The Efficacy and Acceptability of Assistive Devices for the Visually Impaired

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by

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Vision may be the most important sensory mechanism out of the five human senses in regards to processing information of our surroundings and natural world. As of a report conducted by the World Health Organization (WHO), approximately “314 million people worldwide suffer from visual impairment” and out of the 314 million, 45 million are legally blind (Meshram, Patil, & Shu, 2019 p. 449). In an attempt to help alleviate the complications that arise from being visually impaired, assistive devices were invented ranging from the simple walking cane to wearable sensors. With the rapid pace of technological breakthroughs in microprocessors, artificial intelligence, and smart sensors, more high-fidelity assistive devices are being engineered than ever before for the visually impaired. Although the advancement of recent visual aids provides a suitable substitution for vision, the primary struggles lie within the acceptability of these devices within the visually impaired community. In a study conducted with students in an Illinois school system, “a total of 341 students required some form of alternative reading media" and “of these students, only 137 (40%) used some form of assistive technology” (Kapperman, Sticken, & Heinze, 2002, p.107). The fact that more than half of the visual impaired population in the school decided to opt out of the use of assistive technology furthers the question on the acceptability of visual aid. In order to increase the use of advanced assistive technologies, these devices must focus on being introduced in the early stages of visual degradation, the social stigma of using an assistive aid, and expanding their accessibility through organized groups and public programs.

Review of Research

Many researchers and visual aid engineers who have conducted experiments in exploring the acceptance rate of these devices tend to attribute successful acceptance to how well a visual

aid conforms to user needs and requirements. The idea of focusing on end user requirements stems from the principles given by the United Nations Convention on the Rights of Persons with Disabilities (CRPD), who recommends “user centered services” so that “visually impaired people will also be involved in the design decisions about the support or assistance required by [visual aids]” (Meshram, Patil, & Shu, 2019 p.449). Having this bottom up approach in designing these new devices can be proven to be successful in increasing the acceptance rate due to the fact that the design and functionality of the product are focused on the end user of the aid instead of other clients or groups. This focus towards end user development is seen emerging in technology driven industries including smart devices and software engineering. The primary motivation for this method is to “decrease the conflict between application complexity and learning effort” by providing an “[environment] whereby each incremental increase in the level of customizability only requires the user to devote an incremental amount of effort” (Paterno, 2013 p.3). The main idea is to flatten the learning curve needed for new visual aid to reduce the effort needed to implement it in everyday life.

Although end user involvement when designing a device can deliver better results, the focus on the device itself limits the understanding of other factors, such as the user’s social environment when adapting a new assistive device into everyday life. Other researchers advocate that environmental factors such as the entry cost to using these devices and the “potential lack of commercial/corporate interest in pushing high-quality electronic travel aids” (Spagnol, Wersenyi, Bujacz, Balan, Martinez, Moldoveanu, & Unnthorsson, 2017 p.2). This shift in focus from improving the actual physical device to how the device is introduced to its users is argued to be a more effective way in increasing acceptability due to an understanding of continued engagement with the user and the device. A “large number of assistive devices are donated to

low-income countries" and many of these donations are "rejected because they are not able to address the needs of the visually impaired people" due to the lack of "required services" that go hand in hand with these devices (Meshram, Patil, & Shu, 2019 p.449). Some of these services included training for the user as well as maintenance for the device to ensure long usability. Many researchers who support this argument often neglect to add some of the external societal issues which stricken the adoption of these visual aids. One of the most commonly used examples of these social factors being the stigma that often stems from seeing a person using an assistive device in public. These issues concerning a visually impaired individual's self-esteem and overall confidence play a major role in determining the use of visual aids. Therefore, continued research and exploration of the effects of social stigma and its relationship to the use of visual aids would open possibilities to new methods for increasing the acceptability rate of these devices.

Timing and Complexity of Assistive Visual Devices

The most vital time to introduce an assistive device in a person's life is during the early stages of a disability. In the scope of visual impairment, this timing is during a person's childhood development if the individual is born blind or around the first signs of onset visual impairment. A recent study that differentiates the acceptability of technological solutions for visually impaired children and adults shows that during child development, "cortical plasticity is stronger during the first years of life" which is the primary motor that "facilitates the development of new skills" (Cuturi, Aggius-Vella, Campus, Parmiggiani, & Gori, 2016 p.246). With this critical phase in mind the more complex technological solutions for the visually impaired, for example the "K-Sonar Cane" (Bay Advanced Technologies ltd, 2016) or the "Mini-

Radar" (Dakopoulos & Bourbakis, 2010), are centered towards adult use due to the high technical learning curve of these devices. This shows that there is a disconnect between the end user of these assistive devices and the researchers and engineers who are designing and building them. Therefore, taking a step back to inspect when and how people learn their natural skill of vision will help close this gap in order to create more effective devices.

To further add on to the idea of introducing assistive devices early on in a person's life, these devices have to be intuitive and natural to use in order to reduce the cognitive strain on the individual. This will increase the likelihood of a person accepting a certain assistive device in their everyday life. An example of intuitive design is seen in 1829 with the introduction of Braille and in 1921 with the long-cane. These devices are still used within society today due to their proven ability to assist the visually impaired with ease and requires simple training methods. These two solutions to visual impairment incorporate the idea of "active solutions" which "[conveys] sensory information to the brain thanks to a natural and immediate approach" (Cuturi, Aggius-Vella, Campus, Parmiggiani, & Gori, 2016 p.246). The complexity of these new smart assistive devices for the visually impaired serves as a blockade to the individual who is using it instead of providing higher fidelity information in order to enhance a user's experience. Therefore, this brings about the idea that assistive devices are implementing newer technologies in order to serve as a better solution for visual impairment after every iteration without acknowledging how people naturally learn new skills. In order to increase the acceptability of high-fidelity systems for the visually impaired population, there has to be a change in priority with the design of these devices. This change should bring the focus onto the learning tendencies and methods that are effective for people to learn a new skill first before implementing the

revolutionary breakthroughs in technology that are advancing other fields in science and technology.

In addition to focusing on the complexity of smart visual aid devices and its effect on the acceptance rate of the device, another idea to introduce is that the success of these devices is reliant on the synergy of the user and the device. There is a balance that needs to be made with how much information a device can deliver, the reaction time that is required to decide with the information, and the ease of use and general functionality of the device. In a study conducted with "smart canes", users were shown to be more adaptable to their surroundings and reduce the amount of collisions from a mean of 8 collisions per a run to a mean of 6.5 collisions. due to the fact that the design of the smart cane is based on the original white cane and shares a lot of similarities (Kim & Cho, 2013, 102-04). This reduction in collisions showed that the smart cane was an improvement to the regular white cane and that the extra sensors, which provide more feedback to the user, did not negatively impact the user. The individuals who participated in the study preferred that the smart cane had the similar design and methodology of a simple white cane which further supports the relationship of device efficacy and its complexity. After discussing with the participants, the results found that "preference was positively correlated with intent to purchase, but not with full satisfaction" (Kim & Cho, 2013, 107). This shows that individuals are more likely to purchase and use the device if the device falls in line with their previous experience and knowledge even though there could be better options in terms of functionality.

Social Stigma and Assistive Visual Devices

One of the misconceptions concerning the low probability of user acceptance is due to the failures of the assistive aid. However, in a study conducted with visual impaired individuals and their experiences with mobility within an urban city, many stated that most the rejection for assistive devices are due to the glaring eyes of the public. For example, a “college student in her twenties” stated that “she does not use a cane despite tripping frequently while walking”, because visible disabilities “marks people as disabled and exposes them to ableism, or discrimination against people with disabilities” (Wong, 2018 p.89). Some of the lasting effects of this social stigma with disabilities often impacts an individual's sense of independence as well as self-reliance. An assistive device like a white walking cane is found to be effective in preventing collisions with the user, however the white cane usually sticks out to the general public thus leading to either unwanted judgement or interactions. The effects of this distinction can either lead to unwanted bystanders coming to aid the individual or to a greater extent, affecting prospective job positions. Visual impaired individuals often “recall being passed over for employment opportunities because their impairment was visible during job interviews” (Wong, 2018 p.89). All of these side effects from uncontrollable social stigma stem from the idea of the user being outed as having a certain disability. Although some assistive devices can deliver good functionality and a wide range features, the addition of social stigma in the equation of user acceptability results in an important perspective shift on the design of an assistive device.

A possible solution for improving a user’s confidence when using these devices in public is to design for a non-intrusive form factor in order to decrease the visibility of these aids when in use in a public setting. A way to implement these changes for assistive devices is to apply the idea of universal design principles during development of assistive technology. In a study of consumer technology for assistive devices, products that were developed with this universal

design principles then to be more esthetically pleasing and attractive to the user. Thus, decreasing the chance of users rejecting these devices due to an association of developmental disabilities (Cowan & Turner-Smith, 1998). The problem today with the design of these new assistive devices is that "little or no attention is paid to the aesthetics of assistive technology and rarely is competitive marketing an issue" in the assistive aids market (Parette & Scherer, 2004 p.18-19). Due to this lack of attention to the design and aesthetics of assistive technology, the user would feel the lack confidence to use the device in a public setting because of the industrial and conservative design of the device. In addition to implementing the idea of universal design principles, another possible change in device design to combat the effects of social stigmatization is to incorporate the idea of wearables. The "NavGuide" (Patil, Jawadwala, & Shu, 2018) and the "NaveBelt" (Shoval, Borenstein, & Koren, 1998) are some examples of the wearable assistive devices that are worn around the waist of the individual or the knee area respectively. The primary advantage of these wearable device styles is how incognito and concealable the aids are when worn on an individual compared to the waving of a white walking cane or even a smart technology cane such as the previously mentioned "K-Sonar Cane" (Bay Advanced Technologies ltd, 2016). Therefore, making changes to an assistive device to increase functionality and usability for its users is not enough when it comes to make design decisions that could affect the probability of these devices being accepted in the visual impaired community.

In addition to understanding how assistive devices spark social stigma towards the visually impaired, discussing some the root causes of social stigma and why it is so common within our society and societies around the world. In a study of long walking cane use in south India, the majority of the participants listed the "fear of stigmatization" as a primary barrier to

using the walking cane because it “limited their ability to integrate with sighted people” (Christy & Nirmalan, 2006 p.118). This social system within south India is just one of the many places where the visually impaired feel the need to reject the use of assistive devices in order to fit in with sighted individuals. The relationship between stigmatizing attitudes and discrimination can be attributed to the Attribution theory where “persons make attributions about the cause and controllability of a person’s illness that lead to inferences about responsibility” which in turns leads to “emotional reactions such as anger or pity” (Corrigan, Markowitz, Watson, Rowan, & Kubiak, 2003 p.165). In order to improve society's view towards the visually impaired community and to the greater extent, all individuals with disabilities, there must be an emphasis on “counseling people who are blind and the wider community” as a way to increase the “acceptance of the disability and to reduce stigmatization” (Christy & Nirmalan, 2006 p.118). Although the case for trying to change society is a daunting task at the surface, bringing in programs to raise awareness of visual impairments in public systems to help with the acceptance of people with the disability. To further add on to this suggestion bringing public services to the visual impaired, the next major role in aiding the acceptability of assistive devices come in the form of organized groups for the blind as well as their roles in providing programs for the visually impaired community.

Organized Groups and Public Programs

Visual impairment is an ongoing challenge to people within society and is a disability that is relatively common in today’s world. With this disability affecting lives in the millions, many organized groups ranging from independent nonprofits to government entities were shaped to help those who share the alignment. Some of these organizations including the Members of

the American Association of People with Disabilities (AAPD), Association of Blind Citizens (ABC), and National Assistive Technology Technical Assistance Partnership (NATTAP) offer aid to the blind community through the use of grants for assistive devices to eligible individuals with a visual disability (Enhanced Vision, 2020). These programs help with the entry cost to own one of these assistive devices ranging from coupons for top of the line assistive devices to funds for training services. In addition to aiding in the introduction of visual aids to low-income households and communities, NATTAP is known for developing systems and activities to increase the access to these devices.

Another example of the incorporation of services for the visually impaired can be seen through the public sector, especially with public libraries. Public libraries are known to integrate systems that assistive everyone who needs access to their services. Libraries have screen magnifiers, scanning and reading appliances (SARA), digital accessible information systems (DAISY), and voice recorders to name a few of the services offered through public funding (Dodamani, 2019 p.106). As a result, these integrated systems are available for the whole public and often leads to more people with visual disabilities actively engaging in libraries' resources due to the barrier of accessibility being lifted. Additionally, public schools have introduced mandatory services and resources for the visually impaired through the Individuals with Disabilities Education Act (IDEA) of 1997 which was issued by the Department of Education (DOE). This required that all institutions who want to educate individuals with disabilities must follow strict guidelines and requirements. In the realm of visual impairment, the American Foundation of the Blind (AFB) supports the use of a "full range of assistive technology devices and services that are available for [the students]" and the early introduction of these devices in a student's education. This is due to the fact that "proficient in the use of appropriate assistive

technology could have a positive effect on the development of the student's overall self-confidence and self-esteem" (American Foundation for the Blind, 2000). Therefore, more private systems should be placed and follow the footsteps of public programs for the visually impaired communities as a way to increase awareness and social acceptability.

Conclusion

Visual impairment, like all physical disabilities, is a complex issue in terms of incorporating systems and devices to alleviate some of the challenges that come with it. It is shown that in the most serious cases of visual impairment, such as blindness or legally blind, the best solution is to use some sort of assistive technology to aid in everyday tasks. Factors that are affected by visual impairments, e.g. independent mobility, play a major role in determining the success of an individual within their society due to its effects to a person's self-efficacy and confidence. Without these assistive devices and public services in place, many of those with visual impairment would face problems ranging from prejudice, such as the example with employment opportunities, to the inaccessibility to resources. The common misunderstanding when trying to attribute the cause of acceptance rate is to single out the device itself, such as its usability and design, and argue that the device lacks certain features that make it effective. However, this is not always the case in all situations. There is now a better consensus that the acceptability and effectiveness of an assistive device comes from both the device and the environment of the user. An emphasis of the allocation of resources and the awareness of visual disabilities within a community are all needed to increase the acceptability of these devices in public and lead to opening opportunities for the visually impaired. Although there is still further research needed to understand the effects of these methods, opening a dialogue and bringing

attention to these factors is beneficial in creating a guideline for future works and the exploration of assistive devices for other disabilities and conditions.

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