INDIVIDUAL DIFFICULTIES FACED BY PERSONS WITH MOBILITY IMPAIRMENTS

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ABSTRACT

Disabled persons are experiencing additional difficulties when interacting with systems, applications or devices and also have their own unique requirements that enable them to use a system. If the design of the system does not support these requirements, people with disabilities will experience obstacles that may prevent them from interacting effectively with a system. This paper reports on our experience with designing an adaptive web portal that can be used by people with a variety of impairments. We highlight the fact that designing a system that is usable by people with various disabilities, and various severities of a specific disability, is not a trivial task. We specifically focus on design guidelines that were highlighted by participants with mobility or motion impairments during a usability evaluation to show that even within a fairly homogeneous group, several individual differences will exist that may influence the design of adaptive systems.

KEYWORDS

Usability, accessibility, evaluation, mobility impairments

1. INTRODUCTION

In these modern times computers and technology form an integral part of everyday life and everyone should be able to participate in or benefit from the vast amount of resources and opportunities that technology offer. People with disabilities are faced with several barriers when using technology and adapt their interaction with technology through the use of assistive devices and creating their own unique way to interact with the system. If the design of the system does not support their unique requirements, people with disabilities will face many difficulties when interacting with such a system. *Universal design* or *Design for All*'s goal is to address the problem of excluding people with disabilities from using systems, application and devices by designing products, communication and the environment in such a way that they are usable by as many people as possible [Choi, 2006; Gregor, 2002]. In theory universal design seems like the perfect solution. However, in practice this is not so easy to achieve. Each person with a disability has his/her own way of interacting with ICT devices and even prefers to use different assistive devices, depending on their computer literacy and the severity of their disability. Therefore the question arises: how should universal design be applied to optimally design ICT solutions for the wider population?

Although the portal was evaluated by participants with a variety of disabilities, in this paper we only focus on participants with mobility or motion impairments, i.e. a limitation in mobility or a loss or limitation of function in muscle control and/or movement. We describe the results of a usability evaluation involving quadriplegics and present design guidelines that were highlighted by the participants.

2. RELATED WORK

All four participants that took part in our study were quadriplegics, with different reasons why they became disabled. In order to understand the challenges faced by people with disabilities using systems or applications, we need to know and understand what capabilities such a person has [Kotzé, 2005]. Therefore, we have to investigate the requirements, status and available technology to assist these persons in their interaction with computer devices. Much research has been done on the evaluation of new assistive devices or technology for people with disabilities [Bhatia, 2006; Hwang, 2001; Rotard, 2005]. However, less research has been done on how people with disabilities interact with a system and the problems they experience in doing so. People with disabilities often find the standard keyboard and mouse difficult to use, often make unintentional input errors, and therefore make use of assistive devices, such as alternative keyboards.Some users with mobility impairments use binary signals generated by a physical switch, EMG sensor or tongue switch [Trewin, 2006].

In resent years several guidelines were produced on how to design systems that are usable and accessible [Caldwell, 2006; Chrisholm, 1999; Jacobs, 2002]. However, these guidelines do not necessarily guarantee that the end product will be optimal for the usage of persons with disabilities [Jhangiani, 2006; Polk, 2000], as illustrated in the results of our study.

3. NAP PORTAL

The National Accessibility Portal (NAP) is a web-based content management platform that provides a participatory information repository for content and communication services relevant to various disabilities [CSIR, 2007]. The interface was designed according to the W3C Web Content Accessibility Guidelines version 1.0 [Chrisholm, 1999] using style sheets for the general layout, different text sizes and various contrast options. The user has the option of selecting one of three text sizes and one of three colour combinations/contrasts, namely black text on a white background (default display), white text on a black background, and yellow text on a blue background. This functionality was added to enable users to customize text size and colour contrast according to their preferences. The portal was designed with screen readers in mind and tested with Canoo [Webtest, 2007], an automated testing environment for web applications, and Bobby [Watchfire, 2007], an application that tests the accessibility of the system, before the usability and accessibility evaluation took place.

4. EVALUATING THE NAP PORTAL

In this section we discuss the evaluation process followed,. We highlight how volunteers were recruited and how the evaluation was executed.

- **Recruitment**: The required participant profiles were identified and volunteers recruited accordingly using the mailing lists of the NAP project and various communities within the disability domain.
- **Evaluation**: The evaluation of the NAP Portal was done in a static usability laboratory at the University of South Africa (UNISA) and on-site at the Meraka Institute using a portable usability lab, also provided by UNISA.
- **Briefing**: To ensure ethical practice, the guidelines provided by the Human Sciences Research Council (HSRC) of South Africa [Scholes, 2007] were followed. The briefing included the goal of the portal, the goal of the usability test, the process to be followed, as well as the intended use of the results. The participants then had the option whether or not to sign the appropriate form of consent, or opt out of the evaluation. An important lesson learned was that it is crucial to check with the participant whether s/he requires the consent of her/his parent or guardian before participating in the evaluation of the project, even if the participant is older than 21. One of the participants in our study became quite agitated when the consent form was explained to him. Because he had difficulty communicating verbally, he could not easily express the fact that his mother was his guardian and should sign the consent form (although she was aware of the fact that he will be taking part in the study, she did not sign the consent form and legally we could therefore not continue with the evaluation until she did so).
- **Tasks**: The participants were asked to complete a predefined set of tasks representing what the system would typically be used for. The usability evaluation measured the typical user's performance on these tasks. The participants were given one task at a time, and only after they have completed the task, the next task was discussed. The participants' interactions with the system were recorded for later analysis. Any

obvious problems were noted down immediately and many errors were identified very early on and occurred throughout, although several were only highlighted by individuals.

- **Questionnaire**: After the completion of the tasks, the participants answered a questionnaire on their experiences with the system, giving insight into their comments with regards to the portal's look and feel, navigating the portal, locating specific information on the portal, executing tasks, using the portal with their assistive devices, and the usefulness of the portal.

5. EVALUATION RESULTS

Table 1 highlights the demographic profiles of the four participants (any information that might identify the participants have been removed).

Table 1. Demographic profiles of the four participants that have mobility impairments

	Participant A	**Participant B**	**Participant C**	**Participant D**
Gender	Male	Male	Female	Male
Age	36	30	48	46
First language	Afrikaans	English	Afrikaans	English
Employed?	No	Yes	Yes	Yes
Working sector	Private small business	ICT	Academia	Aviation
Computer literacy	Standard everyday use – home computer user	Advanced	Advanced	Advanced
Disability	Mobility impairment (quadriplegic – Frederik's Ataxia), speech impairment)	Mobility impairment (quadriplegic - Physical cerebral palsy, speech impairment)	Mobility impairment (quadriplegic – spinal cord injury). Feeling in palms of both hands, but not in fingers	Mobility impairment (quadriplegic – spinal cord injury). Has feeling in palms of both hands and one finger on left hand
Assistive devices	Standard mouse and keyboard, alternative communications (AAC) device – Pathfinder [Prentrom, 2007]	Smart NAV NaturalPoint, 2007], switch, on- screen keyboard, AAC device – Powerbox [Sensory, 2007]	Flat soft keyboard and wireless mouse. Type with knuckle of thumb. Use sticky keys to enable typing with one hand.	Standard keyboard and mouse. Type with pen and one finger on left hand.

We briefly outline the main issues, noted during the evaluation or highlighted by the participants, below.

5.1 Participant A

- **Navigating the portal**: Was unaware of the accessibility options (such as sticky keys) available under MS Windows and how to use them ([Kotzé, 2005] found that this was the case with many people with disabilities). When he used the mouse, his mouse clicks were too slow, resulting (erroneously) in another window opening that contained the selected information. This is frustrating when browsing the portal, since new windows are opened every time a link is selected with the mouse. Normally he uses Ctrl- and Alt-keys when navigating computer software. However, when we activated the sticky keys with Microsoft Windows XP's accessibility options, the mouse did not function properly anymore when navigating the portal. Therefore, participant A found it very difficult to navigate and use the portal, took extremely long to complete a task, and became frustrated with the system, even though he was very interested in what the portal could offer him. He gave up after two tasks because it was too tiring.
- **Searching**: The field for the search keywords were not activated when he selected the search option and he first had to click in the text field to activate it before entering the keywords. This was a general problem for all, but others with better motor control, did not highlight this as a problem.
- **Layout**: Missed this option to increase the text size entirely although it was available on most of the screens he visited. He felt that the option to do this was not sufficiently described to indicate that the user of the system can adjust the text size of the information on the portal. He also pointed out that he would prefer to have a help option that is clearly visible, where he can get more information on how to use and

navigate the portal. This absence of the help option is a serious shortcoming, identified by all the participants over all the disabilities that evaluated the portal.

5.2 Participant B

- **Navigating the portal:** Although he used assistive devices, he is a very experienced computer user who has mastered his equipment skilfully. He experienced the portal as easy to use, easy to navigate and neither easy nor difficult to find specific information by browsing the portal.
- **Executing tasks:** Very easy to execute and complete the given tasks. Completed tasks in a very short time, since he is a very experienced computer user. He still had problems to select textboxes or radio-buttons and had to try many times before he was able to pinpoint the target with his head mouse and select them.
- **Enjoyment:** The look and feel of the pages was good. Would be interested in visiting the portal again to find information applicable to people with disabilities. Rated his overall level of dis- or satisfaction with the portal as being very satisfied due to the current and planned level of available information on the portal.
- **Shortcomings:** The lack of a 'select all' option when he had to choose checkboxes during the registration process or when submitting content to the portal, is a big shortcoming. This issue was also identified by all the other participants, except for Participant A.
- **What he wish changed or improved:** Increase the target area of radio-buttons and check boxes so that it is possible to make a selection without having to click directly on the circle, or small target. As his mobility impairment makes it difficult to select the radio button with precision, it leads to occasions where he had to try five or more times before he could select the radio button of his choice.

5.3 Participant C

- **Assistive devices:** Typical to spinal cord injuries, she had very little feeling in her hands and lower arms, with some feeling in the palm of her hands. She types by using the thumb knuckle of her left hand and move the mouse using both hands making a selection by applying pressure with the side of her hand.
- **Browsing the portal:** Identified many usability problems, or potential problems, in the portal by just browsing the portal, including the choice of colour combinations, the fact that the content does not fill the screen, long scrolling windows with options at the bottom that are missed by the users, unclear terminology (e.g. the difference between training and education), illogical order of options when using the tab keys, the absence of breadcrumb links on many pages (forcing the user to use the browser's Back button to retrace steps), etc. She completed all the tasks without our intervention during her browsing session and we did not intervene. The only task she did not complete was to 'Register' and to 'Log in'. She questioned the reason, when we asked her to do so: it is definitely not clear why a user has to do so and what the difference between the two options is (see Participant D below).
- **Overall comments:** Commented that the portal does not seem to have been tested extensively with users not involved with the development of the project, but saw it as making a huge contribution to the disabled community if it succeeds.

5.4 Participant D

- **Assistive devices and navigating the portal:** Apart from feeling in the palms of his hands, he also had feeling in one finger on his left hand. He typed using a pen in his right hand and the finger in his left hand and did not use sticky keys. He browsed the portal using techniques he learned for web browsing in the past.
- **Executing the tasks:** Found it easy to execute the different tasks and completed almost all the tasks during his browsing, apart from registering and logging onto the portal. Found some of the terminology confusing, such as the difference between education and training and what information to expect under each of these services. Some technical terms were also confusing to him and would be equally so to other users. The pages where a user can upload content were almost unusable (using too much technical jargon)

as it was unclear and confusing what information to enter in the various fields – almost all the other users we tested made a comment about this. Identified other usability issues related to text entry field formats, such a requited fields, 'select all' option. One interesting problem occurred when the previous participant didn't log out of the system and not allowing him (as new user) to do so. This may cause problems in computer centers where many users will make use of the same computer and must be addressed.

- **Enjoyment:** Look and feel of the pages was good and he would be interested in visiting the portal, since it contains invaluable information for persons with disabilities and their organizations.

5.5 Individual needs

Although participants A and B have similar grades of disability and used similar assistive devices, they had very different experiences on an individual level with the system. The main distinguishing factor was their *level of computer literacy* and the level of *advancement of their assistive devices*. The head mouse of Participant B enabled smaller physical motor movements than the standard mouse used by Participant A. In terms of design, Participant A requires a very elementary and simple design, with as little information as possible and large buttons. For Participant B complexity is not an issue, but the size of the selection area of radio-buttons and text boxes should be larger than standard due to the fact that fine motor control is problematic for him. Participants C and D differed from Participants A and B in that they could both speak and did not have to use special communication devices, only assistive interaction devices. For them the portal was much easier to use and they focused more on the content and functionality problems than on the interaction problems highlighted by Participants A and B.

It is clear that one cannot use a 'one-design-fits-all' attitude when designing a system for people with mobility impairments. Each person's impairments have a different severity and accordingly s/he uses different assistive devices and communication devices to access the system. One should keep in mind to 'design for all', as well as 'for the individual'. Comparing the experiences of only these four users, we would conclude that it will be very difficult to design a single website that will be suitable for a variety of users, and that the only alternative would be a variety of customizable options.

6. COMMON GUIDELINES IDENTIFIED

From the first-level evaluation results a few common guidelines can be already be extracted that should be kept in mind when designing for people with disabilities:

- When there is a choice of a few check boxes, there should be a check box to select all options. This is in fact a universal design option that would benefit all users.
- When radio-buttons are used, the selection area should be resizable to a large size so that the user can select the radio-button with more ease. It is important to remember that users with mobility impairments struggle to move the mouse or cursor with precision.
- When the user has to fill in any form, the first field should automatically be activated. This reduces the effort of the user to first select the field before s/he can start to enter his/her input.
- It should be very clear, in simple terms, using no technical jargon, what the meaning of various text fields are. A 'Help' option with more information will also aid in better understanding.
- Confusing terminology should be removed or amended, for example the difference between 'training' and 'education', 'login' and 'register', 'physical disability' is not the same 'as mobility' or 'motion' disability as visual and hearing impairments are also physical disabilities, etc.

Although it is almost impossible to keep all the various requirements of users in mind when designing a system, taking the above mentioned issues, highlighted by the participants themselves, into account will already improve a system immensely, making it easier to use by people with motion impairments.

7. CONCLUSION

The W3C Web Content Accessibility Guidelines version 1.0 was followed in the design of the portal, but did not guarantee the usability of the portal. The issues around terminology is addressed in the W3C Web Content Accessibility Guidelines version 1.0 under Guideline 14.1, where it is recommended to use the clearest and simplest language that is appropriate for the site's content. However, the best terminology is not trivial to identify. The problems that the participants experienced with selecting radio-buttons or text boxes are not addressed by guidelines in either the W3C Web Content Accessibility Guidelines version 1.0 [Chrisholm, 1999] or version 2.0 [Caldwell, 2006].

From our results it was clear that when designing for people with different disabilities, one design cannot fit all. A better solution will be an adaptive interface that can be customized according to the user's requirements. However, designing a system that is customizable that meets the requirements of people with various disabilities and even various severities of the same disability, is an almost impossible task. Therefore we made our fist attempt in addressing this problem by suggesting guidelines that were highlighted by the participants, with mobility or motion impairments, themselves.

The portal is in the process of being revised based on some of our findings. Despite the shortcomings, all the participants in our study could see the value of the portal and indicated that they would use it again in future. We are also in the process of analyzing the data quantitatively to determine the average times for task, different paths taken to find information, frequency of errors, etc.

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