MASTER'S THESIS \ **WRITTEN RESEARCH**

Those among us who are able-bodied can no longer rationalize treating physically-disabled people as 'them,' an alien minority.

- Ray Lifchez, Architect

INTRODUCTION

Although research has been conducted regarding the effective translation of visual maps into tactile equivalents, it is very difficult for blind and visually-impaired students to find adequate mapping solutions. Most often, tactile maps produced for the blind are simple translations of visual navigation systems, designed from a sighted person's perspective and given a tactile interface. But what if tactile maps were translated from a blind user's point-of-reference? How would they be different? Exactly what design modifications could be employed to improve existing ones?

According to the World Health Organization, there exists worldwide almost 150 million people with a significant visual disability and approximately 30 million people who are blind. In the United States alone, there are roughly 10 million people who are either legally blind or visually-impaired to the point that they have trouble seeing even with corrective lenses. With an increasing number of people falling into these categories – think of all the aging baby boomers – designers will be presented with a very specific set of challenges to design for. Challenges that are rarely considered when designing for sighted people.(Evamy, 9)

How can designers prepare themselves for these unique challenges? What tools can they add to their repertoire to help them provide timely and innovative solutions? Enter participatory and universal design.

PARTICIPATORY DESIGN

On July 13, 1999, ABC's Nightline aired a segment about IDEO, a silicon-valley based industrial design firm renowned for its innovative approach to design. Challenged by ABC to redesign an old, familiar, everyday item – the shopping cart – they agreed. With an incredible deadline of only five days, they set about to completely rehaul the ubiquitous shopping cart, creating a new product based on firsthand feedback gleaned from users themselves as they walked the aisles of Palo Alto grocery stores, with IDEO researchers not far behind.

Designing with the help of users is the driving success behind IDEO's methodologies; methodologies that fit neatly into the realm of what Scandinavian researchers coined "participatory design" in the 1970s and 80s. Motivated by a strong Marxist undercurrrent which fostered workplace democracy and workforce empowerment, participatory design is described as a research methodology that:

Attempts to examine the tacit, invisible aspects of human activity; assumes that these aspects can be productively and ethically examined through design partnerships with participants, partnerships in which researcher-designers and participants cooperatively design artifacts, workflow, and work environments; and argues that this partnership must be conducted iteratively so that researcher-designers and participants can develop and refine their understanding of the activity. The result of the research typically consists of designed artifacts, work arrangements, or work environments.(Spinuzzi, 2)

How It Works

Historically, Scandinavian work in participatory design focused on union-sponsored work environments and systems, looking closely at direct interactions between users and designers. American efforts, however, have been based more heavily on passive observation and artifact analysis. In addition, particpatory design methodologies have spread to other disciplines, most notably human-computer interaction (HCI) and industrial design.(Spinuzzi, p.2)

In practice, participatory design takes place via the following three stages:

Stage 01. Initial Exploration

This first stage involves an in-depth look at the workflow and processes involved in the relevant task(s). The designers meet with the users, learning as much as possible through interviews and analyses about the routines, collaborations, technologies, taskflows, etc. related to the work/task.

Stage 02. Discovery

In this stage, designers and users work to understand and prioritize work/task flow organization. Designers use this information to clarify users needs and goals and then formulate definite outcomes for a specific project/problem.

Stage 03: Prototyping
This final stage involves designers and users iteratively creating low and/or hi-fi prototypes, based on the data and insight gleaned from the first two stages.

Participatory design is a non-linear process; each of these three steps can be iterated several times and in varying orders up until the final set of specs has been determined and the production phase begun.

UNIVERSAL DESIGN
According to Ron Mace, founder of the Center for Universal Design at NCSU (North Carolina State University), universal design is “the design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design.”

Its history starts way before there was any legislation enacted for those with disabilities. At the beginning of the 20th century, the average lifespan was only 47 years and those living with disabilites were a true minority; institutionalized and, for the most part, segregated from mainstream society.[NCSU]

Today, over 100 years later, things are much different. Due mainly to public health and medical advances, the average life expectancy has increased to 76 years, with the quality of these added years being much better than those lucky enough to have survived this long in the past.

According to a 1998 article in the *Denver Post* on aging, nearly 80% of the population lives past the age of 65. Consequently, there are more people living with disabilities. Two World Wars and a multitude of regional political struggles have produced a large population of disabled persons. In addition, vaccines, modern medical innovations, and increased safety measures have enabled humans to survive diseases and accidents that historically would have proven fatal.

Along with these dramatic demographic changes has come increased public awareness toward the disabled and their full integration into everyday mainstream life; primarily in the last three decades via legislation, design movements, and advances in rehabilitation engineering and assistive technologies.

Legislation
Inspired by the Civil Rights movement of the 1960s, the Disability Rights Movement greatly influenced related legislation of the 70s, 80s, and 90s. In 1961, the federal organization that is now known as ANSI (American National Standards Institute) published the first accessibility standard: “Making Buildings Accessible to and Usable by the Physically Handicapped.” A great leap forward for the disabled, but unenforceable unless mandated by state or local legislation.

This spawned some of the major laws that currently govern accessibility today:

1968 - *The Architectural Barriers Act* which required all federally-funded buildings to meet certain accessibility guidelines.

1973 - *Section 504 of the Rehabilitation Act* was the first civil rights law for people with disabilities, outlawing discrimination on the basis of disability.

1975 - *The Education for Handicapped Children Act* guaranteed a free and effective education for all children with disabilities.

1988 - *The Fair Housing Amendments Act* required accessible units be created in all new multi-family housing with four or more units, both federally-funded and private residences.

1990- *ADA (Americans with Disabilities Act)* an all-encompassing legislation, this bill created heightened public awarness surrounding the civil rights of the disabled. It prohibits discrimination in employment, and provides access to public places, services, programs, transportation, and telecommunications.

1996 - *The Telecommunications Act* requires that telecommunications services and equipment be

fully accessible and functional by disabled persons.

As a result of these legislative measures and the rise in an aged and increasingly disabled population, social attitudes towards those with disabilities has changed for the better. Historically, disabled persons were part of an insignifcant, silent minority, shunned for their physical differences. Today, however, whether a person is blind, deaf, or wheel-chair bound, the opportunities for education and employment are much better than they were even 50 years ago.[NCSU] In addition, the business world has recognized the needs of people with disabilities, resulting in innovative products on the marketplace.

For example, OXO International was started when founder Sam Farber asked a few simple questions: Why do ordinary kitchen tools hurt your hands? Why can’t there be wonderfully comfortable tools that are easy to use? His wife’s crippling arthritis was the impetus for these questions:

Seeing an opportunity to help not only people with arthritis but also to create more comfortable kitchen tools for everyone to use, Sam came out of retirement and approached the design firm Smart Design with that challenge. As part of the initial research that included talking with consumers, chefs and retailers, Patricia Moore, a noted gerontologist, was brought on board to help understand the needs of users with special needs.

After hundreds of models, dozens of design iterations, and extensive manufacturing research, OXO was born. In 1990, the first group of 15 OXO Good Grips kitchen tools[Fig.1-3] *was introduced to the U.S. market. These ergonomically- designed, transgenerational tools set a new standard for the industry and raised the bar of consumer expectation for comfort and performance.*[OXO]

Other companies, such as GE and Kohler, are also developing innovative products that adhere to the principles of universal design.

Fig. 1. OXO Good Grips® Indoor Pour & Store Watering Can

Fig. 2. OXO Good Grips® Swivel Scissors

Fig. 3. OXO Good Grips® 16oz Rip Claw Hammer

WHY FOCUS ON DESIGNING FOR THE BLIND?

I first experienced life around blind people when I was about 11 years old. Steve Benson, my mother's fiancée before she died in 1974, played a subtle yet pivotal role in my life for about ten years after her death. A philosophy professor at Fort Lewis College in Durango, Colorado when he and my mother met in the late 60s, he assumed a paternal role for me while they were together, and continued this role after she was gone. A few years later, he married Patty, a middle-aged woman suffering from multiple sclerosis, a disease which rendered her blind in her early twenties. During the five or so consecutive summers I spent with Steve and Patty during the late 70s/early 80s, I experienced first-hand the intimate details of living with a blind person. I can clearly remember hot summer days spent in the artificial, air-conditioned coolness of the Colorado state library for the blind, helping Patty find reading material; she preferred books on tape to Braille (as someone who had gone blind later her in life, her sense of touch would never be as sensitive as someone blind from birth). I remember the blind stares that she met the world with, and how she would turn her whole head to "look" at you, her eyes trailing to focus, stopping almost centered on the right object, but not quite. Generally, though, only those who knew her well saw her without her dark glasses. When out in public, her eyes were always behind a concealing black shade.

I can also remember Patty trying to get lunch ready, padding through the kitchen, feeling her way around the countertops and over the stove to the refrigerator, where more tactile exploration would ensue until she found what she needed. I observed with a deep fascination, always amazed at her ability to adapt and improvise for her lack of vision.

Being only an adolescent at the time, my observations also included small ways in which I could take advantage of Patty's blindness. For example, there were some afternoons when I was expected to take a nap. Or, at minimum, lay quietly and read for an hour or two, but no TV. Well, not wanting to either read or sleep, I would sneak watching TV with the sound barely audible. Patty would come downstairs to check on me and I would always hear her coming; the distinctive shuffle of her feet and cane as she found her way to the staircase; the swishing as her hand felt across and down the wall of the stairwell in order to help guide her foot placement as she descended. I unashamedly took advantage of the situation; watching TV even as she came within inches of me, making sure I was "asleep" as far as her four remaining senses could detect.

It didn't surprise me, then, to find my interest piqued when talking to Dr. Melody Ivory about the University of Washington's tactile graphics project. I met her at a professional meeting during the spring of 2005; she needed research assistants and I was looking for a way to make contacts in different departments on campus. Her research group, u b i t (Universal Benefit for Information Technology) was working jointly with the Computer Science department, developing software to help translate information graphics and images from science and math textbooks into tactile graphics for the blind, ensuring universal access to disciplines historically elusive for the visually-impaired. They also conducted empirical studies of tactual perceptions to aid in the development of resources to assist transcribers with creation of effective tactile graphics. Through the course of my work with u b i t, I was inspired and decided to explore how good design benefits the blind for my Master's thesis.

I can see and that is why I can be happy. In what you call the dark, but which to me is golden.

- Helen Keller

FIELD RESEARCH

In considering how to design for the blind, the most important aspect of my research focused on the human-centered perspective; I needed to put myself in the shoes of blind users. In order to understand the perceptions of someone lacking vision, I first needed to understand physical perception from a sighted perspective.

Visual Perception

One of the biggest surprises during my research was discovering how humans learn to see. I had always naively assumed that if a blind person were miraculously restored his vision, he would simply open his eyes and view the world the way someone sighted from birth does. This is not true. Like language, vision – or more specifically, visual perception – is a learned skill that takes years to develop and contains a window of opportunity best suited for acquisition. If visual perception isn't developed by a certain age due to physiological failure of the eyes, the opportunities for crucial nerve connections to form in the brain are forever lost.

A case in point is a man referred to in a 2003 *Nature Neuroscience* article as "MM". Blind from the age of three, MM underwent a stem cell transplant forty years later, regaining his sight. However, although he could see with his normally functioning eyes, his brain could not perceive what he saw since he had never developed the cognitive capacity for visual perception.

He has incredible difficulty identifying complex shapes (like most objects that we encounter in day-to-day life) and faces. By far the most difficult tasks for MM involve three-dimensional interpretation of his environment. When an image is projected onto the retina, it is two dimensional, because the retina is essentially flat. When we are very young, our brains learn to use depth cues, such as shadows and line perspective, to see the three-dimensional world. Eventually, incorporating these cues into a coherent picture of the world becomes involuntary.

Our ability to judge size correctly is one example of the brain's reinterpretation of two-dimensonal images. When a person walks away from us, the image of her becomes smaller and smaller on our retina. We know that people do not actually shrink as they move away, however. The brain combines the shrinking retinal image with perspective and depth cues from the surroundings, and we "decide" that the person is moving away.

When MM lost his sight when he was three years old, his brain probably had not yet constructed the connections that incorporate separate perceptions into one combined perception. When a person walks away from MM, he has to remind himself that the person is not actually shrinking in size! MM's difficulties with three-dimensional interpretations are also obvious from his explanations of drawings.(Chudler)

For MM, a two-dimensional rendering of a three-dimensional was seen as a "square with lines".(Fig.4) He also had trouble with overlapped images, describing the overlapping area of two transparent squares as a separate shape in and of itself; three separate images presented side-by-side instead of two layered ones.(Fig.5)

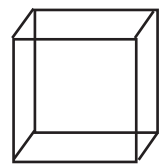

Fig. 4

Fig. 5

Because MM had lost his sight at such a young age, he had missed a critical period of cognitive development during which the brain most effectively forms the neural connections that connect retinal images with practical experience.

During this critical period for the visual cortex, normal visual input is required to wire everything correctly. If input is missing during this period, the brain's links will probably not be built correctly. In fact, brain tissue ordinarily used in visual processing might even be taken over by other systems, perhaps tactile or olfactory systems.(Chudler)

For MM, these other systems, honed in the absence of vision, are often his preferred methods of gaining information about his environment. An avid blind skiier with the help of an oral guide, MM found that skiing with sight was a very different, frightening experience. With trees, snow, slopes, and people whizzing past

– images that for him are mostly indecipherable – he finds it difficult to process such a barrage of visual information. When he wants to ski at peak performance, he closes his eyes.

And Virgil, another blind man who regained his sight after cataract surgery, also prefers experiencing his world by non-visual means, as recounted by one of his physicians:

"Exploring [the statue] swiftly and minutely with his hands, he had an air of assurance that he had never shown when examining anything by sight. It came to me – perhaps it came to all of us at this moment – how skillful and self-sufficient he had been as a blind man, how naturally and easily he had experienced his world with his hands, and how much we were now, so to speak, pushing him against the grain: demanding that he renounce all that came easily to him, that he sense the world in a way incredibly difficult for him, and alien." (Chudler)

Ecological Perception and the Tactile

The crux of this thesis is based on the observations of Virgil's doctor. In creating products for the blind, it is essential that designers try to understand the perspective of a blind user and design accordingly, rather than force on them a product originally designed for the sighted.

In his innovative work on visual perception, James Gibson provides interesting starting points from which to understand a blind person's perspective. He proposed that visual perception is a product of our ecological surroundings. His theory emphasizes the ground on which a living being moves on or around as the basis for perception; we know where we are based on our relationship to the ground and related environmental surfaces at any given moment. The ground consists of different surfaces, varying in postion and distance. Examples of texture elements include pebbles, grains of sand, and blades of grass. While not identical in textured surface, they are similar in spacing and regularity and will present consistently over varying samples. Textured surfaces can surround objects such as those attached to the ground; i.e., rocks and plants, or detached, mobile objects, such as people and animals. Like ground surfaces, these object surfaces also present textures. Both are immersed in a medium; namely water or air. In order to effectively describe this environment, Gibson suggests that we need a geometric paradigm that uses textures and surfaces as its reference points. (Bruce, 302)

In terms of the tactile point-of-reference from which blind people experience the world, Gibson's proposals are very compelling, despite the fact that his research was focused solely on visual perception.

Helen Keller, the renowned blind and deaf scholar, made this observation, echoing Gibson's assertions when describing her own tactile, texture-rich world:

Remember that you, dependent on your sight, do not realize how many things are tangible. All palpable things are mobile or rigid, solid or liquid, big or small, warm or cold, and these qualities are variously modified. The hardness of the rock is to the hardness of wood what a man's deep bass is to a woman's voice when it is low." (Keller, 11)

NAVIGATING BLIND: ORIENTATION & MOBILITY

In researching this topic with the intention of gaining as much insight as possible into a blind person's perspective, I met with Mark Dixon from the Washington State Department of Services for the Blind (WSDSB). Mark introduced me to Mell Toy and Mary Lorenz, both O&M (Orientation & Mobility) Specialists for the state organization. Their primary job is to help the blind and visually-impaired with navigating and wayfinding; basically, how to get around independently so they don't have to rely on sighted people in order to be mobile. Realizing immediately the wealth of knowledge and resources they could provide for my work, I asked Mell if I could accompany someone on one of their O&M sessions. She said yes, so I jumped at the chance. In February, I accompanied Mary Lorenz and one of her students for on O&M lesson.

Since I was just an observer of this lesson, the first thing Mary told me was how important it was to always follow a few feet behind her student, Syd. This would ensure that I remained out of his direct line of hearing, obviously an extremely important sense in the absence of sight.

Syd was fitted with "sleep shades"; in his case, opaque, black sunglasses to completely block out his vision. In his 40s, Syd is an engineer suffering from Retinitis Pigmentosa, a rare, hereditary eye disease in which the light-sensitive retina slowly and progressively degenerates, eventually resulting in total blindness. Symptoms start with poor night vision that becomes increasingly worse accompanied by a decreasing field of vision. (Evamy, 45)

When I met Syd, he was in the later stages of the disease and told me that on good days, his remaining vision was like looking at the world through a hole the diameter of a drinking straw. Like many blind people, his visual capacity varied from day to day. Eventually, though, even this small window of vision would close for him. And for this reason, he was required to wear the night shades during his O&M lessons. Of all the five senses, sight is the dominant source for information. Humans rely on this sense more than any other. Mary didn't want Syd relying on any remaining sight he had, since he would eventually lose that as well; hence, the shades.

Syd's O&M lesson on this particular day included navigating the streets of Columbia City's main business district, just a few blocks away from the WSDSB. Mary started out by telling him where she wanted him to go: a butcher store on Rainier Ave, a landmark of sorts, one that had been in the neighborhood for years. To my fascination, she proceeded to give him detailed information about the architecture of the building façade, focusing mainly on the entryway and the door, explaining in minute detail the texture and shape of the doorknob at the store's main entrance. For a sighted person, this informaion would be relatively meaningless, dwarfed by the prevailing visual cues that we would otherwise rely on for information: e.g., signs and address numbers.

What is interesting to note about textures from Gibson's writings is that, when experienced tactually, they are what they are. There is no chance for optical illusion. For example, the glass panes that Mary described to Syd as identifying factors of the butcher shop can be that and nothing else to the touch. From a visual perspective, however, there is room for error. If the glass is clear enough, it may appear invisible. How many stories exist of people walking through screen or patio doors because they were unable to visually detect a barrier surface? This logically leads to a philosophical question. Is a world experienced solely through touch and sound more "real" than a visually perceived world, given the fact that our eyes often play tricks on us?

As we started out, Mary told me that Syd was actually well acquainted with the neighborhood and she didn't anticipate his finding the butcher shop to be a problem. He was at the end of his training and was familiar with the neighborhood, having navigated around Columbia City many times before.

We left the WSDSB and headed east on Alaska Street toward Rainier Avenue. Syd was doing well and walked with a tremendous amount of confidence, something I didn't really appreciate until I went through an O&M lesson myself. Things got a little more complicated, though, once we turned onto Rainier Avenue and the traffic got heavier. When the blind navigate, especially in an urban area, hearing is very important in determining the direction and proximity of traffic. As we approached intersections and crosswalks, Mary was also a few steps behind Syd. She maintained this position throughout the lesson, only offering direction or stopping to help Syd if he were in direct physical danger.

The butcher shop was only a couple of blocks from the intersection of Alaska Street and Rainier Avenue. Syd walked right past it, realizing after walking half a block longer that he had probably missed it. Mary didn't say a word. Syd then found his way into another shop, feeling his way along the side of the building to find the door. He went in and asked directions, came back out and started walking in the wrong direction, heading south down the street instead of north toward the butcher shop. We followed him, Mary again not saying a word. We went another two blocks. Again, Syd realized he wasn't going the right way. He stopped and asked for directions again, this time with better results. We headed north again, finally coming to the butcher shop. Mary congratulated Syd on finding the place, then we headed back to the WSDSB.

When we came to an intersection on the way back, Syd had trouble crossing the street. First of all, most traffic controls are not placed at standard positions near crosswalks. As a blind person, once you realize you're at a crosswalk via tactile bumps or variations in the concrete texture at your feet, you then need to find the traffic controls to activate the crosswalk signal. Since locations vary, this becomes more complicated for the blind than it should be. Secondly, crosswalks contain ramps for disability access. Unfortunately, they're designed at a 45-degree angle from the intersection into the crosswalk. For the blind, this acts as a physical affordance which will project them directly into the middle of traffic if they're not consciously aware of veering slightly to the left or right as they step off the sidewalk into the crosswalk. And while they would be able to detect this error by sound eventually, the information provided via our ears in terms of location is not as precise or immediate as the same information gleaned visually. By the time they realized they were headed for the intersection, it could be too late.

My second experience with orientation and mobility took a more personal, hands-on note. On Wednesday, March 22nd, I spent the day at the WSDSB going through some of their orientation classes for newly blind people. Granted, I am not "newly blind" and part of me felt like an imposter. Sure, I could see absolutely nothing wearing my black sleep shades, but at any given moment I could take those shades off, immediately regaining full vision and all the benefits that come with it. I won't even try to fool anyone here, least of all myself, into thinking that because of my experience wearing sleep shades for a few hours and dancing with a cane, that I really know what it's like to be blind.

When I got to the WSDSB offices at around 10:00 a.m., the woman at the counter recognized my name immediately. I guess I'd been there enough times to have gained a little notoriety. Most of the people I ve talked to there are intrigued with the work I Rm doing; I get a universal sense of gratitude when I explain that my main goal is to raise awareness through visual communication about the obstacles and challenges that blind people face.

She called for Mary Lorenz lthe O&M specialist who going to be working with me until noon. Mary is fully sighted, although she does wear glasses. She was Syd instructor, with whom I had already gone on an O&M lesson with. This time, however, I was the "newly blind . It was me she was going to show how to navigate a sightless world.

Our lesson started out with Mary asking a few more questions about my thesis and what exactly it was that I wanted to accomplish via that day O&M lesson. We chatted a bit and then headed down the hall to pick out a white cane.

According to the American Council of the Blind (ACB), blind people weren always easily recognized by this universal symbol:

For centuries, the "cane" was used merely as a tool for travel and it was not until the twentieth century that the cane, as we know it today, was promoted for use by the blind as a symbol to alert others to the fact that an individual was blind.

This new role for the white cane had its origins in the decades between the two World Wars, beginning in Europe and then spreading to North America. James Biggs of Bristol claimed to have invented the white cane in 1921. After an accident claimed his sight, the artist had to readjust to his environment. Feeling threatened by increased motor vehicle traffic around his home, Biggs decided to paint his walking stick white to make himself more visible to motorists.

It was not however until ten years later the white cane established its presence in society. In February 1931, Guilly d'Herbemont launched a scheme for a national white stick movement for blind people in France. The campaign was reported in British newspapers leading to a similar scheme being sponsored by rotary clubs throughout the United Kingdom. In May 1931 the BBC suggested in its radio broadcasts that blind individuals might be provided with a white stick, which would become universally recognized as a symbol indicating that somebody was blind or visually impaired. In North America the introduction of the white cane

has been attributed to the Lion's Clubs International. In 1930, a Lion's Club member watched as a blind man attempted to make his way across a busy street using a black cane. With the realization that the black cane was barely visible to motorists, the Lion's Club decided to paint the cane white to increase its visibility to oncoming motorists.(Fig. 6) *In 1931, the Lion's Club International began a national program promoting the use of white canes for persons who are blind Throughout the 1920s and 1930s, blind persons had walked with their canes held diagonally in a fixed position, and the role of the white cane took on a symbolic role as an identifier. But when the blind veterans of World War II returned to America, the form and the use of the white cane was further altered in an attempt to help return veterans to participatory lifestyles at home. Doctor Richard Hoover developed the "long cane" or "Hoover" method of cane travel. These white canes are designed to be used as mobility devices and returned the cane to its original role as a tool for mobility, but maintained the symbolic role as an identifier of blind independence. During this period, the white cane began to make its way into government policy as a symbol for the blind.* (Strong)

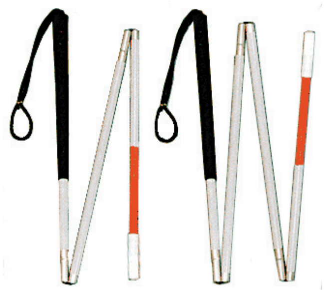

Fig. 6. A foldable, standard white cane.

The white cane I was fitted with was long because of my height. Standing in front of a metal cabinet, Mary opened the door to reveal a multitude of white, red-tipped canes. She eyeballed a few, trying to find one that would work for someone standing almost six-feet tall. I felt for a moment when she held a cane up to my armpits that I was at a ski lodge, being judiciously measured for skis and poles. Shorter skis mean you go slower. This law of physics also applied to white canes, apparently. Having too short a cane would actually slow a blind person down and potentially place them in danger.

When she'd found a cane that looked like it fit me well, Mary started explaining how the handle of most white canes are the same ones manufactured for golf clubs. "Ergonomically and tactually, they just work well," she explained. She then proceeded to point out the flat side of the handle, asking me whether I was right or left-handed. Having discovered that, she then physically showed me how to correctly hold the cane so that the thumb of my right hand rested on the flat side of the handle. We proceeded out to the hallway where I donned my own sleep shades, black cloth eye shades that fit around my head via two elastic bands, rather than the glasses that Syd wore.

With a band of material that fit snugly around the curves of my nose, my vision was completely blocked, save for a small patch of soft light – about the size of a BB – that would sometimes present itself depending which way I moved my head.

With my vision obliterated and armed with my white cane, I was ready to start my first O&M lesson. Standing at one end of a long hallway (approximately 100-feet long), Mary started out by showing me how to hold the cane properly.

In addition to keeping the handle in the correct position, you also have to be aware of where you're holding the cane in relationship to the rest of your body. It should be held toward your center with your arm extended. I found later on that doing this is a lot easier said than done and it takes a lot more concentration to do it right than you might think.

Next, Mary demonstrated ideal rhythm and movement for optimal cane performance. Having observed blind people using canes before, it looks a lot easier than it actually is. In fact, mastering correct usage of a white cane is much more of a choreographed affair than I had ever imagined. First, it's important to hold the handle in the correct position. Second, you have to always be aware of your ambulatory cadence and rhythm. Mary explained how important it is to sweep with the cane to the opposite side of the foot you're stepping forward with; the purpose being to clear the left side of the path while stepping forward with the right foot in order to make sure it's clear for the left foot in advance, and vice-versa. This proved to be more difficult than anticipated, although after about an hour of walking up and down the halls and sidewalks, I started to get the hang of it.

The third most important aspect of correct cane form is clearance. While some people prefer to sweep directly across the floor, keeping the tip of the cane in direct contact with the ground surface at all times, most blind users will tap the cane on the floor; once on the right side, once on the left. This is an effective way to navigate, provided you don't swing the cane into too much of an arc while traversing the middle. Initially, I did just that. Mary had to correct me a few times, making sure that my cane tip was never more than an inch or so above the ground surface.

Mary began the lesson by focusing on one of these issues at a time; first she watched my cadence. When I had that sufficiently mastered, she focused on my hand and arm position until those were satisfactory. Lastly, she made sure I wasn't swinging the cane too high or wide.

In the process of being blindfolded and learning how to use a cane, there were interesting things happening to my existing senses. First, I noticed that my sense of balance was off. Without my vision, I no longer had perspective and depth perception cues. The visual signs and signals that normally indicate whether or not a body is standing upright and perpendicular to the ground weren't available to me. Instead, my body was relying completely on my inner ear functions to determine equilibrium.

Second, my auditory perception was immediately heightened. Since hearing was now my dominant sense, noises seemed amplified to me. Standing in the hallway, I paid a lot of attention to not just the normal sounds – people's voices, footsteps, brushing of clothes – but to the echos that each of these sounds made. Since echos are directly related to the distance of objects from walls and each other, this became an important way to tell which direction people and physical objects were located and/or moving, especially in subtle terms.
Sound also became an important wayfinding device, kind of like Hansel and Gretl's crumbs left in the forest. When Mary and I moved upstairs because the hallway downstairs became too congested, she explained to me that when a person is blind, they measure distances in units of time, while also paying attention to recurring audible cues. For example, when navigating the upper hallway (I did both of them repeatedly, going back and forth numerous times), I knew I was getting toward the end of the space after a certain amount of time had passed, and, more importantly, after I had passed the receptionist's desk which gave off "receptionist sounds", e.g., phone conversations, keyboarding, mouse clicking, etc. Ground surface textures also played a factor. There was a rug at the end of the hall and I knew that when I felt its edge with the tip of my cane that it was time to turn around. In addition, I also became somewhat aware of the "feel" of openings such as doors and hallways.

The final step for my lesson with Mary was to go outside and try my newfound navigation skills there. Due to my inexperience navigating without sight, she decided to keep me close to the WSDSB, just walking around the block onto one of the residential streets. With a more experienced traveler, she would have asked them to find a place along Ranier Avenue, one of the main arterials close to the center.

In theory, you would think that navigating outside would entail the same issues as navigating inside, but that's far from the actual experience. Once outdoors, the guiding aspects provided by the walls and their accompanying echos were gone. In their place were traffic hazards, other pedestrians not used to encountering blind people, and uneven and varied ground surface textures; "terrain features", as we'll explore more in the next section.

The treatment of disabled persons defines the innermost characteristics of a society and highlights the cultural values that sustain it.

- Leandro Despouy, UN Commission on Human Rights

DESIGN**RECOMMENDATIONS**

FINDINGS

Toward a more practical endpoint, the reason for these detailed observations and in-depth research was to make improvements to the University of Washington's tactile maps from a haptic point-of-reference. Existing tactile maps were almost exclusively designed based on the visual, sight-based originals, with little consideration given to the actual needs of users whose perception of the world is based on a totally different paradigm; a world dominated by sound and texture rather than image. The end result of this research leads to the following conclusions about designing wayfinding tools for the blind, most of which have already been determined and recommended by institutions with a long history of experience with and research of blind users.

According to the American Foundation for the Blind, and reinforced by research done for this thesis, tactile maps should be designed according to the following seven guidelines: (Blasch, 295-304)

Size – Tactile maps should be approximately the size of two outstretched hand widths. The hands are a blind persons "eyes", so to speak; this size encompasses their "field of vision".

While interviewing Lindsay Yazzolino, a 17-year old blind high school student, about the UW tactile maps, she noted how large they are: "This would be like taking six posters off my wall every time I needed to find my way around." (Yazzolino)

Simplicity – Include only information that is absolutely necessary. Too many lines and textures on one page are hard to sense haptically, creating confusion and information overload.

Blind subjects I interviewed noted that the UW tactile maps were hard to read based on the excessive amount of information presented all at once. The printing method used (a Tiger Embosser) also made things harder to read, mainly due to the production of poor line quality. Ideally, tactile maps would be produced via thermoform printing methods, i.e., forms embossed on paper via heat.

Content – Include environmental features not commonly found on visual maps that are essential information for a blind traveler: slope, changes in ground surface texture, physical obstacles, stairs, intersections and traffic controls.

In Gibson's writings, he explains various "terrain features", classifying them by affordances. For example:

A brink, the edge of a cliff, is a very significant terrain feature. It is a falling place. It affords injury and therefore needs to be perceived by a pedestrian animal. The edge is dangerous, the the near surface is safe. Thus, there is a principle fo the control of locomotion that involves what I will call the edge of danger and a gradient of danger, that is, the closer to the brink, the greater the danger. This principle is very general.

A step, or stepping-off place, differs from a brink in size, relative to the size of the animal. It thus affords pedestrian locomotion. A stairway, a layout of adjacent steps affords both descent and ascent. Note that a stairway consists of convex edges and concave corners alternating, in the nomenclature here employed.

A slope, is a terrain feature that may or may not afford pedestrian locomotion, depending on its angle from the surface of the level ground and its texture. A ramp with low inclination can be negotiated; a cliff face with high inclination cannot. (Gibson)

While these "terrain features" are presented with enough warning via a visual perspective to prevent disaster, when experienced tactually, detection of these obstacles – and avoidance if necessary – is much riskier. Consequently, these and other obstacles that are avoided or encountered easily by sighted people need to be clearly represented on tactile maps in a way that is easily accessible to the blind.

Scale – Indicate absolute scale, using it consistently.

Absolute scale, which is readily scalable, aids the blind user in creating and maintaining direct relations between objects and locations on a map.

Symbols – Symbols used to denote information should be distinct and as haptically varied as possible to ensure readability.

Layers – Use overlays and underlays to add labels and simplify information. The user places one hand on the overlay and the other on the page below to read related information.

In interviews conducted for this research, more than one blind student mentioned how useful they thought it would be if tactile maps were designed in a multi-page format, more like an atlas.

Grids – Include grids so users can easily locate specific points on the map in relation to one another. These can be included on overlays or underlays.

Like absolute scale, the use of grids help to keep the user orientated based on the relationships of their position and surroundings.

CONCLUSION

In Donald Norman's book *The Design of Everyday Things*, he talks about the "seven stages of action" and how these should be one of the driving forces for designers to consider when creating new products. He lists them as:

1. Forming the goal
2. Forming the intention
3. Specifying an action
4. Executing the action
5. Perceiving the state of the world
6. Interpreting the state of the world
7. Evaluating the outcome (Norman, 48)

He also talks about mental models; e.g., the mind's representation of real or imaginary situations and how important is is for designers to understand the implications of the vast variations in users' thought processes and ways of thinking.

In terms of navigating the physical environment, the first three of Norman's seven actions are universal: deciding that you're going to go somewhere for a certain reason, deciding how you're going to get there, and then going. It's the next two actions that have the potential to drastically influence the design process, especially in terms of designing for the blind. As presented here, the tactile and audible experiences of the blind are much richer than those of a sighted person. Knowing this, designers need to then ask themselves, how does this affect the product I'm designing? What factors should I be considering that I didn't previously have to, now that I know my client's "field of vision" isn't hundreds, sometimes thousands of feet like my own, but rather the mere five- to six-foot span that reaches from one hand to the other?

Design is a very powerful tool, and as those wielding this tool most often, designers have a unique responsibility to truly understand and inhabit the world of their users, and then use this knowledge and the power of good design to enhance this world.

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