An Insight into Designing for Disabilities

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Most designers think of the web only as a graphical or visual medium. This type of thinking and design alienates a large number of users who may be disabled. Designers of interfaces and other systems must understand that good design not only encompasses how information is displayed but also how the information may be interpreted by someone who has a vision, hearing, learning or physical disability; it is the role of the designer to make applications accessible. For this to happen it is important that designers understand the disabled audience, HCI design principles, the importance of information design techniques and the future of computing.

There are two fundamental groups of disabled users: those who have suddenly become disabled, and those who have gradually become disabled, such as the elderly. Both groups share a lot of the same challenges but go about completing tasks in different ways based on their mental models. Because mental models are developed through behavior and repetition, the mental models of someone who has gradually become disabled may be different than someone who has suddenly become disabled or always been disabled.

Those who have become disabled over time have most likely formed some mental models based on their experiences as an able bodied individual. A user who has been disabled from birth might have a completely different mental model because they have never experienced something from an able-bodied person's view. When designing interactive systems for this audience the use of metaphors that match real world systems may not be as effective as they would for users who have become disabled over time. However, having no previous mental model allows the designer a chance to create a new interactive system that may be different and better than anything pre-existing. Many times it is difficult for people to learn new things or new skills because they have preconceived ideas regarding the difficulty or even the underlying purpose of such skill. For example, having no knowledge about how an old system worked, could make is easier on an individual learning about the new system because that individual is starting from a clean slate, without being bogged down from previous experiences. They have no pre-existing mental model to compete or compare.

With the ever-growing number of baby boomers the disabled user is going to make up more of the population. According to the U.S. Census Bureau the number of Americans age 55 and older will almost double between now and 2030. This is an increase from 60 million today to 107.6 million. Furthermore, the Center for Disease Control states that 19% of people over the age of 70 have visual impairments and 33% of people age 70 and over have some sort of hearing problems. Because of this, it's important that interactive applications are designed for an ever-changing user. Users are constantly changing in age, physical ability and mental ability. However, most applications remain static, not compensating for these changes. For those with learning disabilities, applications could be built with minimal functionality, adding more

advanced features over time as the user learns the system. This would allow the user to personalize the application and because there would be fewer functions to learn, the user would also benefit from easier learnability. For the visually impaired, font sizes should be easy to change and information should always be available separate from the presentation to be easily translatable by an audio interpreter or other device.

Lee-Anne Harrison and Peter Robinson stated the following, "Consequently, many design approaches for allowing accessibility by members of either group focus on their disabilities. However, the principal concern for a designer should be physical capabilities, irrespective of cause." In many cases the disabled person learns to use their abilities in ways that the able bodied person does not. A study done by Professor Franco Lepore, Director of the Centre for Research in Neuropsychology and Cognition at the University Montreal, has discovered that people who are blind are better able to hear and localize sound. Realizing this ability allows designers to create applications that use sound for localization, system status and interaction cues.

Fredrik Winberg from the Center for User-Oriented IT Design of Stockholm Sweden and John Bowers from the School of Music at the University of East Anglia developed a game that was to be played by both the blind and able bodied simultaneously. The game provided a consistent experience to both users and focused on the blind user's ability to hear and localize sounds. The game "Towers of Hanoi" consisted of three poles and a number of donut shaped rings of various sizes that fit through the poles. The goal was for the user to move the rings from the far left pole to the far right pole and always stack the rings from largest to smallest. To do this, a tone was generated for each ring with the larger ring getting the deepest tone. A ring's position within the pole was given by the length of the tone generated. For example, a ring that sat above all other rings at the top of a pole would generate a shorter tone than the ring at the bottom. This allowed the user to sonically compare the sizes and vertical locations of the rings. The user could tell where the poles where positioned by a tone generated from the left, right or both speakers for the center pole. There was no part of the game that did not have an audio trigger associated with it.

During the testing of this game, two users were to play at the same time taking turns moving the rings. The sighted user was given only the graphical game with no sounds and the blind user was to rely on only sound. Thus, there was no overlap in the way the user interacted with the game. The two user sat 90 degrees apart from each other with the blind user wearing headphones. It should also be noted that both of the users mouse controlled the same pointer. Thus, if they both moved the mouse at the same time the pointer would move in an unattended way. To gather results three pairs of users were tested and all had some previous knowledge of the game.

From the testing it was discovered that the users would talk aloud to each other to describe their moves and what they were experiencing. By doing this they were communicating to the other user person their understanding of their move and the game. In doing this the actions of one party seemed to be consequential to the other user's next move. During conversation the sited person referred to the towers as 1, 2 and 3 while the blind person referred to them as left, center and right. Even though both persons were playing the same game they communicated about it differently based on how they were experiencing it.

Problems did occur with the blind user when too much time was taken between moves. When this occurred the blind users became disoriented with his position in the game. As a result it would take more time for the blind

user to become oriented again. Problems also occurred when both users would move the mouse at the same time. When this occurred it would either result in the sighted user confirming the blind users move and then making the blind users move. Or cause the blind person to be extremely confused as to what was happening. During the testing every group successfully completed the game and three principles were confirmed. All things that can be done by a sighted user should also be able to be accomplished by a blind user. For effective collaboration the interfaces should also be consistent between each user and each user should be able to manipulate the interface in the same way. According to Mynatt and Weber "If mutually coherent visual and non-visual interfaces are made available, cooperation is thus ensured." This can be accomplished through the use of sound, tactile and other multi modal displays.

Focusing on the user's strengths and sonic cues allowed the designers to build a complex game that delivered a consistent experience to both the disabled and able bodied. The U.S. Census Bureau, states that there are currently 21.3 million people that have a condition that affects their ability to work at a job or business. This group of people accounts for 11.9 percent of the people working between the ages of 16 and 64.

Consistency within an application is also important in the formation of mental models. Depending on the user's disability and experiences, they might not have a fully developed mental model of how an application is expected to function. Any unsuspected changes in consistency within an application can cause the development of the user's mental model to slow down. This break in consistency makes it harder for the user to predict where an item may appear. This can lead to frustration, causing the user's confidence level to drop and as a result begin questioning their every action with the system. By displaying items consistently, it maximizes efficiency, increases learnability, and helps the user better predict their actions.

The way the information is received from the source and displayed on the page is very important. If the information is received in a format that is not accessible then it is hard if not impossible to make it accessible. Information that uses acronyms may be very hard for screen readers to interpret. In most cases instead of reading the acronym the screen reader will interpret the acronym as a word and try to make sense of it. The amount of information that is given to the user is also important. An over abundance of information can be hard on the elderly or learning disabled who have attention problems or learning problems. It’s important that the amount of information be kept to a minimum and is written in a non-technical straight-forward way. Simeon Keates from the University of Cambridge, states, "The design of the interface for maximum user understanding and minimum cognitive load is an essential component of the successful development of a truly usable and accessible product."

Once the information has been received in an accessible format it must then be displayed in a format that is accessible to all users. For example, when buying tickets to a concert, a map of the stadium is usually shown with the seating selection highlighted within the map. Although this makes sense to users with good sight its vital that we think of how this information might be interpreted by a blind user. A better way to display this information might be by using sound. A tone could be generated from a central area, which would be the stage and as the user moved the mouse over the different sections of the theater a tone would be sounded that could be compared to the existing tone emulating from the stage. For instance, when moving the mouse over the rear left section of an auditorium a tone would be generated from the left speaker at a much lower volume than the constant tone coming from the center of the stereo sound.

This would help the blind user understand that their seating is in the back left section of the auditorium. This would also allow the same visual design to be given to both the visually disabled and person with perfect eye-sight. Both groups of people would share the same user experience with a different but specific solution adapted for each.

Using sound for voice assistance can be an important tool for the elderly. Voice assistance can help users build mental models or even learn to use an application without the existence of a mental model. The people at the Speech Project at Oxford Brookes University developed a web browser for the visually impaired that utilized a system called “voice help”. The assistance of “voice help” provided the user with spoken word as to where they were in the application and what actions they could perform at any given point. Through the testing of this application they found that older adults who used “voice help” were able to successfully use the web where they had been unable to before. They also discovered that "Each user's personal confidence increased markedly following a particularly successful interaction, and decreased following a disaster." For an elderly user this type of voice assistance helps keep their attention on the application, allows for them to understand where they are in a process and better helps them predict what might be the outcome of their actions. If the user becomes frustrated and the application makes them feel less confident in their abilities the chances of them using this application again or on a regular basis are slim.

Information should be stored in a way that is independent from the presentation. By doing this, the information is made more accessible to different technologies including audio, visual and tactile. One way of doing this is to use style sheets which are used to control font faces, colors and layout. This makes it easier for a screen reader to interpret the information because there are no presentation control data within the content information. This also allows for the information to be displayed in a text only format that could be transformed into Braille.

Information should be available in multiple formats. This gives both the able bodied user and the disabled user freedom in how they want to receive the information. For example, having a video track with a separate audio track allows a blind user to select only the audio track. This also allows for a faster download which may be beneficial to an able bodied user who does not have a high bandwidth connection to the internet. Having a video with a separate transcript allows a hearing impaired user to download the video and then read along with the transcript. The transcript allows a person who is looking for a quote or specific information to easily search through the document. Having multiple forms of the same information benefits both the able and disabled users.

In the future more accessible interfaces will be designed with the growth of ubiquitous computing and the goal of universal usability. According to Dr. Mark Weiser, Chief Technologist at the Palo Alto Research Center, "Ubiquitous computing is the third wave in computing, that is just now beginning. First were mainframes, each shared by lots of people. Now we are in the personal computing era, person and machine staring uneasily at each other across the desktop. Next comes ubiquitous computing, or the age of calm technology, when technology recedes into the background of our lives." This third stage can already be seen with the expansive coverage of wireless broadband networks and the growth of PDA's, Cellular telephones and other personal communication devices. It is during this stage that universal usability and its objective to make technology universally available both globally and accessibly becomes incredibly important. Those who support universal usability are focused on maximizing the number

of users that a product is accessible to by designing for a user base that is as broad as possible.

With the growth of ubiquitous computing and universal usability the designer might be, by default, designing for the disabled. This is because designing for disabilities and designing for multiple technology devices that can be used in many different environments share a lot of the same challenges. For example, when creating an application that will be used on a cell phone or PDA one may come across the same challenges as creating an interface for someone who has restricted physical abilities or is in a rural area with bandwidth limitations. When designing an application that may be used while driving a car one encounters the same challenges as designing an application for someone who is visually impaired. And when designing an application that might be used in a loud environment the designer must take into consideration the same issues as when designing for someone who is deaf. The solutions that are needed to solve these problems are common to the solutions needed for designing for users with disabilities. In the age of ubiquitous computing the designer should be thinking of these technologies and the challenges that are posed.

With the growth of the baby boomers, ubiquitous computing and the concept of universal usability, designing applications that are accessible will become even more important. Businesses will have to recognize that a greater portion of their audience is disabled, and it will be the role of the designer to make sure that these users are not disenfranchised. Through the use of sound, multimodal display and information design, designers can create innovative applications that are accessible and consistent to both able and disabled users.

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