just the single word that needs correcting but also a few words before and after the misinterpreted word. For example, in the misinterpreted sentence, *the grass is clean*, the user would not only select the word *clean* for correction but would select the entire sentence. This increases the program's likelihood of selecting the proper phrase and makes for easier correction.

Another benefit of selecting a phrase or group of words instead of just a single word when correcting Dragon's mistakes is that the misinterpreted word does not lose its context. Take the misinterpreted sentence *this is claim, old boring* for example. If a user selects the single word *claim* and redictates the word *plain*, the program may type the word *plane* instead of *plain* because it does not know the whole sentence or context. Selecting and repeating the entire sentence increases the chances that Dragon will correctly interpret it the second time it is dictated.

In addition to selecting a similar sounding word instead of the word the user wanted to select for correction, Dragon also selects every single instance of a word when that word is selected. For example, if the word, *the*, was selected for correction, Dragon places a number beside each and every *the* on the screen. The user then chooses which *the* he wants corrected by saying its corresponding number. Dragon could better anticipate its user's needs by selecting the, *the*, closest to the cursor as the cursor is located in the sentence the user is currently working on and therefore, the closest *the* is likely to be the one the user wants corrected. In the event that the closest *the* is not the, *the*, the user wants corrected, then the user would have to move the cursor closer to the, *the*, he wants corrected. Perhaps under this method of word selection, the extra step of moving the cursor is just as bothersome and time-consuming as having Dragon select every instance of a word and choosing which word is to be corrected. The fact that Dragon selects every single instance of a word when that word is selected for correction is another reason to select a string or combination of words instead of just one. The exact same string or combination of words will likely not exist in the document more than a few times and Dragon will only select words that are currently visible on the screen.

Correcting Dragon's mistakes slows down the writing process considerably and so does editing and formatting documents. Editing and formatting include actions such as creating new paragraphs, indenting paragraphs, changing line spacing, inserting page numbers, switching font style and size, and bolding, italicizing or underlining certain words. Dragon users Bob and Tyrell both report having difficulty editing and formatting with Dragon. Referring to editing his essays with Dragon, Tyrell jokes, “if I have to do that, I will kill somebody”. Although clearly kidding, Tyrell’s comment reveals how aggravating the program can be.

Editing and formatting with Dragon is challenging because the user must move the cursor around the screen, scroll up and down, select words and sentences, and click a variety of icons many of which are hidden in drop-down bars, all by dictating memorized voice commands. Although Dragon can perform most of these editing and formatting functions, the program demands a series of specific verbal commands to successfully execute each one. For example, inserting page numbers must be spoken like this: *click insert, click page number, click top of page, click plain number one, close header and footer*. Dragon requires its users to learn, practice and master a particular language to operate it effectively. If the string of commands is not stated accurately, the program will not perform them. Tyrell explains that Dragon NaturallySpeaking is better for editing and formatting than DragonDictate. That noted, Bob experienced his editing and formatting frustrations when using Dragon NaturallySpeaking.

Perhaps one of the greatest challenges about using Dragon is memorizing its voice commands. Tyrell has difficulty remembering all the voice commands. Exact language must be used for the program to recognize the instruction. For example, the user must say *click home* not *press home* or *select home* in order to get Dragon to hit the home icon. Moreover, if the user wants to indent a paragraph, he must say the word *tab*, not *indent*. Here, the user tells Dragon what key he wants pressed – the tab key – instead of telling it the resulting action he wants – to indent the paragraph. Notice that the word *click* is not required to be spoken before the word *tab* like it was in the above example with *home*. This inconsistency in Dragon’s voice commands cannot be explained by reasoning that *home* is a screen icon that requires the word *click* to precede it whereas *tab* is a keyboard key that does not require the word *click* to precede it because *return*, another keyboard key, does in fact require the word *click* to precede it. This variability in Dragon's voice commands makes them even more difficult to learn. While some of the voice commands are intuitive such as *minimize window* or *save file*, others are not. For example, if the user wants to turn the italics off because they are on, he does not say *italics off* like one may assume but instead, he says *click italic* to deselect the italic icon. Nisha complains that Dragon does not recognize certain voice commands. For example, when she says *scratch that*, Dragon is supposed to delete the last phrase she said. Time and time again, Dragon failed to execute this command claims Nisha.

In addition to not performing certain commands, Dragon can also misinterpret commands as dictation and vice versa. For example, the program may write the words *save file* instead of actually saving the file or it may create a new paragraph by moving the cursor down one line instead of typing the words *new paragraph*. Dragon's training guide recommends a solution to this anticipated and commonly experienced problem. It suggests that if the program is typing commands instead of performing them, hold down the *control* key while dictating and if the program is performing dictations instead of typing them, hold down the *shift* key while dictating. Unfortunately, Dragon's recommended solution does not always work. In spite of pressing the control or shift key while dictating, Dragon may continue to mistake commands for dictation and dictation for commands.

Dragon users must dictate most punctuation including periods, commas, colons, quotation marks, question marks and exclamation points. Dragon regularly inserts apostrophes but it is not unusual for them to be misplaced or missing altogether. Dragon also struggles to recognize anything that is not standard vocabulary. Examples include Roman numerals and foreign language abbreviations such as *et al*. Dragon users also need to articulate more clearly than they would if they were talking naturally to another person. While the secondary disability of voice strain can result from voice recognition systems, often the fatigue experienced after long periods of dictation is rooted in the back of the tongue. Articulating clearly for a long time is tiring and takes a toll not only on the vocal cords but on the mouth as well.

The *Premium* version of Dragon is designed to perform Internet commands so websites can be navigated with the voice instead of the mouse. Unfortunately, Dragon frequently fails to execute many Internet commands. For example, Dragon may fail to perform actions such as clicking tabs or scrolling up and down. The program may fail to open links or move the cursor to the search bar. “Pulling teeth” is how Dave describes the process of trying to navigate the Internet using Dragon’s voice commands. While Dave uses Dragon for composing essays, he refuses to use it to navigate the Internet because it is too irritating and ineffective. Amar, who always uses Dragon to compose essays, also refuses to use it for Internet navigation. Amar finds it extremely difficult to surf the net and operate other Internet applications using Dragon. For example, when Amar instructs Dragon to *open mail* or *compose new mail* in his e-mail account, it does not perform the commands. Dragon’s failure to perform certain commands means it is easier and more efficient for Amar to navigate the Internet using the computer mouse. Dragon is quite effective at producing typed documents but it is not very useful for navigating the Internet.

Dragon does not work well if there is background noise. Nisha explains that with her barking dogs nearby, the program struggles to interpret the meaningless sounds instead of filtering them out and focusing on her voice. Furthermore, Amar does not use Dragon in Microsoft Word because the program works best in Dragon’s dictation box – a typing window specifically designed to receive spoken words and commands. Amar then copies the text from Dragon’s dictation box and pastes it into a Word document. Moreover, Amar explains that if something is not “native” to an operating system but is added on afterwards, it does not work as well as if the device or feature was part of the basic system from the start. He gives the example of Dragon’s microphone which he claims is not as effective as the microphone that is built into standard computers.

Training Dragon and receiving technical support for Dragon can be difficult and time-consuming. Amar asserts that Dragon is “not responsive to training”. Amar says that he has to train the program “10 times” to notice even the slightest improvement in its accuracy. By 10 times, Amar means that he must read a different story to the program 10 times. Dragon’s initial training requires that the user read it a story or passage so the program can learn the user’s voice. Dave registers a similar complaint. In spite of reading Dragon four different stories, Dave noticed no improvement in its accuracy. Dave acknowledges that over time, he can actively improve Dragon’s accuracy by consistently correcting its mistakes and teaching it new words but he makes the valid point that this does nothing to increase his productivity right now. Tyrell explains that Dragon would not type his brother’s name correctly no matter how many times he taught it to the program. Clearly, Dragon’s training needs work.

In addition, Amar points out that there is less technical support available for Dragon compared to other programs such as Microsoft Office because it is not as widely known or used. Dragon’s technical support helpline is free for the first year after purchasing the program but then there is a charge for receiving over-the-phone assistance to troubleshoot Dragon’s problems. Amar brings up Dragon’s technical support website on his computer screen to demonstrate its non-user-friendly nature. With its multiple links, the website does not easily allow Amar to find a solution to the problem. Amar suggests that the website provide a search bar in which Dragon users can type their question and get an immediate answer. Bob says “oh yes” when asked if he has phoned Dragon's technical support helpline. When Clark is asked if he phones help lines for AT support, he responds, "all the time". Clark, who knows AT well because it is his job to teach it, frequently seeks assistance troubleshooting and solving the numerous and diverse problems that arise when using different forms of AT.

Somewhat troubling is the fact that the developers at Nuance know how to improve Dragon but they have not yet done so. For example, one of Dragon's feedback surveys asks the user if it would be helpful to move the cursor back to where it was before it was moved to the middle of a sentence to correct a word. As it is now, the user must continually use voice commands to move the cursor back to its initial position. For example, the user must say *go to end of sentence*, *go to end of paragraph* or simply *go to end* to make the cursor return to its original spot. After Dragon's survey, an updated version of the program was introduced still lacking this helpful feature. Today's Dragon users continue to repeatedly move the cursor back to where it was prior to making a correction.

Similar to screen readers that threaten user's privacy as a result of sound output, the sound input required by VRS poses an even greater risk to user's privacy. This is because unlike headphones that solve the privacy problem for screen-reading users, there is no comparable solution to keep private the speech Dragon users must dictate. In recent years, some court reporters have worn a device over their face much like a mask that keeps silent the speech they dictate into it. This device, however, is likely expensive and cumbersome to wear in public. Amar does not use Dragon in public because it disturbs other people. Group work is particularly difficult for Amar because using Dragon in the presence of others can be awkward and embarrassing. For this reason, Amar often forgoes Dragon when participating in group work.

If screen readers and VRS reduce privacy, they become less mobile as they cannot comfortably be used in public. A lot of AT is stationary and immobile for another reason – that is, AT is added onto the AT user's personal computer and is not available on most other computers found in offices, schools or public libraries. Tim's ZoomText software for example is installed on one computer – the desktop computer in his office that does not easily transport. Tim's AT stays in one place and so does Tim if he wants to use the computer. The mobility of some AT users is often restricted to the mobility of their assistive devices.

Like screen readers that can be seen as a cognitive shortcut to reading, VRS can be seen as a cognitive shortcut to writing. Tyrell explains that the teachers of his student Dragon users feel that using Dragon is a form of cheating because they believe it prevents them from practicing the traditional skill of writing. Orality is seldom valued today as it was in the past. Tyrell makes the point that teachers probably would not think a student who wears the optical aid of eyeglasses was cheating. While Dragon provides computer access to many people who would otherwise be denied it, its multiple difficulties and challenges beg the question: at what point does the seemingly helpful technology become more of a hindrance than a help?

Other Assistive Devices

This section examines two other assistive devices called the Life Script Smart Pen and the Mac Surface Pro. Both Tyrell and another research participant named Beth use the Live Script Smart Pen. The pen is a neat visual and auditory tool that costs about $200. Here is how it works. As Tyrell and Beth take handwritten notes with the pen during university lectures, it visually records what they are writing. The pen is then plugged into a computer in which it converts their handwritten notes into text on the computer screen. Beth estimates that it takes 15 minutes to convert 30 pages of notes from handwriting to text, or half a minute per page. In addition to being a visual recorder, the pen is also an audio recorder. While the pen visually records handwriting, it also audio records the lecture or more precisely, the professor’s spoken words.

The pen’s interesting part is that it comes with its own special paper containing micro dots that serve a specific function. Once handwritten notes have been made on the paper, the user can push the pen down on a particular spot on the paper and the pen’s audio recorder will jump to the words in the lecture that were spoken at the exact time when the pen was originally touching the paper in that particular spot. An example will clarify. Tyrell struggles to keep up with the professor when taking lecture notes. As a result, he can only write down part of what the professor says before he must leave that thought or concept and move onto the next piece of material the professor is discussing. When this happens, Tyrell puts an asterix beside the incomplete thought or concept to indicate that it is unfinished or missing information. Once class is over, Tyrell pushes the pen down on the asterix on the paper which activates a micro dot so the pen starts dictating aloud what the professor said about that thought or concept during that particular point in the lecture.

The Live Script Smart Pen helps Tyrell with his auditory processing difficulties more than a typical audio recorder could. This is due to its interactive capabilities with the special paper. Moreover, each piece of paper contains icons along the bottom of it that can be pressed with the pen to activate their functions. For example, Tyrell can adjust the volume of the audio recorded lecture, he can pause it and he can alter its playback speed. Also, Tyrell can jump to points in the lecture such as 20% of the way through, 60%, 80% etc. This is better than a regular rewinding or fast forwarding feature as Tyrell can choose to revisit the lecture at an exact point. Tyrell says that without his assistive computer technologies, including the Live Script Smart Pen, he would really struggle to complete a degree. “The technology…allows me to do things that I would not be able to do”, explains Tyrell.

Furthermore, the pen has a mini window on it – a screen about an inch long and a centimeter wide. The pen’s mini window contains different options that Beth can scroll through by pushing the forward and back arrow icons on the pen’s micro dotted paper. One of these options includes a dictionary that Beth purchased for an extra $15 CAN. When Beth sets the pen to the dictionary option, she can write a word and the pen will tell her its meaning. Beth also takes advantage of the pen’s audio recorder and like Tyrell, she pushes the pen down on a spot in her writing on the special paper to make it jump to the words that were recorded when the pen was initially touching that spot on the paper. The pen’s visual and audio recording features cater to one’s sense of sight and hearing. In this way, it is an assistive tool for both visual and auditory learners.

The Mac Surface Pro is another device Beth uses to convert handwriting to typing. Typing is painful for Beth because of a nerve condition called reflex sympathetic dystrophy that she developed as a result of sustaining injuries from six car accidents. Although the condition is in Beth’s shoulders, it also affects her hands. Beth explains that her nerves go “insane” meaning they become over-stimulated and hyperactive. Beth often experiences swelling and numbness in her hands and she gets regular injections to keep her nerves calm. Handwriting is much easier than typing for Beth because handwriting does not engage her shoulder the same way typing does. Beth states, “it’s not that I can’t (type), it’s just painful to hold my hands a certain way because the condition actually goes in the shoulder”. In addition to not being able to physically type, Beth feels that typing, as opposed to handwriting, restricts her writing. Beth states, “I think when you’re writing it, your ideas flow much better because you know, for me typing it, I get so frustrated that I can't get the characters in there because I don't know, my hand will just go slightly off". Like Tyrell, Beth prefers handwriting over typing. She produces higher volume and better quality work when she uses a pen compared to a computer keyboard.

The Mac Surface Pro consists of a computer screen about the size of a regular book. Beth can write on the screen with the device's accompanying pen and it translates her handwriting into typed text. The screen is broken into two windows – a bottom window in which Beth writes and a top window in which her writing appears in typed form. If the device misinterprets a character Beth has written, Beth simply crosses it out and rewrites it. A single slash through the handwritten character deletes the typed version of the character. Beth describes the Mac Surface Pro as very "forgiving" meaning that her characters do not have to be written perfectly to be interpreted correctly. The characters must, however, somewhat resemble the appearance of standard characters or they will be misinterpreted. For example, Beth writes a word containing two consecutive lower case *ts* but instead of properly separating the *ts*, she attaches them. Beth does this by crossing the *ts* together – she draws two vertical sticks side-by-side and then one continuous horizontal line that crosses both *ts* at the same time. The resulting character looks more like a capital *H* than two lower case *ts* and the device interprets it as such. To fix this, Beth crosses out and rewrites the two consecutive lower case *ts*, this time separating each character so they are correctly interpreted. While the Mac Surface Pro may interpret writing as well as printing, Beth only demonstrates how the device works using printing.

Moreover, Beth can bring up a touch screen keyboard on the Mac Surface Pro that can be used in different programs. The keyboard can be set to show only letters, only symbols and numbers, or both. Beth uses this keyboard in her e-mail account so she can compose typed e-mails by simply pressing the device's pen on the keys. This allows Beth to avoid directly typing with her hands. Beth likes the touch screen keyboard because of its sensitivity – she barely needs to touch the keys for the device to register them. Andrew is the only research participant who does not use AT, however, he considers the standard computer a form of AT in itself because he cannot express himself through handwriting. Andrew must type everything he writes because he cannot get his thoughts out using pen and paper. Andrew dislikes touch screen keyboards for the same reason Beth likes them – their sensitivity. Andrew must hold his wrists up to avoid pressing unwanted keys and this creates discomfort for him. While the touch screen keyboard's sensitivity helps Beth, it hinders Andrew. Making technology more accessible to some makes it less accessible to others.

Like the Live Script Smart Pen, Beth uses the Mac Surface Pro for taking lecture notes. Beth can download the professor's PowerPoint lecture slides and make notes directly on them, either by printing with the pen or by using the pen to navigate the touch screen keyboard. While Beth believes that non-disabled people could benefit from using the Mac Surface Pro, she explains that its cost may prevent them from buying it. Beth paid $1200 CAN for the device. Because it keeps her high functioning as a student, Beth feels the cost of the device was worth it.

General Comments about Standard Computers and AT

When asked if the computer has created barriers for her, Beth agrees that it has but qualifies the claim by explaining that the computer presents more of an obstacle in the modern-day workplace than in a traditional university setting. In school, Beth can use AT to get the job done. In the workplace, it is not so easy. Beth explains that in her experience, most employers want all their employees using the same computer equipment. She says a lot of corporate managers are reluctant to let their employees use their own computer technology because of security and privacy issues. People who run organizations want all company files to remain safe and in the same location. They do not want employees bringing in their own computers, working on them and saving confidential files that leave the office at the end of the workday. Moreover, Beth alludes to the stigma that can accompany AT or any technological tool that deviates from the norm. Referring to potential employers, Beth states, “they walk by and you’re using this (she motions to her Mac Surface Pro), they’re not impressed”. Most employers believe that “everybody should be using the same thing”, explains Beth. They do not like it when people cannot conform to standard computer technology.

Beth no longer works because of her injuries. She says that most office jobs require fast and repetitive data entry from their employees, so much in fact, that job applicants are often asked how many words per minute they can type prior to being considered. Unable to type the regular way, Beth’s employment opportunities are substantially limited. Imitating potential employers, Beth states, “as long as you can type as fast and that, that’s great, we’ll employ you, but if you can’t, well I’m sorry you’re just too disabled for us to employ”.

Beth also points out that employers are hesitant to accommodate employees with disabilities if it negatively affects the company’s finances. Again imitating potential employers, Beth quips, “we want to be advocates for the disabled but as long as the company line isn’t affected”. Beth observes that employers are often willing to alter the physical environment if it means changing something like expanding the width of a doorway or adding another wheelchair parking spot. They are much less willing, however, to modify existing office equipment, not only because of the expense but because of the fear attached to unknown technology. Beth explains that employers have a degree of tolerance for physically disabled people who have difficulty getting to the office but once they are in the office, all people, regardless of ability, are expected to perform efficiently and meet universal standards.

Similar to the author's disability, Beth's disability is invisible and therefore, people do not believe it is real. Beth says that when she has disclosed to past potential employers that she cannot use the standard computer, they look at her skeptically and say, "you look perfectly fine!". Beth explains that it would almost be easier to have a missing limb because then people would understand and believe the extent and severity of her disability. If Beth had no arms, people would not question her ability to access the computer – it would be visibly apparent that she could not. Similarly, Nisha has an invisible learning disability that has been met with disbelief. Before choosing which university to attend, Nisha visited the Student Accessibility Departments at each school to which she applied. Nisha did this to gauge the way in which her disability was received by the staff in the accessibility department. Nisha's past difficulty convincing people that she does in fact have a legitimate problem has made her wary of people's attitude toward it.

Speaking to the concept of extension and amputation, Beth states regarding assistive computer technology: "I think as a student it's an extending force but as a working person, it's like an amputation". While AT is an asset for Beth in school, it is a liability for her in the workplace. Andrew also speaks to the concept of extension and amputation. Andrew explains that he would be "devastated" if his computer was taken away from him as he would no longer be able to function at his current level. The computer enables Andrew to communicate in written form and in this sense, it extends part of his brain. To deprive Andrew of his computer is almost like cutting off a part of him. Andrew states, "if I can make a comparison to a regular amputee… I think I would probably feel depressed, almost like, you know, how an amputee can feel depressed about the loss of a limb".

When asked about his relationship with computer technology, Andrew responds, “it’s a strained relationship sometimes”. Andrew explains that his relationship with the computer is somewhat stressful and worrisome because he is dependent on it. As a university student, Andrew must use the computer and therefore, he feels “sort of tied to it”. Without the computer, Andrew would be more disabled. He states, “I wouldn’t be in university today if I wouldn’t have a computer to do this writing on so it’s absolutely a critical part”. By critical part, Andrew means it is a vital component of his life and himself. While Andrew needs the computer to succeed as a student, the computer threatens Beth’s academic success. Fortunately, AT allows Beth to partially bypass the standard computer. Talking about her assistive devices enabling her to attend university, Beth states, “I think without this stuff, I don’t think I could do it”. The standard computer emancipates Andrew and subordinates Beth.

Tim does not experiment with his AT to discover everything it can do because he is afraid of breaking it. Fear of the technology not working prevents Tim from pushing it to its limit or using it for all it can be used for. “You’ve got a tool that can do probably 20 times more things than what I actually use it to do”, states Tim. When it comes to testing technological capabilities, Tim does not venture too far out of his “comfort zone”. He admits that he is not technologically inclined and therefore, he must depend on the expertise of others to help him fix his AT if it breaks. Tim describes this dependence on other people as a type of “confinement”. He explains:

> As much as I hate using this word I’m going to use it in this context – you are ‘confined’ to your reliance upon others. And I don’t like using the word confined, lots of people with disabilities hate the word confined, but in this case I think it’s probably appropriate because I don’t have the technological savvy to problem solve these issues on my own. I’m just not technologically literate.

While AT can grant PWD a degree of freedom and independence, it can also leave them quite helpless if it fails to work properly.

During his interview, Tim addresses the problem that AT often trails behind standard computer technology. He explains that AT has not “kept pace” with regular technology but is constantly in “catch-up mode”. “The adaptive technologies are perpetually late”, observes Tim. One of the main reasons for this, according to Tim, is that computer companies such as Microsoft often rush to get their products on the market and then later think about modifying them to accommodate PWD. With profit as their primary motive, these companies frequently neglect the needs of PWD and in doing so they delay the timely and full participation of PWD in society.

Interacting with the computer while using AT is “entirely different” than interacting with the computer without using AT, explains Clark. Watching and listening to the research participants interact with their computers was interesting. Their exchange and relationship with the technology is unlike that of most people.

Discussion

The paradoxical power of computer technology to both enable and disable has been recognized in the literature on technology and disability. Scholars have acknowledged that computer technology can be both a blessing and a curse for PWD, simultaneously helping and hindering them (Annable, Goggin and Stienstra 146; DeWitt 315–316; Fichten et al. 180; Hollier and Murray 124; Lupton and Seymour 1853; Ring 79). Some scholars have focused on the Internet as a liberating and oppressive force for PWD (Cole; Pilling, Barrett and Floyd), while others have focused on how the computer creates physical barriers for people with motor or sensory impairments (DeRuyter et al.; Goggin and Newell; Guillou et al.; Hwang et al.; Light and Drager; McNaughton and Bryen; Newell et al.; Nicolle et al.; Pilling, Barrett and Floyd; Sanford, Story and Ringholz). In this latter type of work that focuses on the computer’s physical effects, AT is often offered as the solution to overcoming the computer's restrictive interface. AT is presented as the answer to providing computer access for PWD. In this way, most research until now has concentrated on the benefits of AT (Boonzaier 10; Dewitt 327; Fleischer and Zames 211; Pilling, Barrett and Floyd 43; Sagstetter n.pag.). There has been much less inquiry into AT's negative effects (Forgrave 122–126; Goggin and Newell 41). While the positive outcomes of AT are fairly obvious, the adverse consequences are less clear and have therefore been less studied.

This study narrows the gap in the existing research on assistive computer technology by carefully examining the drawbacks of AT, including its many constraints and defects. At a basic level, this study sought to explore the relationship between PWD and computer technology. More specifically, its purpose was to examine how standard computers produce or exacerbate disability and how assistive computer technology improves or alleviates disability. Another layer of the research involved analyzing the complex mix of benefits and difficulties experienced by PWD using a variety of assistive devices.

This kind of analysis in which the specific limitations of different types of AT are identified and investigated is largely absent from the field's body of literature. Although a few studies point to the future direction of AT by offering broad and general recommendations to improve it (Baxter et al. 222; DeRuyter et al. 266; Williams, Krezman and McNaughton 195; McNaughton and Bryen 219-226), the majority of research has neglected to study the intricate and individual issues that arise from using distinct forms of AT. By discovering the personal and particular problems experienced by AT users, this study addresses that which has generally been ignored in previous AT research. It doing so, it has helped fill a void in the field of computer technology and disability.

Many disadvantages of AT were evident throughout the study, however, two significant disadvantages are worth highlighting. First, using AT to compensate for a primary disability can create a secondary disability. For example, screen magnifiers require their users to perform a tremendous amount of mouse movement and clicking that can result in repetitive strain injury or swollen and overworked arms as was the case with Tim and Pat. Likewise, voice recognition systems can cause voice strain and fatigue due to the amount of talking required to operate them. Accommodating one disability with the use of AT can produce another disability.

A second notable disadvantage of AT is that it places an unrealistic expectation on AT users. For example, it is widely misperceived that AT provides a perfect solution for PWD. Unaware of AT's numerous limitations, many people expect AT users to access the computer to the same extent as non-disabled people. This expectation presented itself in Tim's case. Tim complained that people expect him to access e-mail attachments that his screen reader will not read. Although likely aware of Tim's severe vision impairment, people maintain their unrealistic expectations of him because they mistakenly think AT provides him with full computer access. The commonly shared belief that AT is the ultimate fix or complete cure for providing computer access to PWD, is troubling and in need of correction.

Computers pose a problem for PWD and more computer technology – AT – appears to be the solution. This is computer technology's disability paradox. Another disability paradox lies within AT itself – that is, AT simultaneously serves as a help and a hindrance to PWD. Indeed, there are both positive and negative effects of AT but what is more, AT can have opposite effects on the same skill or activity. For example, the skills of reading and writing as well as the activity of thinking or one's cognitive load, are both positively and negatively affected by the use of AT.

This contradictory capacity of AT to have conflicting effects on the same skill or activity was apparent throughout the study results.

First, screen readers can facilitate or inhibit reading. For example, reading with Kurzweil slows Dave down compared to an average person silently reading although without it, he could not absorb or retain written material at all. Moreover, it is time-consuming to prepare documents to be read by Kurzweil but the program can also enable users to process a large volume of written information in a shorter time than regular reading or while engaged in another activity. This was the case with Tyrell's brother and Bob, respectively. Also, Kurzweil can mispronounce or skip words and translate unwanted markings or superfluous information but it caters to one's sense of hearing which means some people like Tim, Nisha and Kate may process information better than regular reading. Next, Tim and Pat can access written material on the computer screen using the ZoomText screen reader, however, ZoomText fails to interpret images and can misinterpret symbols, abbreviations and information that is presented in charts. When this happens, ZoomText becomes more of a detriment than a benefit to reading.

Secondly, AT is both an asset and a liability in terms of writing. For example, Dragon makes writing possible for Amar who cannot handwrite or type but more difficult for Tyrell who has trouble forming and dictating full sentence structures. For Dave, Dragon can be useful or futile depending on the type of writing he is composing. For example, if Dragon lacks the vocabulary Dave needs, it becomes more burdensome than helpful. Additionally, June's accent prevents her from using Dragon to write anything whereas it enables Tyrell students to write something. Also, Nisha struggles to write using Dragon because of its lack of accuracy interpreting both words and voice commands yet she is able to edit and improve her writing by hearing it read back to her through Kurzweil.

Lastly, AT can increase and decrease one's cognitive load. For example, Dragon increases Tyrell's cognitive load because he must formulate an entire sentence structure before verbally translating it. On the other hand, Dragon decreases Amar's cognitive load because he does not have to concentrate on spelling or grammar as he would if he were writing instead of speaking the words. Furthermore, the ZoomText screen reader increases Tim's cognitive load because he must decode the short forms it reads literally to him. In contrast, screen readers can decrease one's cognitive load because their users do not have to visually decode words letter by letter – they can simply hear them instead. This was the case with Dave who deliberately lightened his cognitive load by choosing to only listen and not look at the computer screen as it was read.

AT not only has positive and negative effects but it also has opposite effects on the same skill or activity. This complicates its dual nature to both help and harm PWD.

In addition to AT's multiple and diverse technical problems that were examined in the study, there appears to be several significant social costs to using AT. In fact, four social costs were found. These social costs all resulted from using *alternate* AT in which sound is produced as an alternative input or output strategy.

The first social cost is that using *alternate* AT can result in a loss of privacy causing embarrassment or discomfort. This was the case with Tim in which sound output jeopardized his privacy and also the case with Amar in which sound input made him feel awkward in social situations.

The second social cost is that a perception exists that *alternate* AT users are at an unfair advantage or are somehow completing their work in an illegitimate manner. This was evident in

Tyrell's case where teachers felt that student Dragon users were not exercising the traditional skill of writing. Using AT was viewed as a form of cheating or a type of cognitive shortcut.

The third social cost is the strong corporate resistance to supplying PWD with technological accommodations. This emanated from Beth's case in which she described the reluctance of employers to accept alternative ways of accessing the computer. While this corporate resistance to AT could be considered an economic rather than a social cost, permanent unemployment resulting from disability has social consequences of its own.

Finally, the fourth social cost involves AT use by people with invisible disabilities. This presented itself with Beth and Nisha who have both struggled to convince people that their disabilities are real. When people cannot see a disability, they often have difficulty believing one exists. This disbelief, however, is not the social cost. The social cost is that the use of *alternate* AT reveals an otherwise unknown disability. People with invisible physical or mental disabilities who must use AT that requires sound input or output are forced to disclose their disabilities. These *alternate* AT users do not have the option of keeping their disability private. Disabilities that may have otherwise remained secret are exposed. *Alternate* AT users not only deal with the challenges and frustrations that accompany AT but they also pay a social price for using it.

Similarly associated with the use of physical aids such as a cane, walker or wheelchair, there is a social stigma surrounding technological aids. When people cannot do an activity the way it is traditionally done, whether it be climbing stairs or accessing the computer, they are often marginalized by society. Many people view the use of AT as odd or peculiar. As something that is foreign and unknown to most people, AT can be seen as bizarre or deviant. The use of AT disturbs people's conception of how the computer ought to be used.

Research has shown that the more people can relate to an assistive aid, the more open and accepting they are of it. In other words, if people can envision using the aid themselves, they are likely to adopt a positive attitude towards it. For example, one study demonstrated that people are more tolerant of guide dogs for the visually-impaired compared to canes. This is because people are more familiar with dogs than canes and many of them know what it is like to have one as a pet. Similarly, if people have experienced AT or can imagine themselves using it, there is a better chance they will approve of and embrace the technology.

As alternative input and output methods increasingly become integrated into standard computer technology, they become more widely received and used by people regardless of their ability. Take the Siri iPhone for example. This version of the iPhone allows its user to talk to it. Essentially, it receives voice input like Dragon. Siri users can compose text messages and e-mails by talking instead of pushing buttons. They can also verbally instruct the phone to navigate the Internet. People free of disability have taken advantage of this convenient feature. Able to use their hands, they actively choose to engage the technology via a method commonly used by PWD – sound production. This research on physical aids suggests that the design of assistive tools could be improved by taking into account the social psychology of the familiar and by avoiding features and interaction modalities that may trigger alienation and stigma.

Conclusion

Computers put PWD at risk of becoming even more disadvantaged. Although assistive computer technology reduces this risk by providing partial computer access to PWD, it does not eliminate the precarious possibility that PWD may be further denied economic, educational and social opportunities. As the use of computers increasingly becomes a necessary part of our everyday lives, the study of computer technology and disability takes on new importance and urgency.

Future research in the field must work closely with both PWD and AT users as not all PWD use AT. First, more research needs to be done with PWD to discover how the standard computer inhibits them. Studying how computer technology restricts PWD may improve the future design of computers so they are accessible to all users. In addition, more research needs to be done with AT users to discover how AT presents obstacles for them. Studying the downside of AT, including its significant social costs, may refine and reform the design of assistive devices so they are easily used and widely accepted.

The personal, one-on-one interview is likely the most effective method for carrying out future research with PWD and AT users. Due to the sensitive nature of the subject matter, focus groups in which other people are present may discourage the active and full participation of research respondents. Moreover, surveys in which communication is largely limited to the number, variety and depth of survey questions would not garner the rich and detailed responses elicited by the private interview that involves two-way communication between the researcher and the research participant. The interview process allows a professional and partly personal relationship to develop between the interviewer and the interviewee and this temporary partnership is inclined to generate the comfort and trust required to obtain valuable data. Additionally, interviews are the best way to conduct future research as being physically present together enables the research participant to demonstrate his computer and AT use to the researcher.

Limitations of future studies on computer technology and disability can be minimized by sampling a diverse population and also by studying all different types of AT used by people with all different types of disability. Future research could benefit from categorizing the different types of AT as well as the different types of disability. For example, AT could be classified as enhanced or alternate and disabilities could be classified as physical or mental. The physical disabilities could be further classified as motor or sensory and the mental disabilities could be further classified according to the specific type of learning disability or cognitive challenge. Researching what types of assistive technologies are used, why they are used and whom they are used by will help improve AT and this will better the lives of PWD.

Computer accessibility must be addressed at all stages of the design process. Manufacturers, computer programmers, software companies and AT developers need to be actively involved in and firmly committed to creating accessible computer technology for all people, especially those who suffer with disability. If this fails to happen, PWD will be kept in the margins of society and their future disenfranchisement will be virtually guaranteed.

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Interviews

Andrew. Personal interview. 16 May 2013.

Beth. Personal interview. 15 May 2013.

Bob. Personal interview. 14 May 2013.

Cipryk, Clark. Personal interview. 26 Apr. 2013.

Dave. Personal interview. 16 Apr. 2013.

June. Personal interview. 6 May 2013.

Kate. Personal interview. 22 Apr. 2013.

Nisha. Personal interview. 15 May 2013.

Nolan, Tim. Personal interview. 15 Apr, 2013.

Pat. Personal interview. 7 May 2013.

Tyrell. Personal interview. 1 May 2023.

Amar. Personal interview. 19 Apr. 2013.

Appendix A – Recruitment Flyer

DO YOU USE *ASSISTIVE* COMPUTER TECHNOLOGY?

Research Participants Wanted

For One-Hour Interview

As a Master's student in the Communication and Multimedia Department, I am studying alternative computer interfaces used by people with disabilities.

This study has been cleared by the McMaster Research Ethics Board
The Office of Research Ethics – 905.525.9140 ext. 23142 or
ethicsoffice@mcmaster.ca

CALL HOLLY

9	9	9	9	9	9	9	9	9	9	9	9
0	0	0	0	0	0	0	0	0	0	0	0
5	5	5	5	5	5	5	5	5	5	5	5
6	6	6	6	6	6	6	6	6	6	6	6
3	3	3	3	3	3	3	3	3	3	3	3
0	0	0	0	0	0	0	0	0	0	0	0
8	8	8	8	8	8	8	8	8	8	8	8
1	1	1	1	1	1	1	1	1	1	1	1
9	9	9	9	9	9	9	9	9	9	9	9
5	5	5	5	5	5	5	5	5	5	5	5

Appendix B – E-mail Recruitment Script

Dear SAS Student,

My name is Holly Moist and I am a student in the Master of Arts program in Communication and New Media at McMaster University. I am doing a major research project on the positive and negative effects of computer technology on people with disabilities and to proceed, I need to talk to people who are experiencing some type of condition or impairment that requires them to use assistive computer technology.

This topic is of interest to me because I must use a voice recognition system to access the computer. If you also use an assistive computer device for whatever reason, will you please grant me a one-hour, audio recorded interview at a mutually agreed upon time and place?

Aside from the interview consent form requiring your signature (and this form is kept confidential by me, the researcher), this study is completely anonymous as your name will not be used in the final paper or anywhere else. Please find attached a copy of the interview consent form for more details about the study.

If you want to volunteer for this important research that could help create accessible communication technology for people with disabilities, please contact me to arrange an interview at your convenience. Please respond by sending me a new e-mail instead of replying to this one. My e-mail address is moisthj@mcmaster.ca and my cell phone # is 905.630.8195.

This study has been cleared by McMaster Research Ethics Board – ethicsoffice@mcmaster.ca or 905.525.9140 ext. 23142.

Thank you very much and I look forward to hearing from you.

Best regards,

Holly Moist

Appendix C – Interview Consent Form

Spring 2013

Informed Consent Form

Technology and Disability: A Help or a Hindrance?

Student Investigator: Holly Moist – Master's Student
Department of Communication Studies and Multimedia
McMaster University
905.630.8195
E-mail: moisthj@mcmaster.ca

Faculty Investigator: Dr. David Harris Smith
Togo Salmon Hall, Room 303
905.525.9140 ext. 23248
E-mail: dhsmith@mcmaster.ca

Purpose of the Study

This study will explore the paradoxical power of computer technology to both help and hinder disabilities by interviewing people whose disabilities require them to use assistive technology to access the computer. The standard computer is not accessible to many people with physical, mental or sensory impairments, however, it is often the addition of *more* computer technology, in the form of assistive devices, that enables people with disabilities to access computers. This double-sided nature of computer technology to simultaneously serve as an asset and a liability to people with disabilities is the focus of the project.

Interview Procedures

In this one-on-one setting at a mutually agreed upon location, I will ask you how computer technology has been both a benefit and a detriment to you because of your disability. More specifically, I will ask you how the standard computer has created barriers for you and how assistive computer technology has helped you to overcome these barriers. The interview will be approximately one hour long and I will audio record your responses to ensure proper quotation. No notes will be taken during the interview. Each interview will be transcribed by the researcher shortly after the interview takes place. The final paper will be completed by September 2013.

Potential Harms, Risks or Discomforts

The risks involved in participating in this study are minimal. Our discussion will involve talking about your disability and this may make you uneasy. You do not need to answer questions that you do not want to answer. The steps taken to protect your privacy and mitigate potential risks are described below.

Potential Benefits

Investigating how computer technology both liberates and oppresses people with disabilities may serve as a catalyst to modify and redesign computers to accommodate all users. This study will not benefit you directly.

Confidentiality

Your privacy will be respected. In the final paper, I will mention the type of disability but your identity will not be attached to it. You will remain completely anonymous, however, you may be indirectly identified based on the information provided. All of the information obtained by me will be kept confidential. Both the audio recorder and the transcribed interview notes will be kept at my home, not the McMaster campus.

Participation and Withdrawal

If you decide to be part of the study, you can stop (withdraw) from the interview for whatever reason, even after signing the consent form or part-way through the study or up until May 15, 2013. After May 15, 2013, you can no longer withdraw from the study. If you decide to withdraw, there will be no consequences to you. In cases of withdrawal, any data you have provided will be destroyed unless you indicate otherwise. All research participants must be 18 years of age or older.

Compensation / Reimbursement

The research participant will not be compensated for participating in the study.

Study Results

You may obtain information about the results of the study by contacting me after June 1, 2013. The final paper will be ready in September 2013.

This study has been reviewed and cleared by the McMaster Research Ethics Board (MREB). If you have any questions or concerns about the study, you may contact:

McMaster Research Ethics Board Secretariat
c/o The Office of Research Ethics
Tel: 905.525.9140 ext. 23142
E-Mail: ethicsoffice@mcmaster.ca

CONSENT

I have read the above information and consent to be audio recorded in this study. I have been given a copy of this form.

Name of Participant: ______________________________________(please print)

Signature of Participant: ____________________________________ Date: ________________