ViSiO:
A New Design Approach for Academia to Work with the Visually Impaired

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1. Assistive Technology and the Visually Impaired

Globally in 2002 more than 161 million people were visually impaired. Of this total, 124 million people had low vision and 37 million were blind. Despite ongoing efforts to develop assistive technology to offset the implications of this range of disabilities current research indicates that roughly one in three assistive devices are abandoned.

These figures are truly staggering. Clearly there is a problem, and it should be evident there is a significant opportunity for involvement of the design community to advance the state of the art.

2. Assistive Devices and Abandonment: Why Do Devices Fail?

According to Marcia J. Scherer, the Director of the Institute for Matching People and Technology, on average, about one-third of all assistive devices are abandoned, and we don't know how many more are users who are using devices that they are unhappy with simply because they have no other choice [18 p. 117]. Scherer [18 p.118], In quoting from Phillips and Zhao [11], Scherer notes that there are several reasons for device abandonment, including: Lack of motivation to use the device; Changes in the user's functional abilities; Lack of meaningful training on how to use; Ineffective device performance; Accessibility problems; and overly complicated devices. Because [18 p. 118] assistive devices are typically abandoned because they do not meet a person's needs or expectations, we need to consider the fact that people will select AT based on how well they satisfy needs and preferences followed by attractiveness and ease of use/appeal [19 p. 3]. The fact that there are a wider variety of AT devices available might also be a factor in discarding a device more readily as well [20 p.156].

In the case of acquired disabilities (versus a disability one is born with) the abandonment rate for assistive Technologies is similar—up to 33% three months after discharge from the hospital, with reasons including "…poor device performance, non-participation in device selection, reliability, durability, comfort, and ease of use." [10 p. 7].

The common thread to these problems with assistive technology integration and discontinuance, then, start with how the person with the disability comes to terms with and adapts to their disability, both in terms of personal and cultural guidelines. This is why, as Scherer [19 p. 3] notes, we must start not with the technology but the person's needs, desires and goals; because all of this design, is, of course, to help the person do what they want to do, first and foremost.

On a similar note, Pape et al. [10 p. 17] suggest that the best coping strategy for people recently disabled is to use active problem solving in conjunction with moderate hope for a better future which suggests there may be a double benefit in having visually impaired people actively participate in the design of AT devices that may suit them better; the participants will provide valuable insights and perhaps help themselves to cope with their disability more effectively.

Figuring out why devices are abandoned, as Reimer-Reiss and Wacker [14 pp. 3-5] note, is important, but figuring out why the majority of people continue to use AT devices (or the other 68% of AT users) is equally useful [15 p. 2]. In conducting their panel review of several groups of AT devices, Batavia and Hammer determine that the most important considerations for people with visual sensory impairment was that the devices were affordable, effective in improving their living experience, dependable, and portable [1 p. 434].

3. Preliminary Exposure: Working with the Visually Impaired Community

In 2004, Barbara Marjeram, Executive Director of the CNIB (Canadian National Institute for the Blind) approached the School of Industrial Design at Carleton University to discuss the possibility of a research project with their support. By 2005, we had put together three teams of students and faculty from the Industrial Design Program and the Systems and Computer Engineering Program and were given initial support for the project from the CNIB's E. (Ben) and Mary Hochhausen Access Technology Research Award.

Initially one ID team and one systems team, each comprised of four students planned to work together on issues related to the travel and navigation experience of the visually impaired. The third team of industrial design students targeted the home experiences of visually impaired seniors. All three projects began with an attempt at an empathetic experience. Each of the students in each team was blindfolded and asked to travel to the meeting room along different routes with a sighted faculty member leading the way. The students, still completely unsighted, were introduced to each other. In many ways, this initial experience highlighted the very assumptions that present obstacles in the design of products by sighted individuals for the visually impaired. We had no idea, at that point, of the variety and differences in impairments that affect visually impaired individuals.

The teams subsequently began an extensive literature search, conducted expert interviews with sighted professionals who assist in the education and training of VI (visually impaired) individuals, and spent long hours shadowing fourteen VI individuals and some of their family members. The teams, through this initial research came to understand the magnitude of the population affected by visual impairments, the support services and organizations in place in Canada, and specifically in the province of Ontario, and the nature of the different eye conditions. Research also provided insight into the daily life and personal concerns of the wide range of people affected by visual disabilities. This led to an investigation of coping methods such as instruction in orientation and mobility and dependence on other senses for feedback. The teams identified specific "tools" used to assist in daily activities, sensor and feedback technologies used to enhance daily activities, and popular products already in use.

The industrial design students also developed a range of user personas by compiling their research into simple scenarios or stories to illustrate daily experiences. These scenarios highlighted the opportunities for personal wellbeing and for task specific interventions. They indicated a need for products that are easy and intuitive to use, increase social interaction and decrease social isolation, simplify everyday tasks, optimize use of remaining vision, are affordable for low-income individuals, and reduce the stigma associated with adaptive aids.

The students put together a list of design opportunities for devices that users had identified for situations such as: assisting in dark and nighttime environments, aiding in public transportation, easing travel in poor weather conditions, supporting independent travel abroad and in unknown environments, providing information for way finding and identification, identifying the status of safety signals, warning about obstacles on route, providing orientation data, location and heading, allowing for independent shopping, and organizing home activities.

After prioritizing the information, and assessing the availability of users and experts to provide feedback throughout the design development process the students undertook a number of design projects including: *Auditory Companion*, a navigation aid for visually impaired adults; *Connexions*, a 3D musical puzzle for visually impaired elementary school children, *Tactile Mahjong* for visually impaired seniors, and *Soundwave*, an audio instruction mat for the visually impaired.

Concept development progressed through the standard design phases of ideation, preliminary design development of ergonomic and usability models, user testing and feedback, iterative design detailing, and final concept presentations. Along the way, reviews were held with instructors, users, members of the CNIB and designers at Humanware, an international company with offices in Montreal who develop and market a range of assistive devices for the disabled.

4. Challenges and Opportunities in Research and Design for the Visually Impaired

The project concepts developed during this class were well received by the CNIB and clearly of interest to the visually impaired user community, but the class was over and the concept prototypes, although convincing, were far from production ready. This had been a worthwhile experience for all participants but we couldn't help but speculate whether or not there might be a better way to carry this initiative forward.

The preliminary project helped establish a good working relationship with the visually impaired community. The results of the project in conjunction with further research have helped us identify the primary challenges and opportunities for future research, design and development. The project has also enabled us to map out a longer-term strategy for working with this specialty population that can be broken down into three major categories—technical, social, and logistical—with recommendations for further action.

Technical Challenges and Opportunities

1: The Nature and Scope of Visual Impairment

It was evident from these studies that the majority of 'sighted' people we spoke with assume that the white cane implies that an individual cannot see at all. In contrast our preliminary research identified a range of vision impairments with different effects on sight. Part of the process of understanding how to design assistive technology (AT) devices for people who are visually impaired must involve an understanding in the types of visual impairment that exist. Frebel, for example, defines the three main types of visual impairment as cerebral, cortical and cognitive, noting that confusing these types can lead to a misdiagnosis of a person's abilities, particularly if they are young children [5 p. 117]. In particular, children with cerebral visual impairment might only be able to see objects that are in motion, leading the child to either be unable to do stationary tasks (thus being mislabeled 'retarded' in their development) or to move around a worksheet to read it (thus being mislabeled as hyperactive) [5 p. 118]. Accordingly Frebel goes on to recommend the use of classification models that consider vision used in everyday life situations, such as that created by Hyvarinen [5, 8].

Recommendation: Developing a greater understanding of these differences will allow for a wider range of design opportunities targeting specific vision disabilities particularly as they relate to everyday life.

2: Leveraging Other Senses

It also became apparent during these studies that there is a significant opportunity for the visually impaired population to learn to cope with their impairment by focusing on their other senses such as hearing, touch, memory, and smell. In parallel, there also appears to be an opportunity for designers to learn how the visually impaired currently use other senses to navigate and to leverage this knowledge to extend those capabilities through the design and development of new multi-sensory assistive devices.

As types of visual impairment vary, so too do means of getting around in one's environment when visually impaired. In a recent study in England, Gardiner and Perkins use qualitative exploratory fieldwork to observe how 16 visually impaired people navigate around 2 wooded parks [6 p. 84]. Sound was the primary means for fixing locations, such as noting the outside of the park by traffic sounds or noting the deadening of bird calls in a forest area [6 p. 85]. Objects that made a constant sound (such as a river) could be judged for distance within 20 yards; while changes in surface conditions (inclines or the presence of concrete paths) would be interpreted as "gritty" or "slight rises" [6 pp. 86-89]. The results suggest that vision is not the only requirement to understand space, but touch, smell and sound as well, and that "visually impaired people need information about space beyond their immediate vicinity, to use in conjunction with their understanding of nearby environments." [6 p. 89].

At the same time, there is a limit to the amount of perceptual information that a person can glean from their environment. In their study of 12 sighted and 7 visually impaired individuals, Gustafson-Pearce et al. determined that visually impaired people had significantly more problem identifying items across all environments, particularly if there was interference of other sounds over ambient sounds in the environment [6 p. 28]. This means that designing interfaces that use sound to communicate information might prove to be more of a distraction than a helpful assistant, depending on how the person responds to verbal information.

These same studies suggest the use of tactile maps could be of great use to persons who are visually impaired, provided that the map in question takes into account the need for multiple sensory surveys [6 pp. 90-1]. In fact, the design of tactile maps highlights another problem with trying to design products for those who are visually impaired; most designers (and researchers of the visually impaired) have their sight, and it becomes a difficult process to 'defamiliarize' one's self with the commonsense notions of how things are perceived by others [2].

Recommendation: The challenge is to determine which senses to augment and which combinations of sensory augmentation techniques and technologies are appropriate for which tasks.

3: (AT) Devices for Everyday Needs
Based on the initial research for the student projects we discovered many sighted people assume visual impairment also limits mental and physical capabilities that seem to have narrowed down the types of assistive products that are developed. For example, if there is an assumption that a visually impaired person would not have the ability to do aerobic exercise, then it would limit the focus on the design of assistive products that might help provide significant health benefits.

Recommendation: The opportunity to involve visually impaired users in the design process from the initial research stages could balance the tendency to make assumptions and open the door to new creative opportunities for assistive devices.

4: (AT) Devices to Support Social Interaction
There are two user populations where research in this area is important. Young children with VI impairments are separated from "normal" children and need disability specific training and there are very few products that help integrate these children into other social relationships. At the other end of the spectrum, seniors who have slowly become more visually impaired can often no longer interact with family, friends, and colleagues as they did in the past. This problem is often accompanied by cognitive impairments, underlining the need for easy to learn, easy to use products to make it possible to maintain interaction with others.

Recommendation: There is an opportunity for designers to focus on the design of products that will enhance interaction between visually impaired people and "normally sighted people."

Social Challenges and Opportunities
5: Information Support Systems
In Canada, visually impaired individuals receive government subsidies to purchase assistive equipment/devices. In Ottawa, the Assistive Devices Program (ADP) provides a 75% discount on products for the visually impaired once every five years. Discussions with the visually impaired indicate that this requires them to prioritize their needs, and even then, in some cases, subsidized products, such as the Jordy at $5283 are still unaffordable. If a person purchases a product that they discover is not appropriate after several months of use, no further subsidy will be available for five years and it becomes difficult to purchase another expensive device that might be more suitable.

Recommendation: There appears to be limited information or perhaps more correctly limited access to information to support the appropriate selection of assistive technology. It would therefore be useful to clearly identify and validate the appropriate market fit for any new assistive devices.

6: Leveraging the Social Support Network
The social support network for the visually impaired community has an active interest in contributing to the development of affordable products for the challenges of daily living. The experience of the students and faculty was that the CNIB and other VI organizations were exceptionally committed to supporting the projects in any way they could.

Recommendation: It would be of significant benefit to engage the support community in the research, design and development process to strengthen their involvement and understanding of the contribution of the design community.

Logistical Challenges and Opportunities:

7: Interdisciplinary Collaboration

Given the complexity and interrelated multidisciplinary nature of the factors we need to contend with in working with the visually impaired, all research and design in this field will necessitate interdisciplinary collaboration at some level. Some of the primary fields involved include psychology, physiology, engineering, rehabilitation medicine and industrial design. It is evident from the experience of past student projects and reinforced by research literature in many of these fields that interdisciplinary collaboration can be complicated by differences in disciplinary methods and differences in desired outcomes. In addition at the operational level of a student project, for example, differences in deliverables for students from different disciplines can be a source of friction that may jeopardize overall project goals.

Recommendations: It would be of significant benefit to create the infrastructure to coordinate and manage projects of this nature to help ensure continuity in goals and objectives as well as continuity of development over time.

8: Common Language

As with most interdisciplinary initiatives language, jargon and acronyms specific to each discipline tend to complicate communication and collaboration. When you begin to actively involve the user community in the research, design and development process the issues of language and use of terminology become even more apparent. It is not uncommon for terminology in one field to mean something very different in another which at times can lead to serious misunderstanding. In order for interdisciplinary collaboration to work well, a shared language is needed to help connect the designer and user and share their experiences [3; 9; 13; 21; 22].

Recommendations: Although there is no readily apparent means to resolve this issue, publicly accessible documentation, explanation, and dissemination of common terminology and related reference materials would be a good starting point.

9: New Design Metrics

Designers are trained to be highly visually literate and imbue physical solutions to users' challenges with visually sophisticated cues. What is the perception of an aesthetically pleasing design to a vision-impaired individual? What is the equivalent for sounds (earcons), or vibrations (vibracons), or for smells (?).

In order to work effectively with the visually impaired community it will be necessary for designers to address the inability of current visual-centric design research methods to appropriately and adequately address and communicate the concerns and constraints of visual impairment that have led to failure of many previous product solutions.

Pape et al. [10 p. 13] suggest that for assistive technology to be considered "functional" it has to allow the person to complete a daily task within what they consider to be a 'reasonable' time frame, and it can't consume too much physical or mental energy in its use. Scherer goes a step further and suggests that in order to meet a person's needs or expectations, we need to consider the fact that people will select AT (assistive technology) based on how well they satisfy needs and preferences followed by attractiveness and ease of use/appeal [19 p. 3].

Recommendation: There is an opportunity to redefine the design metrics used to evaluate the success of new products for the visually impaired community. As Scherer suggests we must learn to measure the success of assistive devices not in terms of the technology but rather in terms of the person's needs, desires and goals; because all of this design, is, of course, to help the person do what they want to do, first and foremost.

10: New Design Research Methods

Based on the design research methods used for the student projects it became apparent we did not have a thorough understanding of the range of needs of the user population nor a full understanding of how they currently use existing assistive devices. Traditional ethnographic design research techniques often refer to the need to identify previously missed subtle insights into the [user] behavior. However, in the case of a visually impaired user this is not so obvious. The visually impaired person is often highly cognizant of his or her behaviors to accommodate for the impairment. For example, while visually impaired users escorted students through their own home environments they noted the importance of having each "landmark" in place. They also explained to students the necessity of order and organization, so for example canned goods are placed directly in cupboards in the area designated for each type of food- vegetables, fruits, soups, etc. and cans were marked with elastic bands to identify contents before being shelved in the home.

These issues point to the need for new design research methods to provide a more informed understanding of the context of use, needs, wants and desires of the visually impaired. One of the better ways to do this involves the use of participatory design which calls for involvement of end-users as "co-creators" in the design of products to better match their perceived needs [17, p. 30]. In this type of situation participatory design has several advantages, including engaging the user, sensitivity to the user community, and the potential to provide insights into how and why products are received and used as they are. Participatory design engages the user because, from the beginning, the user is part of the design process, and that engagement reflects the need to actively solve problems, because design, by its very nature, is about "thinking, deciding and solving problems" through the construction of plans for complex objects [16: 69-70]. This approach also supports the realization that people tend to work as 'everyday designers', by modifying existing designs to suit their purposes [23 p. 277; 24 p.1]. By engaging the user you expand the range of inputs that will facilitate the design of appropriate systems that fit the user's real needs, drawing on their tacit knowledge of work tasks [4] and individual needs [7] as well as their perceptual model of how the device should function [12 pp. 39-40].

Recommendation: Expanding the repertoire of design research tools to include participatory design methods would help designers build a more informed understanding of the context of use as well as a better understanding of the wants and needs of the user community which in turn will lead to the design of more effective assistive devices.

11. Continuity
The class was over and the concept prototypes, although convincing, were far from production ready. This had been a worthwhile experience for all participants but we couldn't help but speculate whether or not there might be a better way to carry this initiative forward. How could we transfer the knowledge gained during this project in a way that would support continuity and ongoing development?

Recommendation: This particular point underscores the need to establish the infrastructure to support a long-term relationship to build and maintain continuity if there is a real expectation to contribute to the visually impaired community in a significant and meaningful way in the long run.

5. A Research and Design Strategy for Working with the Visually Impaired

Based on this investigation we have begun to build the infrastructure to support an ongoing research and development initiative to work in collaboration with the visually impaired community. There are five facets to the proposed program that have already been put in place and/or are well underway.

1. The Design Research Centre
The cornerstone of the project is the rejuvenation of the Design Research Centre within the School of Industrial Design to manage ongoing sponsored research, design and development initiatives. The Design Research Center was established in the early days of the Industrial Design Program by the founding director of the School, Wim Gilles, with the intent to foster and support ventures of this nature. The function of the Design Research Centre will be to establish the research agenda for the School; manage and support ongoing research projects; and actively pursue research funding on an ongoing basis. In the long-term we hope to be able to add dedicated research staff to the Centre funded through

ongoing research activities. The Design Research Centre will be critical to maintain continuity in working with the visually impaired community.

2. Faculty Research Initiatives
The goal of the faculty research initiatives is to develop long-term research and development projects that will typically run for a duration of one to five years. A preliminary research grant submission prepared in tandem with this paper to investigate and develop new design methods for working with the visually impaired community is currently under review and we anticipate notification of the grant competition results in the fall of 2007. We are also reviewing other possible opportunities to collaborate with the visually impaired community.

3. Grad Curriculum Initiatives
The School of Industrial Design is in the final stages of establishing a new graduate program (MDes) that will be key component of our strategy to initiate and support an ongoing design research agenda. The new graduate program is focused on interdisciplinary design development and we anticipate the program will be up and running for the fall of 2007. The graduate program will support medium-term research and advanced design applications that will typically run for a duration of one to two years. It is our intent to integrate collaborative research initiatives with the visually impaired community into the new curriculum.

4. Undergrad Curriculum Initiatives
The School of Industrial Design already has a well-established undergraduate program that conducts sponsored design projects with both industry and not-for-profit organizations. The undergraduate program supports short-term applied projects that typically run for a duration of one semester or less. As previously noted we already have established an ongoing working relationship between our undergraduate program and the visually impaired community.

5. Interactive Products and Sensor Lab
The School of Industrial Design has received funding for and is currently in the process of setting up a new Interactive Products and Sensor Lab which will have the resources to provide technical support for ongoing initiatives to design develop and prototype multi-sensory assistive devices for new applications in working with the visually impaired community.

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