A QUALITATIVE ANALYSIS OF INNOVATIONS, PREFERENCES, AND DEFICIENCIES ASSOCIATED WITH TECHNOLOGY FOR VISUALLY IMPAIRED PERSONS

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ABSTRACT

The technology revolution has dramatically impacted all of our lives. For visually impaired persons the emergence of assistive technology has created more opportunity and allowed for greater independence. However, there is still a long way to go. Unfortunately, not every product that is developed for people with visual impairment is ultimately adopted by the community. This paper explores assistive technology in four categories: navigation, education/occupation, social collaboration, and everyday tasks. It is vital to understand the needs and preferences of the visually impaired in order to make the technology more useful. This paper will explore current technology use and shortcomings for visually impaired persons, as well as future technology developments, and will incorporate new insights that were gained through interviews with members of the visually impaired community.
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Chapter 1

Introduction

Technology is constantly changing the way we interact with our environment. The prospects of technological advancements are especially exciting for the visually impaired. Today technology facilitates a wide variety of tasks that were once very challenging for the visually impaired. As technology continues to advance, however, there is also the fear that the visually impaired will be left behind. Many of the large technology companies do not necessarily account for the needs of persons with visual impairment due to the relatively small size of the community. Another issue is the lack of understanding concerning the technology needs and preferences of this niche community. So, even when developers have the best intentions, their product may not be widely adopted by the visually impaired community. In order to develop technology that is truly helpful for persons with visual impairment, it is necessary to understand the problems that they face with current technology.

In order to foster the understanding mentioned above I conducted ten interviews with members of the visually impaired community. Overall the interviews revealed a few common themes. Many visually impaired people feel that technology related to education and careers needs to be a significant focus in technology development. When it comes to navigation, people in the visually impaired community are interested in technology that would have more informative real-time information about their surroundings. Multiple interviewees discussed repurposing non-assistive technology, like FaceTime and Skype, and using it for assistive purposes. Overall, visually impaired persons want technology that is simple more than
technology that is discreet. However, discretion seemed much more reliant on individual opinions and some people do value it more than simplicity. Another common theme seen throughout the interviews is the integration of assistive technologies into other technologies, such as smartphones. Most interviewees described integration as a huge plus based on familiarity with the technology and lessened cost. Many of the big technology companies are taking over some aspects of assistive technology, but upgrades tend to introduce changes that reduce accessibility. A stronger emphasis on maintaining accessibility in commonly used technologies could greatly benefit people with visual impairment. Many interviewees relayed frustration regarding updates to the iPhone and the navigation app Uber. Many people with visual impairment rely on some mainstream technology, so it is vital that these technology developers do not accidentally roll back accessibility during technology updates.

In this paper, I will review many technological systems for people with visual impairment that are either currently available or are in development. Then I will analyze the ten in-depth interviews that I conducted with members of the visually impaired community in order to get a better understanding of this niche community’s relationship with technology. Finally I will conclude with a discussion of future implications.
Chapter 2

Literature Review

The rise of technology has had a tremendous impact on the visually impaired and visually impaired community, but the path to modern accessibility has been lengthy. Technologies that can assist people with visual impairment have been available for decades, but their wide-spread use is a relatively new phenomenon. Take the screen reader, for example. A screen reader is a text to speech program that modern-day visually impaired persons use to navigate the internet and other computer based applications. The origins of this modern staple, however, were much more modest, arguably dating back to 1939 (O’Brien, 2005). This was the year that the first speech synthesizer was introduced at the New York World’s Fair. The device, called VODER, was not intended for use by the visually impaired community; it was created to study telephone voice encryption. The system was bulky and had poor quality, but it was the first time a human voice had ever been synthesized. The next steps forward occurred in the 1970s at MIT; these systems formed the basis for most modern-day synthesizers. Most efforts to synthesize human voices were actually not targeted to benefit people with visual impairment, instead researchers were focused on understanding speech synthesis. However, a few companies did begin to look into developing these technologies for visually impaired persons. In the 1960s, IBM released a talking typewriter, specifically for persons with visual impairment, and in 1976, Ray Kurzweil developed the Kurzweil Reading Machine for people with visual impairment. The machine consisted of a scanner to scan printed reading materials and a full text-to-speech program to transfer the information to the user. This system was used in libraries and blind education centers, but it did not gain widespread popularity for individual users due to its astronomical
cost. The first screen reader for DOS became available in 1988. This finally began opening up employment opportunities for the visually impaired (O’Brien, 2005). Technology influences nearly every aspect of life, but this paper will focus on how technology impacts visually impaired people in four key areas: navigation, education/career technology, social collaboration, and life skills.

**Navigation Technology**

One of the most widely used tools for navigational assistance used by persons with visual impairment (PVI) is the white cane. There are a few explanations for the prevalence of white canes, but simply put, they are the cheapest and easiest to learn (Lakde & Prasad, 2015). As useful and practical as the standard white cane is, it still has significant shortcomings. Picture a busy city sidewalk scene. Using the cane, you can detect objects on the ground in front of you, and you can adjust your route to avoid them. But what if an obstacle is not on the ground? For example, some apartment buildings have protruding windows. In scenarios like this, the white cane fails to serve its purpose. Similarly, some PVI prefer the use of a guide dog, but a dog cannot sense obstacles at human’s eye level. Guide dogs are also very expensive, costing between $45,000 and $60,000 (Sullivan, 2013). While the failure to adequately detect obstacles at all heights is a vital capability for navigational technology, it is by no means the only consideration. Both technologies mentioned above require a high level of participation from the PVI. The user still needs to know exactly how to get to their desired location because neither one offers directional assistance. A navigational system with locational awareness would be useful in many more scenarios. Additionally, many people with visual impairment report feeling
stigmatized. Therefore, another important consideration for the development of these technologies is discretion. So, to address the limitations of the current navigational standards, many researchers are exploring more technology-driven, creative solutions.

To address some of the concerns outlined above, one path of development focuses on simply augmenting the standard white cane. One benefit to this approach is that many PVI already use a cane, so there is less of a learning curve. One such product was developed at the University of Michigan’s Mobile Robotics Lab and is called TheGuideCane (Shoval, Ulrich, & Borenststein, 2003). Like the white cane, a user holds the cane out in front of them, but in this case the user does not need to actively scan the area. TheGuideCane is much heavier than a standard white cane, so it has wheels to help support its weight. The cane contains a computer; when an obstacle is detected the computer analyzes the environment for an alternate path and physically steers the user to avoid the obstacle. A mini joystick is on the cane’s handle, and the user inputs a desired direction of motion; the direction of motion at any given time is assumed to be straight forward unless otherwise indicated. The ultrasonic sensors on the cane can detect obstacles in a 120 degree sector in front of the user. In experimental trials, untrained participants were able to immediately follow the directions of the cane even in crowded conditions. The force-feedback approach utilized by the system is intuitive and therefore does not require very much training. This system requires a much lower level of active participation than the standard cane because the computer decides which direction to turn in order to avoid any given obstacle. One drawback, however, is that the system is certainly not discreet. The cane itself is much bulkier than a standard cane, and thus draws more attention to the user.

A system called the EyeCane uses tactile and auditory output as an add-on to the standard white cane (Maidenbaum et al., 2014). Some PVI have expressed concerns with regards to the
standard white cane. This includes fear of striking people or fragile objects, difficulty in
detecting objects at different heights, and social stigma associated with cane usage (Maidenbaum
et al., 2014). In order to address the concern of striking people, the EyeCane alerts the user when
objects are in the user’s path. This cane also addresses the issue of detecting objects at various
heights by providing distance feedback from two distances. Objects around waist height are
detected directly ahead at a distance of 5 meters and objects on or near the ground are detected
directly ahead at a distance of 1.5 meters. This information is transferred to the user with
auditory and tactile feedback through a handheld sensor on the cane. The device does require
active participation; the user must scan the environment via the same method that is utilized for a
standard white cane. In experimental trials, participants were successfully able to use the cane
with only five minutes of training usage (Maidenbaum et al., 2014). Currently the EyeCane is
used as an attachable handle for any walking stick, so it is possibly still stigmatizing for the user.
However, the research group hopes to eventually eliminate the need for the white cane
altogether, making their device a stand-alone handheld tool.

An estimated 64% of American adults own a smartphone (Smith, 2015). As the
popularity of smart phones increases, a logical area of research for assistive technology focuses
on smart phone applications. A system proposed in 2010 by researchers Peng, Peursum, Li, and
Venkatesh is a smart phone application that uses the phone’s camera. A user walks forward
holding their phone at a 45 degree angle. The application analyzes input from the camera to
determine if there are any obstacles. If an obstacle is detected, the phone vibrates to alert the
user. The application provides two options for receiving alternate path feedback. The system
provides verbal feedback telling users which directions are safe to move towards. Or the user can
point the phone around them until it stops vibrating, indicating the path directly ahead is safe.
Initial feedback from study participants indicated that they felt the system was useful, but holding the phone at the correct angle at all times was difficult (Peng et al., 2010). This system addresses the issue of discretion, but it only provides obstacle detection; it does not help with wayfinding.

Another important area of research is independent navigation using public transportation. A group of researchers in Japan developed a smart phone system to help visually impaired users orient themselves within a metrobus system (Mata & Claramunt, 2011). Components of the system include a smart phone, a GPS, and a compass device which interact using Bluetooth. An audible interface allows users to listen to relevant information. The system’s primary capabilities are designed let the users know where they are within the metrobus environment. For instance, users can find out where a station exit is by simply tapping on a button; the system will then use the compass and GPS to identify the user’s location and play relevant audio files to guide them towards an exit. An initial study of the prototype found that users were able to successfully interact with the system and found that it improved their confidence when using the metrobus. Additionally, the system itself is discreet and does not require the PVI to purchase a separate technology that needs to be carried around. One possible downside is the reliance on solely auditory feedback, which can make navigating a crowded environment more difficult due to PVI dependence on hearing.

A different system proposed by Amemiya and Sugiyama is a small handheld mobile device that uses the “pseudo attraction force technique” to guide users on a pre-determined path (Amemiya & Sugiyama, 2009). In addition to helping with wayfinding, this device also serves as an obstacle detection system. If the user strays from the path, they will experience the illusion of being pushed or pulled in a certain direction until they are back on the path. One advantage of
this system is that by limiting auditory feedback, users have their full hearing ability to understand the environment around them. Initial studies found that users could intuitively understand the feedback without any prior training. They were also able to return to the intended path using the device. This device is discreet and easy to learn. (Amemiya & Sugiyama, 2009)

Ariadne is a phone application that utilizes the phone’s embedded location, the map service, and the voiceover screen reader. Although the system does not provide step by step directions, it has several functions that help the user become aware of their location (Ciaffoni, 2012). There are three main features of the app. The first feature gives the user information about their current position. It can be set to give this information automatically, at fixed intervals, or manually. The second feature allows the user to bookmark a location, and one option allows users to be alerted when they are near these locations. The third feature is map exploration. When a map is on the screen, the user can touch the map and the name of the location will be read aloud. This allows users to gain a spatial understanding of the area around them, such as the layout of streets. (Ciaffoni, 2012)

Ride sharing services like Uber and Lyft immensely impacted public transportation. Users now have the ability to request a ride to their exact GPS location within minutes, without the hassle of finding a taxi service phone number and figuring out how to describe a location. Since many visually impaired persons are using smart phones, it is important to know whether these services have had the same impact on the visually impaired community. Uber partnered with organizations like the National Federation of the Blind and LightHouse for the Blind in San Francisco to gain input from the visually impaired community. Using VoiceOver IOS compatibility, the Uber app can successfully provide accessible transportation for people with visual impairment. This technology can be used in conjunction with a wireless braille display,
and it is available in all Uber cities and languages. One visually impaired technologist who consulted with Uber during this time remarked that “Uber is the single best advancement for the mobility of blind people in the past decade” (May, 2015). It appears that this segment of the technology revolution really is working well for the blind community.

Another method of navigation relies on wearable devices to guide users. Most wearable devices are attached to the head, chest, or hand. Researchers at the Georgia Institute of Technology are developing an audio based wearable navigation system. Aptly, they call the system SWAN, which stands for the System for Wearable Audio Navigation. Whenever possible SWAN utilizes non-verbal audio feedback. SWAN allows the user to keep track of current location and direction of travel. It also helps people with visual impairment to navigate various environments, identify and follow a safe walking path to a destination, and be aware of relevant features of the environment (Wilson, Walker, Lindsay, Cambias, & Dellaert, 2007). The current model uses advanced position tracking technology and sonification of navigation routes and environmental features. Users can even annotate an object they encounter, such as “a favorite coffee shop, or a section of sidewalk prone to flooding after rain showers” (Wilson et al., 2007). SWAN consists of a portable computer, audio processor, audio output hardware, tactile input devices, and position/orientation tracking. Components are stored in a backpack to enable mobility. In order to maintain the user’s ability to hear their surroundings, bone conduction headphones are used. The system is thorough, and the use of a backpack would not be stigmatizing. (Wilson et al., 2007)

One particularly popular area of study revolves around smart glasses. The Royal National Institute of Blind People in the United Kingdom is currently working on a smart glasses project (RNIB, n.d.). The glasses can accommodate multiple types of visual impairment, but they
were found to be most effective for people with some central vision. Their current design has two cameras, one on each side of the head to capture distance. The area directly in front of the eyes is transparent so that the user’s eyes can be seen. The glasses also have a night vision mode. While they are not completely discreet, they are miles ahead of other wearable devices. The prototype was tested on 200 individuals in the UK and participants reported more confidence walking through unfamiliar or darkened areas (RNIB, n.d.). While this system is less powerful than the SWAN system described previously, it is also more manageable due to the simplicity of the system.

Recently the development of self-driving cars is garnering a lot of interest. While these cars are not being specifically made as a technology to help the visually impaired, there is little doubt that advancements in this field would greatly increase mobility and independence among persons with visual impairment. Huge strides in the field have been made. In 2009 Google began efforts to design a car of this type (Krafick, 2016). Their prototype is currently in the testing phase, and is being driven around Mountain View, California; Austin, Texas; Kirkland, Washington; and Metro Phoenix, Arizona. However, test drivers are currently aboard all vehicles since the technology is still in its preliminary stage. Ride-sharing service Uber similarly launched a project in Pittsburgh, Pennsylvania. The Uber project is currently in the pilot stage, and like Google’s model, the cars still have a human driver present in case interference is needed. Autonomous vehicle technology is still in the very early stages of development and design, and there have been significant setbacks along the way. For example, entrepreneur and owner of Tesla Motors Elon Musk is also in the race to develop the first autonomous vehicle. Unfortunately, the testing of the autopilot feature Tesla had been working on resulted in a fatal crash (Singhvi & Russell, 2016). The system is now being revamped to address the shortcomings
that led to the death of the driver. Widespread use of fully autonomous vehicles is still years away, but this technology is likely to provide tremendous benefits for the visually impaired.

**Education and Career Technology**

A major focus for improving access to educational and job training materials is the creation and enforcement of accessibility standards. The amount of information on the internet is vast, but it is of little value to PVI if the website was not designed with accessibility standards in mind. A 2015 survey by Web Accessibility in Mind (WebAIM, 2015) indicated that approximately 61% of screen reader users believe that web accessibility has either not changed or has gotten worse (WebAIM, 2015). The World Wide Web Consortium (W3C) has a list of guidelines for web accessibility for a range of disabilities, including blindness and low vision. The overarching goal of these guidelines is to ensure that websites are perceivable, operable, understandable, and robust for all users. The issue, however, is that the guidelines are not universally adopted. Currently, software is used to test for accessibility. (Ferriera, Nunes, & Silveira, 2012) After a thorough review with visually impaired persons, Pereira et al suggested a different system of web accessibility evaluation requirements. In order to promote equality in the workplace of government agencies, Section 508 of the Rehabilitation Act of 1973, (29 U.S.C. § 794 (d)), was written into law. Section 508 is an amendment that was added to the law in 1998. This law requires that federal agencies have their electronic and information technology available to persons with disabilities. Essentially this means that when federal agencies develop, acquire, maintain, or utilize electronic and information technology, visually impaired employees must be able to access the information. Unfortunately, this law is not always adequately
enforced. In fact the government has been sued multiple times over failure to adhere to this law. Even though the law was written in 1998, lawsuits over violations can be found as recently as 2013. On April 26, 2013 a lawsuit was filed against the department of Homeland Security for failure to provide adequate access to the intranet, online training modules, and shared documents. The presence of this law is advantageous for visually impaired government employees, but the lack of enforcement is extremely disappointing. In order to help visually impaired workers, Section 508 compliance needs to be upheld.

The majority of persons with visual impairment utilize screen readers to some extent. In the United States in 1995 over one million people with visual impairment rely on screen readers to access the internet (Thylefors, Negrel, Pararajasegaram, & Dadzie, 1995). Given the rapidly increasing popularity of the internet, it is safe to say the current number of people in the United States using screen readers is larger than the 1995 estimate. Unfortunately, the software is very expensive and so most public computers are not equipped with the capabilities. This limits visually impaired persons’ abilities to access information if they are not around their personal computer. Researchers at the University of Washington are developing an on-the-go screen reader called WebAnywhere. The design allows users to access the internet from any computer without installing any software, provided that the computer is capable of producing sound. The system is compatible with any operating system and web browser. To utilize the system, users navigate to its webpage, then WebAnywhere reads aloud the interface as well as the content of the webpage. From here, users can input the URL of a website they would like to visit and the site will be opened up inside the content pane of the system. Users can skip forward and backward in content by character, word, or sentence. Each user sets up a personal account to store their system preferences and can log into this account from any computer. WebAnywhere
is free, unlike traditional screen readers like JAWS, which can cost over $1,000 (JAWS). There are, however, some limitations of the system. The current system is only designed for websites, so desktop applications like Microsoft Word or Excel will not be accessible. A study conducted found that all participants were able to utilize the interface. (Bigham, 2009)

One educational system aims to help students with visual impairment in math classes. Math is a requirement for almost all students, but it can be especially challenging for visually impaired students. Students either need an aid with them to read the formulas out loud or the problems need to be printed in Braille. Having an aid with the proper training available to assist a student is expensive and often unrealistic. In addition, the process of printing Braille is complicated and braille is not universally known among PVI anyway. So, a group of researchers in Thailand proposed a better solution called i-Math, which functions as a math expression reading system. This system was developed specifically for visually impaired students in Thailand, but a similar tool created in other languages would have the opportunity to benefit a much larger community.

Free access to educational and recreational reading materials through community libraries is an important way to promote knowledge. However, not all libraries account for visually impaired persons when managing their literature base. In June 2014, the Accessible Books Consortium (ABC) launched with the goal of increasing the base of literature available in accessible forms worldwide. ABC is an umbrella organization that consists of the World Blind Union, DAISY Consortium, International Author’s Forum, International Federation of Reproduction Rights Organizations, and International Publishers Association (Wise & Martin, 2014). The group has three strategies for increasing accessibility to literature: capacity building, inclusive publishing, and facilitating cross border exchange. Capacity building involves training,
education, and showing organizations how to get access to books in accessible formats. Inclusive publishing encourages book publishers to print literature that is already in an accessible format, such as braille. In order to facilitate cross border exchange, ABC maintains the TIGAR book exchange. The exchange is comprised of a database of 238,000 accessible format books in over 50 languages (Wise & Martin, 2014). Similar to a library system, membership in TIGAR is free. An increased collection of accessible information has the potential to contribute to education, job training, and leisure reading for visually impaired persons.

Social Collaboration Technology

Social media is becoming more and more present in daily life. As usage of social media increases, can this social benefit be extended to people with visual impairment? A 2015 study of screen reader users by Web Accessibility in Mind (WebAIM, 2015) found that only 12.7% of respondents indicated that social media is “very accessible” to them (WebAIM, 2015).

Researchers at the University of Birmingham conducted a survey of visually impaired youth to determine their social networking views. Most of the students surveyed (91%) responded that they were able to set up their own social networking site without assistance. When the students were asked to name the social networking sites they knew, 100% of them listed Facebook (Hewitt & Douglas, 2015). In response to consumer feedback, Facebook created the Facebook Accessibility Team to address concerns with accessibility across the software platform. Using input from various organizations like the American Foundation for the Blind, the team developed functions that allowed PVI users to access all parts of the site. The team also put extensive work
into the mobile applications for users (Holton, 2015). One particularly challenging aspect is the presence of visuals, either pictures or videos. Previously when a visually impaired user encountered a photo on Facebook, a screen reader would announce who shared the photo followed by just the word “photo”. In 2016, Facebook released new technology to help visually impaired users have the same Facebook experience as sighted users. Automatic alternative text generates descriptions of photos using object recognition technology. So, as users scroll past an image a voice-over will list the items the image may contain. For example, a user could now hear something like “image may contain three people, smiling, outdoors”. Socialization is increasingly happening online; with new provisions, like those at Facebook, visually impaired persons can interact with their network with ease.

The VizWiz smart phone application facilitates collaboration between visually impaired users and sighted people. In the app the user simply takes a picture of anything and records any question they have about it. They can then choose who they want to send the question to from a menu. Users can send the question to email or Twitter, but two options that are unique to the app are a Web Worker or IQ Engine. The Web Worker is a volunteer who reviews the users question and answers it to the best of his/her ability. The IQ Engine is a character reader, so it is primarily useful to gain numerical information from the photograph. This application allows for users to connect with real humans hence enabling social collaboration.

Contrary to popular literature, a study on cohabitation involving one person with visual impairment conducted by Branham and Kane found that accessible technologies are often used collaboratively. The researchers found that the technology needs of PVI can conflict with the needs of the sighted partner causing decreased accessibility overall (Branham & Kane, 2015). In the home, for example, PVI often adhere tactile labels to objects like the microwave, however
this can obscure the actual label, making it harder for someone without visual impairment to use the object. The difficulty of accommodating technology needs for sighted and visually impaired partners can also be seen with finding entertainment that adequately serves both partners. Often this can result in partners being unable to play games, watch movies, or find other entertainment options. A lack of bonding over entertainment can have a negative effect on the relationship. (Branham & Kane, 2015)

**Life skills Technology**

Multiple online services allow people to buy their groceries online and these services normally include the option for home deliver. A few examples of these services include FreshDirect and PeaPod. Both visually impaired and sighted people use these services, but in-person grocery shopping for PVI could be rewarding and social. When PVI go grocery shopping, the standard is to go with a sighted person who can typically be categorized as a social worker, a store courtesy shopper, or a friend/relative. However, many researchers are working on technology to help the visually impaired with independent grocery shopping. In 2010 a group of researchers from the University of Utah developed a system called ShopTalk. The system consists of a small OQO computer, a wireless barcode reader, and a numeric keypad. A major finding from experimental trials of ShopTalk is that independent PVI can execute verbal template based route and product search instructions in supermarkets with a 100% accuracy rate (DeGraw, Gharpure, Kulyukin, Nicholson, & Sute, 2004). The group is currently developing a new system called ShopMobile that will remove the need for the external barcode scanner. ShopMobile consists of only a camera-equipped smartphone and a hard case for the phone that
includes stabilizers to attach the phone to the shelf in order to scan the barcode. A major drawback to this system is that it does not offer in-store navigation. Therefore, actually finding an item would be difficult without additional assistance from a sighted person.

The advent of the smartphone has brought a host of possibilities for success in everyday tasks. The app LookTel is a money reader that uses the phone’s camera to identify the denomination of the currency the user is holding. Previously PVI had to rely on a sighted person to know a bill’s value because all US paper bills are printed on the same size and textured paper. Another useful app is called ColorID, which again takes advantages of smart phone cameras. The user simply points the camera at an object and the app will say what color it is, using specific shades like “pale yellow green”. This is especially useful for tasks such as picking out clothing or figuring out if a fruit or vegetable is ripe. For the visually impaired it can be unsettling if a person approaches too quietly and their presence is unknown to them. A video motion detector called VM Alert detects motion and alerts the user with either a subtle tone or an alarm. An app like this can help users feel safer when travelling alone. As mentioned earlier, a PVI’s sense of hearing is very important to their safety when navigating. One app, called Awareness! The Headphone App, attempts to alleviate this concern by feeding in outside noise via the microphone when a user is wearing headphones. This way the user can walk down the street and listen to music while still being in tune with their surroundings. These apps are simple technologies that serve to assist with everyday tasks.
Chapter 3

Methodology and Procedure

After reaching out to the National Federation of the Blind chapters in the Washington, D.C. area, I met a woman who was eager to assist me with my research. Through her contact, I was able to find the other participants in my study. She reached out to other members of the visually impaired community who she thought might like to participate in my research. Keeping in mind that I was hoping to speak with people from a wide variety of ages, she sent me email addresses of friends who had confirmed that they would like to participate in the interviews. I emailed each participant on her list to introduce my research and myself. I touched on the types of questions I would ask and provided an estimate of the expected length of the interviews. After initially contacting the participants, I sent a proposal detailing the study procedure to the Penn State IRB. After suitable revisions were completed, the IRB approved the proposal. Abbreviated documentation submitted to the IRB can be found in Appendix B

IRB Supplemental Materials

Because of the qualitative nature of this study, interviews primarily consisted of open-ended questions. A complete list of interview questions is available in Appendix A

Interview Questions. This type of interview format allowed participants to share anecdotes and experiences along with their answers. A few questions, however, included rating technology systems or technology preferences on a scale of 1-10. In order to get a better idea of the most
prevalent technology systems, the first section of questions revolved around the technology they currently use. I asked them to elaborate on which technologies they use in each of the four categories included in this paper. For each of those categories, I also asked about any shortcomings with the currently available technologies. The final question in this section was intended to determine the criteria they utilize when choosing technology. The information from this section allowed me to get a baseline for their current technology standards. My next set of questions was based primarily on technology preferences. The literature regarding the development of assistive technology caused me to wonder which advancements persons with visual impairment are interested in, and which could potentially provide the most benefit. For example, how important is simplicity? Some of the technology that I read about seemed like it would be useful but was incredibly complicated to use or required extensive training. So I decided to ask participants on a scale of 1-10 how important it is for a device to be simple to use. Another thought I had while conducting introductory research revolved around discretion. Some potential products described in the literature utilized extensive equipment on various body parts. Because discrimination can be a concern for persons with visual impairment, I wanted to know if discretion was an important factor to members of the visually impaired community. For example, would an obvious camera attached to the head or chest be acceptable, or would a more discreet device be preferred? Including these items as a rating allows for easy comparison between participants. A variety of articles centered on iPhone applications, which can provide instant access to helpful assistive services. The downside, of course, is that the functionality of the app is limited to the functionality of the phone. Based on this discrepancy, I asked participants how important it is for the technology to be built into a product they already owned, such as a phone or white cane, as opposed to the need to purchase a new device. Then I moved into a short series
of questions for each category. For navigation, I was interested in understanding how the visually impaired community interacts with ride-sharing apps like Uber and Lyft. Many navigation devices on the market rely solely on audio feedback, so another question focused on preferred feedback type. For education, I asked if they had any thoughts on technology that could have helped them while they were in school. My questions for social collaboration are regarding assistive technology used in collaboration with a sighted person and social media platforms. Lastly I came up with a series of questions about future technology. I asked each participant to choose the category that they believe technology development had the potential to benefit the most visually impaired people. Then I asked which category they personally would benefit from the most from technological development. My final question asked participants to rank on a scale of 1-10 how interested they would be in using a few specific technology developments. The technologies I specifically asked about were self-driving cars, a system to independently navigate public transportation, technology to increase web accessibility, entertainment that provides an interface for both visually impaired and sighted users to use together, technology to assist with independent grocery or clothes shopping.

After initial contact with participants to determine interest in participation, I set up interview times. Once the phone interview began, I re-introduced myself and reminded the participants about the interview’s purpose. I then asked if they would still like to participate in the interview. If so, I asked if it was okay if I recorded our conversation so that I could refer back to it while summarizing and analyzing the results. All the participants agreed to be recorded. I used the phone application TapeACall to record the conversations. Interviews were coded using a combination of pre-set codes and emergent codes. The pre-set codes were determined based on the typical interview responses I expected to get. Some of the codes included: affordability,
inclusivity, and effectiveness. These predetermined codes were informed by the literature review. The emergent codes were obtained from common interview responses that were not anticipated.

**Participant Demographics**

The insights of ten subjects were gathered during this study yielding almost 7 hours’ worth of interview material. An overview of the demographic information is displayed in Table 1 below. It is important to note that one participant declined to provide any demographic information except for his age and gender. The sample consists of six men and four women between the ages of 25 and 52. All participants in the study are legally blind with varying onset ages. This sample is not necessarily representative of the visually impaired community as a whole. All participants live in the greater Washington, D.C. area. This geographic constant could potentially impact their use of technology. As one participant astutely pointed out, Washington, D.C. has a fairly extensive public transportation system. Therefore, navigating the city is easier in that context than it would be for a visually impaired person in a rural or a less developed urban area. Another evident difference in this group is employment status. In 2014, only 40.4% of working age adults with significant vision loss were employed (Erickson, Lee, von Schrader, 2016). In contrast, all individuals except for one in this study are employed full time. Another difference can be seen in the educational background of the participants in this study. In the United States, approximately 14.4% of visually impaired persons have attained a bachelor’s degree or higher according to the National Federation of the Blind (NFB, 2016). Every
participant in this study except for one attained at least a bachelor’s degree. The one participant who did not attain a bachelor’s degree does have an associate’s degree. In fact, six of the 10 participants hold either a master’s degree or doctoral degree. Even though this sample of individuals is not wholly representative of the community at large, their shared insights provide valuable information nonetheless.

Table 1. Participant Information

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<th>Employment Status</th>
<th>Education Level</th>
<th>Years with Visual Impairment</th>
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Chapter 4
Findings

Throughout the interviews a few common themes emerged regarding different aspects of assistive technology. On the topic of navigational technology, interviewees discussed two common technology improvements. The first is a technology that would have more informative real-time information about their surroundings. This includes both businesses and also everyday objects like trashcans or mailboxes. Participants also mentioned a need for an indoor navigation system. When it comes to life skills technology, there is a lot of variation for the types of technology people use. Many participants used non-assistive technology like FaceTime or Skype for completing everyday tasks. Participants also felt that there is a strong need for improvements for education and career technology. This would help the extraordinarily high unemployment rate for people with visual impairment. For technology related to social collaboration the main theme was inclusion. The improvement of artificial intelligence will be able to help people with visual impairment interact with pictures on social media sites better. The development of entertainment that would provide interfaces for visually impaired and sighted users to use together will also help foster inclusion. Overall, participants believed that simplicity is more important than discretion with regards to technology. However, the importance of discretion appeared to be much more variable based on the individual. Even though the majority of participants valued simplicity more than discretion, there were two people that placed more importance on discretion. Additionally, many interviewees discussed the value of having assistive technology integrated into other technologies, such as apps on a smart phone. Most participants felt that integration is a huge plus. Some factors they liked about integration were
familiarity, cost, and convenience. One participant who is an assistive technology specialist described the negative effects of integration. Mainly he described that big corporations are not as beholden to make sure their platform is accessible for visually impaired users. Another common theme that emerged was the need for technology developers to ensure accessibility before introducing a technology update. Many visually impaired people utilize mainstream technology like smart phones and laptops, so when these technologies are updated it is important that visually impaired users do not lose any functionality.

Findings Related to Navigational Technology

Many of the people I interviewed used similar technology for navigation. Everyone who participated in the study uses a white cane and Uber/Lyft for navigational purposes. The most commonly used technology after that was iPhone maps, which is not surprising since only one person in the study did not use an iPhone. Counts of the technology used by participants can be seen in the figure below.
Figure 1. Navigation Technology

Ariadne and BlindSquare are applications that are only available on the iPhone for various navigational purposes. Ariadne does not provide turn by turn directions, but users can touch parts of the screen to hear the name of the street they are on as well as the names of streets they are passing by. BlindSquare does not provide route planning or turn by turn directions, but it does announce points of interest and intersections. BlindSquare works in conjunction with a software called FourSquare which is a database of restaurants, bars, and stores. If a point of interest is not in the FourSquare database it will not be announced. The user’s phone must be held either horizontally with the screen facing up or vertically with the back of the phone facing the direction of travel in order to provide accurate information. Sendero is another navigational technology and is available on both iPhone and Android. Sendero tells users their current address and nearest point of interest based on a user-chosen category when the user shakes the phone. It does not, however, provide any route planning or turn-by-turn directions.
The most common shortcoming related to navigational technology that participants mentioned was its imprecision. Walking directions given by Google Maps or iPhone Maps will often only get you to the general vicinity of the building and then users are on their own from there. This isn’t generally an issue for sighted persons, but for the visually impaired it can be a significant impediment. Due to this shortcoming, several people relayed that much of their current navigation practices require a lot of mental attention. As one participant described it, “A lot of the navigation that I will do is using my brain so there’s a lot of mental mapping, there’s problem solving and we use a lot of cognitive retention.” (personal communication, December 29, 2016). While these skills will always be a necessity for persons with visual impairment, advances in technology could greatly improve their navigation experiences as a whole.

In addition to more precise technology there were a few common technology opinions that participants brought up. The first was a system that would tell the user what they are walking past in real-time. One interviewee explained:

I would like some technology that if I’m walking by something it tells me what I’m passing. Like if I’m walking by on the street and it tells me ‘there’s a 7/11 to your left’ or the different stores or places around me. Like if a CVS opens up in my neighborhood I wouldn’t know until someone specifically tells me even though I walk around my neighborhood all the time. I wouldn’t know what’s there, what’s closed, what new thing opened up. Unless I ask somebody or somebody tells me ‘oh there’s this new place that’s opened up, have you checked it out?’. So simple things like that where a sighted person can walk around their neighborhood and know what is around them. That would be really nice to have. (personal communication, January 10, 2017)
One note, however, is that this participant is an assistive technology specialist who uses an Android phone. The technology most similar to the one she describes is BlindSquare, which is only available for iPhones and is not as comprehensive as the technology system the participant envisioned above. One participant who is a BlindSquare user mentioned that the accuracy of BlindSquare’s information does somewhat depend on the phone’s tilt. A technology that can perform the task proposed by the participant above would allow visually impaired users to interact with their environment closer to the way sighted people do. This capability would be especially useful in a new city or unfamiliar area. It would also increase visually impaired users’ independence.

Similarly, multiple participants also mentioned the need for systems related to understanding smaller objects in their path. This would have dual purposes of obstacle navigation and recognition of useful public objects. For example, if a person with visual impairment was looking for a mailbox or a bench, a system that could recognize these objects in real time would be extremely useful. This was shared by one participant:

> Things besides restaurants would also be helpful to know about. Like a mailbox if I’m looking to mail something or a trashcan if I’m looking to throw something away. Those sorts of things that are in the path but aren’t going to be identified as a location to navigate to. It would just be good to know that they’re around. Those things I wind up usually asking other people on the street to help me find. (personal communication, February 1, 2017)

Being able to independently interact with one’s environment is a common theme the participants mentioned when asked what direction navigation development should take. A technology like this would also help address the current concerns of object detection while navigating. One
participant described a scenario where she was attempting to traverse a metro station and her cane went right in between the cones causing her to walk full throttle into the cone (personal communication, December 29, 2016). While this participant was not injured, under different circumstances the failure of a cane to detect an obstacle could be more dangerous.

Another update to navigation technology that was mentioned by a few participants is indoor navigation. A widespread indoor navigation system does not currently exist for consumer use. So, navigating through buildings requires a lot of trial and error. People with visual impairment have a lot of suggestions for improving navigational technology. Most navigational systems that are heavily used by the participants in the study rely solely on audio feedback. The device’s feedback ultimately influences how successful that technology will be in helping the user accomplish the task. So, ensuring that a useful and comprehensive feedback is used is important. Most participants specifically mentioned using earbuds in one ear while navigating outdoor environments so that they could listen to the directions on their phone and also still hear their surroundings. About half of the participants stated they liked having just audio. Some were curious about the addition of haptic feedback, but were not sure how they would feel about it without actually testing it out. In this case participants commented on haptic feedback that would reinforce verbal directions by vibrating to signal a turn for example. Others had stronger feelings against the addition of haptic feedback. They believed it might feel like sensory overload, like one participant who explained:

That’s a lot of your senses I think it would feel like overdrive. If I’m walking, then I’m already listening for my surroundings so let me just listen to the audio that’s incorporated into my surroundings already. And my cane is tactually feeling when I get to the corner.
But if you’re going to throw in another component like a vibration I think that would be overwhelming. (personal communication, December 29, 2016)

On the other hand, half of the participants said that they would be really interested in having both audio and haptic feedback for navigation. As one participant phrased it:

A combination of haptic and audio would be good. Especially when you’re walking out on the streets and things like that. You know you have to turn left but sometimes with the cars and the noise pollution you can’t necessarily hear the voice, but you can feel the vibration. So I think a combination of both. If you can hear it, that’s fine. If you can’t, then you have the other option. I think that with most of these tools having a fail-safe or a Plan B is always nice because they don’t always work in all situations. (personal communication, February 11, 2017)

Overall, people had different feelings about the type of navigational feedback they would like to receive. So, having a technology that would allow users to choose their own feedback type would likely have a higher adoption rate since it has the power to cater to more visually impaired persons. The main theme of navigational technology development is simply improving the way people with visual impairment are able to interact with their environment.

Findings Related to Life Skill Technology

Throughout the interviews many participants mentioned the use of non-assistive technology in a way that turned it into assistive technology; using mainstream technology for assistive uses was a particularly common theme for tackling everyday tasks. The most common
example of this by far was the adoption of Skype and Facetime to receive help from a sighted person. Because those technologies are associated heavily with visual communication, the prevalence of their use in the visually impaired community is somewhat surprising. In my sample, six participants specifically mentioned using those technologies for assistive purposes. Of course some participants do use it for the visual aspect, which solely benefits their sighted friends and family members. However, many participants described scenarios in which they used Facetime and Skype to solve unique problems they were facing. Participants described a variety of everyday tasks that they utilized Facetime or Skype to complete accurately. For example, one participant described how she and her husband were baking a cake and could not tell what temperature the oven was set to. Instead of taking a random guess, they Facetimed a sighted friend and asked her to help them set the correct temperature (personal communication, January 10, 2017). Another participant described how she often video chatted a friend if she had an important meeting or date to double check that her outfit was acceptable (personal communication, February 11, 2017). A different participant described how he would use Skype to call his mother, who lived in a different country, and get assistance identifying spices and products while cooking. He even described it as “one of [his] fondest memories of using technology” (personal communication, January 5, 2017). So, not only was Skype able to serve as an assistive technology, but it also helped the mother and son feel closer. Perhaps the most poignant anecdote regarding this type of technology was one participant who described a situation in which she was travelling overseas and needed to know her passport number. She had concerns about trusting a stranger to accurately relay the information without taking advantage of the situation. So, she Facetimed her family back home and had them read the information off
of her passport (personal communication, February 1, 2017). The emergence of new technology like this allows for unique problem solving in the visually impaired community.

The utilization of Skype and Facetime was by far the most prevalent example of using non-assistive technology for assistive purposes. One participant, however, described how he uses the traditional functionality of Amazon Echo to assist with everyday tasks. When asked to describe his use of Amazon Echo he recalled,

> It’s pretty useful. Anything from shopping to scanning the news, listening to podcasts, checking the weather. It does a lot of things that people don’t think. Like calorie tracking, for example. It’s just a consumer item, but a very useful one in my opinion. (personal communication, February 11, 2017)

Even though Amazon Echo was not designed to specifically be used as an assistive technology, members of the visually impaired community can benefit from its typical functionality.

When considering the world of technology developments, it is easy to limit your view to items like phones or laptops. But, other sectors of technology developments also have significant impacts on the visually impaired community. When it comes to technology for everyday tasks, there were not as many clear cut areas for improvement. This makes sense because unlike screen-reading technology, for example, there are different options for different lifestyles. Most, but not all, participants used apps on their smart phone for a lot of day to day tasks. Color ID, TapTapSee, and MoneyReader were mentioned by the highest number of participants. After speaking with the participants, it was clear that the iPhone is taking over many functions that would have required a separate device in the recent past. Some participants, however, do still choose to use standalone devices for some tasks. Color identifying technology is one of the tasks that had the most variation in usage. Most participants reported using an iPhone app to identify
colors even though they admitted that it is not always reliable. In fact, sometimes the apps would not be able to complete the task at all. One participant who uses a standalone device called Colorino explained why she chose to forgo the phone app:

   I’ve looked at apps on the phone and they’re not as accurate as this device is. The apps definitely need improvement. I haven’t found an accurate one yet. When you point at one color it keeps on jumping and saying different colors so you have to guess. It’ll say ‘black’ then ‘blue’, so which one is it? (personal communication, January 10, 2017)

She decided in the end that a separate color identifier technology would work best for her. Having technology on a smartphone that can help with everyday tasks is incredibly convenient, but there is certainly a long road ahead until the performance can match some stand-alone devices.

   Another frustration that was expressed by multiple participants was inaccessible kitchen appliances. An inaccessible microwave can be fixed by using braille dots on the buttons or purchasing a talking microwave that is specifically made to be used by people with visual impairment. However, larger appliances like stoves and dishwashers can be more difficult. Technology is moving more towards touchscreen for everything, including dishwashers and refrigerators. If these touchscreens do not have built in functionality to read the screen contents out loud, it will make the everyday tasks of cooking and cleaning unnecessarily harder. Especially in recent years, electric stoves have increased in popularity compared to gasoline stoves. As innovators develop new designs for the appliances, some have chosen to make the stove surface completely flat which can be problematic for people with visual impairment.

   These new stoves are very flat, so you don’t know where to put your pot you don’t know where the burners are. Visually a sighted person can see where to put the pot, but I don’t
know where to put it. I’m not going to put my hand on the stove and burn it every time I want to cook because that’s the only way I will know where the burner is. There should be some sort of tactile indicator where we can tell where to put the pot or set the oven temperature. If they don’t have talking part you would not be able to do that. (personal communication, January 10, 2017)

This lack of accessibility is not just inconvenient, it’s dangerous for visually impaired people. These problems are not easily remedied when the user is renting the living space. An inaccessible appliance cannot simply be replaced without the owner’s approval. The added expense that would come from having to purchase all new appliances would render the situation difficult even for visually impaired homeowners who do not have the same restrictions.

**Findings Related to Educational and Career Technology**

When I asked participants to identify where technology development can provide the greatest benefits for the visually impaired community, almost everyone chose “Education/Career Technology”. Prior to the interviews I theorized that most people would choose “Navigation”. This highlights the importance of including members of the visually impaired community in the development of technological advancements. Technology is evolving rapidly which can cause feelings of both excitement and apprehension for members of the visually impaired community. Many interviewees brought up just how different assistive technology was only a few years prior, and remarked how much better their educational experiences would have been if they had access to today’s technology. But the optimism over today’s technology that many people
expressed does not mean that educational and vocational technology is perfect. People brought up a lot of the same concerns in this area. The consensus was mainly that better access to technology for education and occupational purposes would allow members of the visually impaired community to be more self-sufficient and contributing members of society. Unfortunately, these systems are very expensive, leaving out a significant segment of the visually impaired population who cannot afford the technology. Several participants brought up the need for the development of more affordable assistive technology, especially screen-readers. Since so many careers rely on at least some use of the computer, expensive screen-reading systems might dissuade employers from hiring visually impaired persons. If the cost of the technology could be reduced, this could potentially assuage some concerns that employers may have about hiring people with visual impairment. Since these screen-reading technologies are non-optional for the vast majority of careers, many visually impaired workers would be at a loss without access to one. One participant frustratingly exclaimed that she wouldn’t be able to perform any of her job tasks without JAWS (personal communication, December 29, 2016). Many people I interviewed brought up these concerns. One participant stated:

Look at how high the blind unemployment rate is, obviously there’s still a lot of work to be done there. I think there’s other reasons and issues besides technology but especially bringing down the cost. Some of the technology I use is pretty expensive and getting other options for people like getting screen readers that are cheaper so that you don’t have to have thousands of dollars in order to get a laptop to talk to you, I think that would be really helpful. (personal communication, February 1, 2017)

Other participants mirrored the same concerns as above. Developing technology related to education and careers would have a ripple effect that would greatly improve the employability of
members of the visually impaired community. The importance of investing in technology to aid with education and jobs was elegantly summed up by one participant:

   It would allow us to be more productive members of society. It would help us get things done more efficiently. I think it has an all-around impact. If we can access educational things well then we’re more likely to do well and get good grades and get jobs. For example, there’s a lot of tests like the GRE and GMAT. For my CPA exam, for example, their platform wasn’t compatible with JAWS, or they didn’t allow it or something like that. I don’t know what their reasoning was but I literally had to have someone sit there and read me all of the numbers. Good thing I have a good memory. (personal communication, February 11, 2017)

Experiences like this highlight just how important it is to foster better access to educational and vocational resources for people with visual impairment. Not only did this participant have to pass the rigorous CPA exam, he had to do so while memorizing the numbers a stranger read to him. This clearly puts visually impaired students at a disadvantage and creates an intimidating environment.

   Additionally, advancements in technology in this field would allow people with visual impairment to do their jobs more effectively. Many people conveyed experiences in which they had to ask their sighted coworkers to help them complete a task because a necessary website or software was inaccessible. This is frustrating for all parties involved. One woman recounted:

   At work there’s a database that is not accessible at all with JAWS because it’s 20 years old. So whenever I have to sign for equipment the person that gets the equipment for me has to sign it in and out for me because I can’t utilize that database for equipment.

   (personal communication, December 29, 2016)
Experiences like this lead to concerns of job stability for some members of the visually impaired community. If visually impaired workers cannot perform their jobs due to inaccessible technology, then their jobs are at risk through no fault of their own. This experience highlights a broader issue of whose responsibility it is to increase accessibility for the visually impaired community. Does that responsibility fall on the developers of platforms like websites and databases or on technology systems like JAWS which translate those interfaces to accessible formats? Overall, many people commented on the limitations of JAWS. Even though JAWS is essential for allowing people with visual impairment to navigate the internet, it still has significant shortcomings. Several participants raised the issue of inaccessible PDFs and graphics-based interfaces. If PDFs are not searchable then they cannot be used as-is by visually impaired people. Those documents would then need to be run through a separate software before the work can even begin. When these issues are encountered, workers with visual impairment need to go through extra steps just to get the information into an accessible format, and sometimes even that is not possible. This can also be an issue for the creation of professional documents. All these extra steps that people with visual impairment need to complete just to do their job slows their productivity.

Assistive technology has the potential to positively impact younger visually impaired persons as well. In addition to developments in technology for jobs, it is important to develop technology for K-12 visually impaired students as well. If these students don’t have access to the technology they need to effectively learn certain subjects, that puts them at a distinct disadvantage to their sighted peers. Two participants both brought up the challenges of learning spatial concepts in school. They described how having 3-dimensional models could have helped them internalize many concepts better. A participant explained, “It would help if there was a type
of technology that was immediately accessible to visually impaired people that can convert graphical information into a tactile format. I know that 3D printing is becoming more and more prominent, maybe something like that.” (personal communication, February 11, 2017). Another participant also commented on the difficulty of understanding 3-dimensional graphs. The development of educational tools to help students with visual impairment would ensure that they are not excluded from learning. One participant discussed her concerns with the current status quo of assistive technology for students with visual impairment:

> There’s a lot of programs for kids in the elementary grade level that are not fully accessible, so a blind student wouldn’t be able to benefit. So then he or she is left behind, excluded. And we don’t want them to be excluded from any type of programs that are part of curriculum. (personal communication, December 29, 2016)

In order to guarantee that persons with visual impairment have proper training to enter the workforce, we first need to make sure that visually impaired students are given the tools that they need to build a strong educational foundation. That foundation begins in elementary school, but the improvement of technology like JAWS will help secure opportunities for both older students and persons with visual impairment in the workforce.

**Findings Related to Social Collaboration**

The technology available for socialization and social collaboration is not necessarily high on the list of priorities for the visually impaired. This does not mean, however, that it is unimportant or should be ignored. The way we interact with the people in our lives is a vital part
of the human experience and feeling isolated can have detrimental effects. One participant remarked on the culture of viral phone games by saying, “My friends are all talking about ‘Words with Friends’. Games that a lot of other people are playing together are not accessible so it feels kind of segregated” (personal communication, February 1, 2017). Many participants mentioned existing platforms that they use to play accessible games with friends who are also visually impaired. However, there is not currently a platform available that has an interface for both visually impaired and sighted users to use together. Many participants expressed genuine interest and enthusiasm when asked how interested they would be in using an entertainment system that had interfaces for both visually impaired and sighted users to use together.

The presence of social media in our daily lives has been steadily increasing in the recent years. Social media has become incredibly important to younger generations for creating and establishing friendships. One participant explained the difficulty of interacting with social media:

The tricky part about social media is that there are lots of pictures. With VoiceOver on Facebook, artificial intelligence has played a significant role in understanding pictures. For example, if you were to post something on Facebook and I was checking the newsfeed out it would say something like ‘so-and-so’ posted a picture. So I would click on it because now I’m curious and then VoiceOver would say something like “photo shows 1 person, dog, tree, outside, bright”. So it’s actually giving me more information than before artificial intelligence came along it would be like ‘so-and-so’ posted a photo and that’s all I would know. Is it super accurate? No. (personal communication, December 26, 2016)

As artificial intelligence continues to be explored, its benefits will eventually make the use of social media more inclusive. Facebook is already attempting to integrate rudimentary artificial
intelligence, but not all social media sites have followed their lead yet. The main theme that was present within technology for social collaboration is inclusion. Visually impaired persons want to be able to interact and bond with their friends, and social media or collaborative games are a popular way to do so.

**Findings Related to Future Technologies**

Based on technologies discussed in the literature review, participants were asked to rate five technologies based on their level of interest. The figure below depicts a summary of participants’ level of interest in the following technologies: self-driving cars, a system to independently navigate public transportation, a technology to increase web accessibility, entertainment that provides an interface for both visually impaired and sighted users, and technology to assist with independent grocery or clothes shopping. The graph summarizes the mean rating for each of the five sample technologies. Underneath each category on the graph the standard deviation, minimum rating, and maximum rating can also be seen.
Overall, there was relatively high interest from interviewees in all five sample technologies. Technology to increase web accessibility was the most popular with a mean rating of 8.8/10. It also had the least variability of the technologies; the lowest rating given by a participant was a 6 and four people rated the technology as a 10/10 for interest level. This is consistent with most participants’ responses that their most pressing need is related to jobs; technology that makes it easier to work, and to get to work, is crucial. Any future technological enhancements that will improve employability for persons with visual impairment will have the greatest chance of making a real difference in the lives of visually impaired persons. Interest in a system to help navigate public transportation varied widely and was overall the lowest rated with a mean rating of 7.4/10. This technology had the most variability in responses with a standard deviation of 2.76. This could potentially be due to differences in personal access to navigation.
There was also fairly high interest in entertainment that would allow visually impaired and sighted users to use together; this is likely due to the lack of availability of such products. As discussed in the literature review, having a shared source of entertainment is important for bonding. A system to help assist with independent grocery or clothes shopping was also highly variable with ratings that ranged from 3/10 to 10/10. This is only a small sample, but the full interviews definitely reinforce the high interest in technology to increase web accessibility.

**Criteria for Assistive Technology**

Overall the participants in the study had very similar criteria for the adoption of a technology system. The most commonly given criteria were effectiveness, simplicity, and affordability, and each of these criteria were mentioned by four people. Other criteria included efficiency, portability, and ease of integration. Technologies that accomplished multiple functions with one device, and technologies that received recommendations from peers were also discussed positively. The following sections will break down some themes present in the adoption of assistive technology.

**Simplicity**

A few other issues related to the adoption of assistive technology affect the education and vocation of persons with visual impairment. A lot of the technology that is available for people with visual impairment has a steep learning curve. Because these technologies are vital for a visually impaired person’s employment, more effort should be put into creating simpler
technology or working to simplify currently difficult technology. Several participants voiced concerns specifically regarding the visually impaired population that is also elderly. A lot of the technology that is available for people with visual impairment takes extensive amounts of training to use. Recently a lot of technology is being developed on the iPhone as well. One participant who works as an assistive technology specialist stated that the elderly population with visual impairment gets very frustrated when the technology is extremely complicated and may eventually just give up trying to learn it even if it would have a positive benefit in their lives (personal communication, January 10, 2017). If developers want their technology to be adopted by the visually impaired community as a whole, it needs to be user-friendly. Additionally, many people also brought up the concern that not all visually impaired people know all of the technology that is available to them. So educational experiences should include training on existing technology as well as education regarding exactly what the options out there are. As one participant explained:

Most people who become visually impaired have no idea about assistive technology and don’t know that it is extremely important in order to obtain employment as a blind person. Especially JAWS, that’s the only way you’re going to be able to work. These devices need to be simple so that people don’t get frustrated and can use these devices to go back to work. (personal communication, January 20, 2017).

People cannot be expected to automatically know every technology that is available to them. One participant noted that she often listens to assistive technology podcasts in order to keep up to date. However no one else in the study made mention of using any podcasts to learn about new technology.
When considering the simplicity of technology, many people felt strongly that it was important. It’s vital to ensure that a technology is not overly daunting if subpopulations like elderly people with visual impairment are going to be able to benefit from it. Even though not everyone reported being bothered by steep learning curves, a technology system that is universally understood can overall be more helpful.

**Discretion**

Discrimination can be a concern for some people who are visually impaired. For example one participant described being denied four or even five Ubers in a row because of his guide dog (personal communication, February 11, 2017). So, having technology that allows a visually impaired person to blend in more with the general population might be appealing to some visually impaired persons. Participants’ thoughts on the value of having discreet technology varied widely. Responses ranged from several people reporting a 3/10 importance to several reporting 9/10 importance. Many people acknowledged that it is definitely a plus, but whether or not it would dissuade them from using a technology varied from person to person. Instead, participants brought up the separate issue of portability. As one participant phrased it, “It doesn’t bother me if it’s visible, I just don’t want it big and bulky” (personal communication, January 20, 2017). Many participants echoed these same thoughts of valuing functionality over discretion, but of course there still have to be some limits. One participant explained:

For me, if it’s useful and it does what it’s supposed to do and it’s practical, that’s all that matters. If that means I have to carry a 50 pound item then obviously I’m not going to want it. But the discreetness of a tool doesn’t bother me. It wouldn’t prevent me from
using a tool at least, if it was getting the job done. (personal communication, February 11, 2017)

On the other hand, there were a few participants who cared more about having a device that is discreet. One participant said “I’m big on being able to integrate into society with sighted peers with limited distraction” (personal communication, January 30, 2017). Or another participant who similarly remarked, “I hate anything bulky and obnoxious. I like technology to be very portable. Like IOS devices are very sleek, they’re very fashionable” (personal communication, December 29, 2016). This issue may be traced back to technology developers failing to seek input from the visually impaired community regarding the technology they are designing for them. Perhaps this is due to a conception that visually people would not really care about the aesthetic of a device, since they would not be able to see them. This issue was spelled out by one participant:

I think too frequently companies come up with these products that may be helpful. They may be beneficial but the “cool factor” is so low that nobody would really want to use them. Unfortunately I think designers of these technologies don’t always pay attention to that. And while it does a great thing, it’s an ugly product and I think that designers don’t put a lot of effort into designing products that look pretty for blind folks. I guess they think we don’t care, but we do. (personal communication, January 5, 2017)

Most people ranked simplicity as being more important than discretion in technology. There were two participants, however, who ranked both simplicity and discretion very highly but with a slight preference on discretion. The figure below shows how each participant rated the importance of discretion and simplicity on a scale of 1 to 10.
As a whole, the importance of discretion is a lot more variable than simplicity. The lowest score for discretion was a score of 3 whereas the lowest score a participant assigned simplicity was a 7. Additionally, several people rated simplicity to be a 10 for importance, but no one felt that strongly about discretion.

**Integration into an Existing Technology**

When a new technology is incorporated into an existing technology it has the potential to reach a larger audience. Many visually impaired people already own technology like a smartphone or a white cane. This may make them more inclined to use a new technology that’s incorporated into a technology that they are already familiar with. One participant expressed her support for the idea by saying,

Simplicity wise I already know how to use my phone so even if it’s a new app it’s going to be somewhat familiar because it’s integrated into something I already know how to use. It’s just one less thing to have to hold on to or learn how to use. It seems simpler and
more streamlined and also probably cheaper than buying a new piece of equipment.

(personal communication, December 29, 2016)

The majority of participants felt the same way. They believe that integrating new technology into already available technology is a huge plus. “Let’s not reinvent the wheel, take what we have and just add to it” said one participant (personal communication, December 29, 2016). However, many also remarked that a standalone device was not necessarily a deal breaker as long as it truly performed better. This thought was summarized well by this participant,

A lot of my tools run off the iPhone, but if I had a device that did the job better that wasn’t necessarily an iPhone I would give it a try. If it works better, then I’m more likely to go with the new stand-alone tool if it actually does the work better. For example, I prefer scanner over the phone OCR tools because scanner you stick the paper in and it’s a scanner bed you don’t need to worry about angles or anything like that. But at the same time then you have to have a separate scanner. (personal communication, February 11, 2017)

Overall, most participants stated that they would prefer that the technology be incorporated into technology they already use. They gave reasons similar to those mentioned in the quotes above: cost, efficiency, convenience, et cetera. However, one participant has strong, in-depth remarks on the potential downsides of having technology all incorporated into, say, an iPhone for example:

You have a lot of these big corporate entities saying that they are providing you with accessibility. Like Apple and Microsoft. They have assistive components of their operating systems. And I have a lot of blind friends of mine who feel it’s the greatest thing that Apple is doing this because then they don’t have to spend money on additional assistive technology to make it possible to access a phone or computer. But I see that also
as a threat because the visually impaired community is a small component of the population that these corporations are targeting. I think that because of that we are not going to get high priority when they are innovating. I’ve already seen it with some of the new versions of VoiceOver with Apple. Many times Apple would come out with an upgrade, and their braille display access is broken. It’s not ready for primetime, so you lose access that you may have had before. And they say they’ll come out with an upgrade that will fix it, and sometimes you sit around waiting, and waiting, and waiting for the access to come out. And what happens if your job is dependent on that access, then what? They are under no pressure to really fix that because they could lose every blind client they have and it’s not going to hurt them anything significant. They can do without us, we cannot do without them if our job depends on it. And at the same time they can still come out and claim that their technology is accessible simply by having some level of access. But the question is, is it sufficient? Does the quality of access allow the blind person to do their job effectively? To me, that is a big problem. If a screen reading company comes out with a screen reader that has these glaring problems, then they’re under major pressure to get it right. It doesn’t mean that they get it right all the time; they have their own challenges as well. But they are under way more pressure to get it right than these big corporations are because we are their prime customers. So they better cater to us, or they’re going to be out of business. Big companies like Apple and Microsoft are really under no such obligations. If they innovate so much that they make the products better, on the surface it looks good and makes sense and seems wonderful. We should be cheering when Apple and Microsoft gets things right. But it also, for me, is a threat because we can easily be left behind if they make a business decision that in the next
product release the challenges of accessibility are too great for them to deal with. I do not trust big corporations in handling the needs of persons with disabilities. (personal communication, January 5, 2017)

So, while the idea of integration is extremely appealing, there is absolutely cause for concern as well. Many people spoke about variations in accessibility along with technology updates. When technology is updated for mainstream users, it’s important to ensure that the innovations are compatible with accessible technology as well. Otherwise, there is a risk of leaving our visually impaired peers behind.

Overall, the majority of participants were in support of integrating technologies. The major theme of integration is the convenience factor. Integrated technology is more convenient because it’s easier to learn and does not require the user to carry additional tools.

**Consistency and Reliability**

Throughout the interviews, discussions about advancements in mainstream technology leading to diminished accessibility was a common theme. As technology companies introduce new interfaces or operating systems, they can cause compatibility issues with voice over technology. This concept spanned navigational technology, personal technology, and even kitchen appliances. Everyone that I spoke with used the ride-sharing services Uber and Lyft, and almost everyone had similar thoughts. Many people described how much they liked the services, often describing a heightened sense of freedom and independence. One person described how Uber really changed how they were able to navigate their area, “Before ride-sharing apps came into
existence, blind people had to completely organize our day one day in advance. I just couldn’t do things on the fly unless there was someone around who could drive” (personal communication, December 29, 2017). Many others echoed similar thoughts about how the rise of ride-sharing services had bolstered their independence while navigating. One participant commented on this shift in independence as follows:

With cabs I was always asking someone to either hail a cab for me or I would call, but then I need to ask someone when it arrived. So with Uber and Lyft I’m able to be more independent because I know the person’s name, I know approximately when they’re supposed to be there because the app will tell me. I have a better chance of finding the car or calling them up and saying ‘hey I’m on this corner, I have a white cane, and I’m waving my hand. Do you see me?’ I don’t have to involve other random people on the street. (personal communication, February 1, 2017)

Other participants noted the affordability and good customer service that they have experienced with Uber. One participant even noted that it “almost feels as though it was a friend picking you up and dropping you off” and that Uber gave him a “sense of freedom [he] never had before” (personal communication, January 5, 2017). He even went on to call it “one of the most brilliant apps ever invented” (personal communication, January 5, 2017). It’s safe to say that ride sharing services like Uber and Lyft have drastically changed the landscape of available navigation options for the visually impaired. However, except for one participant, every person reported that each time the Uber application is updated some of the functionality was no longer compatible with VoiceOver technology on the iPhone. As one participant phrased it, “The beauty and the beast of new apps is development. Once they develop something that works they come out with a brand new app that’s totally different and that’s not accessible” (personal communication,
February 11, 2017). Eventually, the app would fix the mistakes, but even today it is not fully accessible. The only person who reported an increase in accessibility after updating the app was also the only person in the study who uses an Android phone. She reported that Uber was initially not very accessible on her Android device. Important functionality, such as the ability to rate the driver or ensure an accurate pickup location, was not accessible. After the most recent update, however, she reports that the app has become more accessible. Although some features, like the driver’s arrival time, are still not usable (personal communication, January 10, 2017).

So, even with Uber on an Android completely updated, the full functionality of the app cannot be utilized. On a positive note, it does seem that her experience with the app has slowly gotten better. Unfortunately, no one else that I spoke experienced the same improvement in accessibility. The various accessibility issues were similar for most participants, as one participant expounded:

The new interface is harder to set the pickup location and destination. For example let’s say you set the destination to say Walmart. The destination is set to Walmart but it doesn’t say it aloud so there is no way to confirm that you actually set the right place. The same thing carries over for the pickup location. You set it to one thing and it jumps to another thing. It’s just difficult to navigate now. The UberPool feature doesn’t work very well. It’s also very hard to place a complaint now. I’ll have to sift through 15 different menus or it won’t even read one of the menus, it’s just difficult now. There’s also the pin drop option which is just not possible; you’d have to be able to see the map. (personal communication, February 11, 2017)

Uber has become a popular choice in the world of navigation for both visually impaired and sighted users. The increased independence that the app offers to visually impaired persons is
immense. Even though the visually impaired population is a relatively small segment Uber’s client base, they have the potential to be a very loyal base of customers. With so much support from the visually impaired community, it would behoove Uber to look into its accessibility standards before it rolls out upgrades.

Unfortunately, this phenomenon is not limited to just ride-sharing services. As technology develops, creators attempt to create more sleek devices by eliminating under-utilized features. Regrettably, this can have a significant impact on people with visual impairment. One woman that I interviewed chronicled the struggle of finding a new laptop that would be accessible with JAWS, an absolute necessity.

Nowadays computer companies are eliminating a lot of the keys that sighted folks don’t use, but they don’t realize that we need those keys for things like JAWS. Like the home key. Or somehow they combine it with the other keys. So one time I had a laptop where my page up and page down keys were part of my arrow keys so every time I needed to press the home key I had to press the fn key to get the home key. So that’s an extra step. So if a command requires alt+ctrl+home, I would have to press alt+ctrl+fn+home. So already the key strokes are complicated, but now I have to press additional keys to get just this one key that I need. So when they’re making these systems I just wish that they would keep in mind that although a lot of people don’t use home keys or insert keys, the people who use assistive technology, especially screen reading technology, we need all the different keys because all of those keys are used. (personal communication, January 10, 2017)

Because the visually impaired community is such a small segment of the population, developers do not necessarily consider them when designing a product upgrade. Many of them are likely
unaware of how the system upgrades affect this population. Because JAWS is absolutely essential for using a computer, eliminating keys that JAWS needs to operate will have a profound impact on the visually impaired community. Another potential example of the decreasing accessibility of technology updates can be seen with the iPhone. The same participant above also commented on a rumor that Apple is considering getting rid of the home button. For sighted users, this change may not seem like a problem, some technology users may even welcome the change. However, the visually impaired community finds the home button extremely useful for the functionality of the phone (personal communication, January 10, 2017). This is important because the iPhone is known for being a very accessible touch screen phone utilized by many visually impaired persons. Only one participant in this study uses an Android over the iPhone, and this was solely due to work obligations. So, if the iPhone became less accessible the visually impaired community would be immensely impacted.
Chapter 5

Implications in Future Technology

One of the most pervasive issues that participants discussed is the period of diminished accessibility that occurs when technology is updated. If the technology is specifically marketed for people with visual impairment, the vendors are under more pressure to get it right. But if it is not specifically an assistive technology, there is a greater risk that the company will not rigorously ensure the accessibility for visually impaired users. In 2016, Microsoft rolled out accessibility enhancements in Office 365 that were specifically designed to address issues raised by the visually impaired (Jenorezak, 2016). They encouraged users to become part of the early rollout, and to report any usability issues via the Microsoft Accessibility Forum. These are promising steps in the effort to ensure that accessibility issues are resolved prior to software being widely distributed. As new technological enhancements are developed in the future, technologists need to partner with organizations that champion accessibility to ensure that new products and features are as easy to adopt as possible. They also need to make sure that upgrades take accessibility into account prior to wide-spread distribution.

Unfortunately, even when these protections are in place to ensure accessible technology, it is not always enforced. According to section 508 of the Rehabilitation Act of 1973, all federal agencies must give their employees access that is comparable to the access other employees receive. Unfortunately, several people that I interviewed work for government agencies and still have accessibility issues for websites and databases that they need to complete their jobs. This is in direct violation of section 508. Therefore, one simple way to increase accessibility for those workers is stricter enforcement to make sure agencies are complying with the law. This would greatly assist any visually impaired government employee. We also need to be vigilant to ensure
that laws protecting the visually impaired remain in place. Some of the laws that protect people with visual impairment may appear to be expensive, however the cost of unemployment is extreme and outweighs the cost of ensuring that accessible technology is available.

In order to help increase the dismal unemployment rate for people with visual impairment, it would be beneficial to have widespread job training programs. Numerous non-profits work to help visually impaired persons to obtain employment. One example is a called BlindinBusiness. This UK-based charitable organization was founded by three visually impaired university graduates who struggled to find employment after graduation. BlindinBusiness provides training and support and they also help businesses to become more accessible to visually impaired employees (Mitchell, n.d.). In the United States, many states and localities have occupational training, but the quality and breadth of the training depends heavily on where you live. Perkins School for the Blind is helping to bridge the gap by providing on-line training both in the USA and in 44 other countries. According to Dave Power, current president of Perkins, “We created an online course for other companies to teach them how to hire people with visual impairments. We also provide webinars and courses and issue certificates like an online university. We are partnering with Uber, Harvard, Dunkin’ Donuts, State Street Corporation, and more than 35 other companies to help them hire more” (Ekiel, 2016). Powers is a strong believer that innovation is the key to improving the lives of visually impaired persons. When asked what technology has the greatest potential to change the lives of people with visual impairment, he replied “Autonomous vehicles! Transportation is a barrier to employment for people who are visually impaired. The best technologies will be those that work for everybody and happen to benefit people who are blind.” (Ekiel, 2016)
An additional implication deals with the types of technology that are being developed. A significant amount of the new technology is being delivered via iPhone applications. This is a very convenient and generally inexpensive way to deploy the new tools. However, currently the product quality is variable. Improvements in iPhone applications have the potential to bring tremendous benefits to the visually impaired community; future developments using this technology are essential.

Another issue that multiple people presented is the difficulty in knowing what technology is available. Innovations in technology that help educate and train people with visual impairment continue to evolve. According to Forbes, “Technology innovation is making education for the blind and visually impaired better, cheaper, and more seamlessly integrated into both traditional classrooms and online settings” (Szczerba, 2015). Some of the new technologies touted by Forbes include Braille Note Apex, TypeAbility, and Virtual Pencil math software. Braille Note Apex can be used for the traditional office functions including word processing, email, and database management, calendar and address list. This technology can be configured to use either a braille display or a speech synthesizer and it can also be used to read PDF and PowerPoint files. TypeAbility teaches keyboard typing in 99 lessons and Virtual Pencil Math software can be used to teach math to visually impaired students. This technology is relatively new, and no one mentioned using it in the interviews. Both students and working visually impaired persons can benefit from a software like this. One issue may be the lack of awareness about the product. Organizations that support people with visual impairment are the primary vehicles for disseminating information on new technology for visually impaired people. Continued funding for these organizations is necessary to ensure that visually impaired persons have access to information on technological advances.
The appropriation of non-assistive technology, like FaceTime, for assistive purposes was a theme seen prominent in life skills technology. This innovative use of mainstream technology has the potential to benefit a lot of visually impaired people due to widespread availability and affordability. While the benefits that these technologies can provide is evident, it may not be immediately known to all visually impaired persons. It is also likely that there are other ways to appropriate non-assistive technology that were not mentioned in these interviews. Promoting the assistive aspects of non-assistive technology could help spread these techniques to more visually impaired people. An outlet like a podcast, blog, or newsletter would be one method to spread this information. Or, a more personal approach could involve visual impairment support organizations encouraging the development of mentoring groups to further spread tips about technology systems. A solution similar to these would also address the concern listed above regarding not knowing all the technology that is available.

In some cases, technologies are not available because we do not currently have the capacity to create them. Take the self-driving car as an example. While many companies are currently in the process of testing self-driving cars, none of the cars are safe enough to take to market yet. Companies are trying to solve the issues and finish developing the technology, but they do not have the capability yet. On the other hand, however, there are occasions when the technology is available, but no one has taken the time to develop them. This could be due to a lack of awareness or a lack of developers who want to develop assistive technology. For example, the technology system described by one participant that would automatically tell her about businesses and restaurants in her surroundings. Since Google Maps already has building tags and VoiceOver capability, it would seem like a relatively simple task for Google to combine their turn-by-turn directions and building tags into one accessible technology. There is not an app
that is currently available that can do both of those things. Or, another issue that participants mentioned was inaccessible appliances. There is certainly technology available that could read out the settings on an appliance with a touchscreen, but manufacturers may not realize the importance of a feature like this for the visually impaired community. For this reason it is important to get more people with visual impairment involved as end user designers. As members of the community they are designing for, designers with visual impairment could bring more innovation and ideas to assistive technology.
Chapter 6

Conclusion

After conducting interviews with members of the visually impaired community, it became clear that there is a lot of technology out there to help people with visual impairment. However, much of the available technology has significant shortcomings. The visually impaired people I spoke with had a lot of good feedback regarding the state of assistive technology. Although navigational technology is available, it lacks precision. Visually impaired persons are particularly interested in technology that could identify objects and businesses real-time, so they can more easily determine what is in their vicinity. Having a choice in navigational technology options is also important because preferences in navigation are quite variable; options that may work for some visually impaired people are confusing to others. Technology that is not primarily geared towards the sighted is widely used to facilitate everyday tasks. In particular, Skype, Facetime, and Amazon Echo are all extremely useful. However, when the technology that people with visual impairment rely on is ‘upgraded’ it often introduces significant problems. This is partly because the redesign of layouts and features is more difficult for the visually impaired to adjust to. However, the main issue is that initial upgrades tend to introduce usability issues, and it often takes a long time for these issues to be resolved. Also, new releases tend to have compatibility issues with the other devices that visually impaired persons use. This was particularly important for several of the key technologies that visually impaired people have come to rely on – specifically Uber, JAWS, and iPhone applications. Artificial intelligence has the potential to provide significant benefits for people with visual impairment, and Facebook is
already making great strides in using this to improve usability for people with visual impairment, but some social media sites have not followed their lead yet.

Although technology for navigation and social purposes is important to people with visual impairment, participants expressed the most interest in better technology for occupational and educational training. Difficulties in gaining meaningful employment were the most pressing challenge for visually impaired people, and this is an area where technology could lead to significant improvements for people with visual impairment. The need for more affordable assistive occupational technology, especially screen-readers, was mentioned by all the survey participants.

Technological advancements in this century have had an incredible impact on the visually impaired and a host of additional tools are currently under development. While this has brought tremendous benefits to people with visual impairment, additional progress is still needed. The preferences and needs of visually impaired people must be taken into consideration, and special attention must be paid to designing technology that is both simple and reliable. Tools and training that enhance employment options for visually impaired persons are particularly key. The partnerships between some software companies and the visually impaired are helping to drive these improvements; in the future expansions of these partnerships would help to drive the innovation that will be truly revolutionary for the visually impaired.
Appendix A

Interview Questions

I. Current Technology
   a. Do you currently use any technologies in this category?
      i. Navigation (eg. White cane, gps)
      ii. Education/Vocational (eg. Braille, screen reader)
      iii. Social collaboration (eg. Social media)
      iv. Life skills/everyday tasks (eg. Apps to tell you colors, distinguishing clothing etc.)
   b. Are there any shortcomings/challenges in the technologies for each of these categories? Any aspect that current technology doesn’t address?
      i. Navigation:
      ii. Education/Vocational:
      iii. Social collaboration:
      iv. Everyday tasks:
   c. What are some criteria you have when choosing technology systems?

II. Technology preferences.
   a. On a scale of 1-10, when choosing a technology how important is it that a technology is discreet? Can you elaborate?
   b. On a scale of 1-10, when choosing a technology how important is simplicity to you? Can you elaborate?
   c. Would you rather have a technology that is discreet or simple? Why?
   d. For you, how important is it for a new technology to be incorporated into an existing technology (e.g. smart phone or white cane) vs the need to purchase a new device?
   e. Navigation
      i. Ideally, when using navigational technology what type of feedback would you prefer? (i.e. audio, vibrational, tones, some combination)
      ii. Have you ever used a ride-sharing service like Uber/Lyft? How was the experience and how could it be improved? If never used, why?
   f. Education
      i. Can you think of an educational experience that was especially difficult for you, what kind of technology could have made it better?
   g. Social Collaboration
i. Is there any assistive technology you use in collaboration with a sighted person? (Eg. Games, entertainment)
ii. Do you use any social media platforms? Can you tell me about your experiences interacting with them?

III. Future Technology
a. Which of these 4 categories do you think the most visually impaired people would benefit from with regards to technology development? Why?
b. Which of these 4 categories would you personally benefit from the most with regards to technology development? Why?
c. Specific technologies: Rate on a scale of 1-10 how interested you would be in using the following technologies:
   i. Self-driving cars
   ii. System to independently navigate public transportation
   iii. Technology to increase web accessibility
   iv. Entertainment (games, movies, etc.) that provides an interface for both visually impaired and sighted users to use together,
   v. Technology to help with independent grocery or clothes shopping,

IV. Demographic Information
a. Age,
b. Gender:
c. Employment status:
d. Education level:
e. Level of visual impairment and years with visual impairment:
Appendix B

IRB Supplemental Materials

HRP-591 - Protocol for Human Subject Research

Protocol Title:
A Qualitative Analysis of Innovations, Preferences and Deficiencies Associated with Technology for Visually Impaired Persons

Principal Investigator:
Name: Emily Egan
Department: IST

1.0 Objectives

1.1 Study Objectives
The purpose of this study will be to investigate visually impaired persons use of technology. Relevant topics of discussion will be technologies they currently use, how they chose it, important features and considerations for technology, and preferences for future technology development. For the purpose of this study, I will focus on technology related to navigation, education, social collaboration, life skills/everyday tasks.

1.2 Primary Study Endpoints
Gather qualitative information through interviews with persons with visual impairment.

2.0 Background

2.1 Scientific Background and Gaps
After researching developments in technology for persons with visual impairment it became clear that many researchers do not get feedback from the visually impaired community until a prototype has already been developed. In order to create more useful technology for this community it is important to fully understand what they are looking for in the technology they use.

2.2 Study Rationale
In order for technology to be adopted by the public it needs to be appealing to its target population. In order for technology developers to be able to make a tangible impact on the lives of the visually impaired, they must understand what this niche market would truly find useful.

3.0 Inclusion and Exclusion Criteria

3.1 Inclusion Criteria
1. Adults at least 18 years of age.
2. Visual impairment

3.2 Exclusion Criteria
None

4.0 Recruitment Methods

4.1 Identification of subjects
Participants will be recruited by a known contact in the National Federation of the Blind D.C. chapter. Known contact will ask potential participants if they are
interested in being interviewed for my research. If so, the contact will then give me their email and I will reach out to confirm that they are indeed interested in participating.

4.2 Recruitment process
Potential subjects will be contacted by email. I will explain the purpose of my research and ask if they would like to participate.

4.3 Recruitment materials
An email describing myself and the topic of my research.

5.0 Consent Process and Documentation
5.1 Consent Process
5.1.1 Obtaining Informed Consent

5.1.1.1 Timing and Location of Consent
Since interviews will be conducted using the phone, verbal consent will be obtained at the beginning of the phone conversation.

5.1.1.2 Coercion or Undue Influence during Consent
Participants will be informed that they can discontinue the interview at any time and do not have to answer any questions they do not wish to.

5.2 Consent Documentation
5.2.1 Waiver of Documentation of Consent (Implied consent, Verbal consent, etc.)
Consent to interview the participants will be requested at the beginning of the phone conversation. Verbal consent will be used since these interviews will take place over the phone. This will make the process simpler for participants so that they won’t have to print out and sign a document of consent and send it back to me. I will ask for their consent to interview them regarding their current assistive technology use, their technology preferences, and their thoughts on future technology development.

6.0 HIPAA Research Authorization and/or Waiver or Alteration of Authorization
6.1 Authorization and/or Waiver or Alteration of Authorization for the Uses and Disclosures of PHI
Check all that apply:

☒ Not applicable, no identifiable protected health information (PHI) is accessed, used or disclosed in this study.
☐ Authorization will be obtained and documented as part of the consent process.
☐ Partial waiver is requested for recruitment purposes only (Check this box if patients’ medical records will be accessed to determine eligibility before consent/authorization has been obtained).
☐ Full waiver is requested for entire research study (e.g., medical record review studies).
☐ Alteration is requested to waive requirement for written documentation of authorization (verbal authorization will be obtained).
7.0 Study Design and Procedures
7.1 Study Design
The study will consist of survey questions that will be administered over the phone to visually impaired persons.

7.2 Study Procedures
7.2.1 Phone Call
The study will consist of a single phone call per survey participant.

7.3 Duration of Participation
Each interview will last approximately 20-45 minutes.

8.0 Subject Numbers and Statistical Plan
8.1 Number of Subjects
I expect to have ten participants.

8.2 Sample size determination
The sample size is relatively small due to the need to limit the survey to visually impaired persons. Additionally, the study will involve a fairly lengthy telephone interview, so a large sample size would be unmanageable.

8.3 Statistical methods
The data will be synthesized using mainly qualitative analysis; the quantitative data will also be summarized and graphed using Microsoft Excel.

9.0 Confidentiality, Privacy and Data Management
9.1 Confidentiality
9.1.1 Storage of Data and/or Specimens
Interviews will be stored until May 2017.

9.1.2 Access to Data and/or Specimens
The summarization of the data will be used in a SHC honors thesis that will be available via the SHC thesis archive site. Raw data will not be accessible by anyone other than the PI.

9.2 Subject Privacy
I will assure the participants that I will not retain nor report on any identifying information.

10.0 Risks
A concern about the loss of confidentiality is a small potential risk, however the questions I will ask will concern the participant’s technology preferences and it will not include any highly personal questions.

11.0 Potential Benefits to Subjects and Others
11.1 Potential Benefits to Subjects
Contributing to a base of knowledge that will develop better technology for their community.

11.2 Potential Benefits to Others
The development of technology for the visually impaired community that is reflective of preferences and needs.

12.0 Resources Available
12.1 Facilities and locations
All participants are members of the visually impaired community in the greater Washington, D.C. area. Interviews will be conducted over the phone.
12.2 Feasibility of recruiting the required number of subjects
A group of ten participants will be used for the study.

12.3 PI Time devoted to conducting the research
The PI is receiving credit for this research and will devote time equitable to a 3-credit course.

13.0 Adverse Event Reporting

13.1 Reporting Adverse Reactions and Unanticipated Problems to the Responsible IRB
In accordance with applicable policies of The Pennsylvania State University Institutional Review Board (IRB), the investigator will report, to the IRB, any observed or reported harm (adverse event) experienced by a subject or other individual, which in the opinion of the investigator is determined to be (1) unexpected; and (2) probably related to the research procedures. Harms (adverse events) will be submitted to the IRB in accordance with the IRB policies and procedures.

14.0 Study Monitoring, Auditing and Inspecting

14.1 Auditing and Inspecting
The investigator will permit study-related monitoring, audits, and inspections by the Penn State quality assurance program office(s), IRB, the sponsor, and government regulatory bodies, of all study related documents (e.g., source documents, regulatory documents, data collection instruments, study data etc.). The investigator will ensure the capability for inspections of applicable study-related facilities (e.g., pharmacy, diagnostic laboratory, etc.).
BIBLIOGRAPHY


Academic Vita

Emily Egan

Professional Experience

Summer Analyst, Summit Consulting
June 2016-August 2016
Contributed to client contracts for the Department of Labor. Analyzed data using SAS and STATA regarding retirement benefits and health claims. Generated and formatted graphics in Word and Excel for client reports.

Load Analytics Intern, Exelon-Baltimore Gas and Electric (BGE)
June 2015-August 2015
Coded programs in SAS that analyzed hourly electricity loads in order to predict future loads. Reduced prediction margin of error from 11.6% to 3.9%. Updated defunct code from an electric vehicle study to reflect current goals.

Senior Statistics Learning Intern, The Pennsylvania State University
AUGUST 2014-December 2016
Responsible for overseeing students’ progress and providing instruction in statistics and Minitab software. This will also include collecting, analyzing, and presenting program retention data.

Undergraduate Research Assistant, Human-Computer Interaction Lab
September 2015—December 2016
Assist a project team that is developing a device to aid blind and visually impaired persons with grocery shopping. Assemble literature briefs and run experimental trials with participants.

Undergraduate Research Assistant, Child Attention and Learning Lab
September 2014-May 2015
Processed data for an MRI study using SPSS. Assisted in general research responsibilities.

Education

The Pennsylvania State University, University Park, PA
Schreyer Honors College

Leadership

FOUNDING MEMBER AND SECRETARY OF ANTI-HUNGER GAMES FOOD DRIVE CLUB
September 2013-January 2014
Spearheaded a food drive competition involving 11 residence halls. Coordinated efforts with local families and churches and solicited support from local businesses.

CLASS REPRESENTATIVE FOR SPRINGFIELD BENEFITTING PENN STATE DANCE MARATHON
MARCH 2014-May 2015
Elected Class Representative for the 95 members of the Springfield Sophomore class. Organized fundraisers to help Springfield raise $236K to support THON’s fight against pediatric cancer.

OTHER
September 2013-present
Penn State Lion Scout: Served as campus tour guide, volunteered at prospective student events.
Mu Sigma Rho: Inducted into the statistics honors society April (2016).
Schreyer Honors College Mentor: Served as mentor for freshmen honors college students.