Designing Chairables: Assistive Augmentations to Support Power Wheelchair Users

Patrick Carrington
UMBC
1000 Hilltop Circle
Baltimore, MD 21250
carpat1@umbc.edu

Amy Hurst
UMBC
1000 Hilltop Circle
Baltimore, MD 21250
amyhurst@umbc.edu

Shaun K. Kane
UMBC
1000 Hilltop Circle
Baltimore, MD 21250
skane@umbc.edu

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Abstract
Emerging wheelchair-based assistive technologies could benefit from the user-centered, Inclusive Design process with wheelchair users. We have worked closely with power wheelchair users to understand their preferences regarding assistive devices. Our users preferred assistive devices that augment their existing capabilities and maintain form-factor requirements for their environments. Adhering to stricter user-centered design processes will allow the HCI community to move beyond basic technology to build systems that are both useful and desirable. In this paper we discuss our experiences designing technology for and with power wheelchair users.

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Power Wheelchair; User-Centered design; Input; Output; Accessibility; Assistive Technology; Participatory Design

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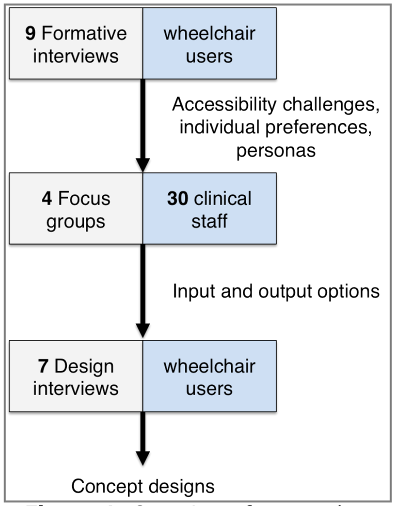

Figure 1: Overview of our study procedures. We began with initial formative interviews with power wheelchair users; followed by a series of design oriented focus group sessions with clinical staff; ending with validation of design recommendations from the focus groups with one-on-one design interviews.

Introduction

Interacting with objects in the environment while using a power wheelchair can be difficult due to motor impairments that may affect the user's hands, arms, neck, and head. Interacting with mobile devices can be especially difficult due to these factors as well as physical restrictions imposed by the wheelchair's frame. We may be able to solve these accessibility issues by designing new systems to take advantage of the physical abilities of the user, and leveraging the wheelchair's frame when designing assistive systems.

Past research has attempted to solve the problem using assistive robotics, which led to several promising systems that can handle the functional tasks of an able-bodied individual through the use of robotic arms and complex sensing. However, much of this research lacks input from users in real-world contexts. These systems are well suited to replace a missing functional ability but their potential to work with a user and effectively augment their capabilities is unclear.

As interface designers and developers of assistive technologies, we have a responsibility not only to build capable technology but also to develop effective user interfaces that enhance users' sense of their own independence. In this paper, we describe our experience designing wheelchair-based interactive systems for and with power wheelchair users.

Designing Wheelchair-Based Technology

There are several examples of intelligent wheelchairs that leverage alternative controls or operation methods for supporting mobility and navigation for people with severe mobility impairments. These solutions range from intelligent and autonomous navigation through an environment [1],[6], to control methods using gaze [7], body motions [4], and voice commands [5]. Solutions like the PerMMA system [8] have been developed to utilize robotics in order to augment the physical abilities of the wheelchair user to empower them to complete tasks using a robotic arm.

The addition of robotic arms, and other similarly high-profile solutions, to the wheelchair may exaggerate a user's dependence on them. User-centered participatory approaches can help to identify these issues during the development process. Unfortunately, many of these examples limit the involvement of users from the target demographics to proofs-of-concept and basic functional evaluations. We feel it is important to consider the social and ethical implications of using assistive technologies as these factors contribute to eventual technology adoption and use [3].

Our Research

We explored the device and interaction preferences of power wheelchair users through multiple design sessions and interviews with 13 power wheelchair users and 30 clinicians [2]. The structure of our exploration is presented in figure 1. We first conducted formative interviews and design sessions with power wheelchair users, developed design prototypes during a series of focus group style design sessions with clinicians (Figure 2) at a spinal injury rehabilitation clinic, and evaluated these design options during interviews with power wheelchair users. We then explored the placement and form factor possibilities for inputs and outputs on a power wheelchair, and finally identified preferences for designing wheelchair-based interactive systems.

Figure 2: Focus group with clinical staff. Participants designed input and output solutions for power wheelchair users based on personas. Solution components were identified on post-it notes and placed on the wheelchair in desired locations. Final solutions were discussed as the group.

Lessons from our Exploration

Our findings support the application of emerging technology to develop assistive augmentations, which we call *Chairable* [2]. Additionally, the process of conducting this exploration illuminated several considerations that might be overlooked by current design practices.

Interactive Prototypes Foster Creativity

During our design interviews, we used a Makey Makey microcontroller board to demonstrate rapid, physical prototyping of interfaces. Initially, during the formative interviews, participants only chose traditional push button interfaces and touch screens as possible inputs. To help participants think more broadly, we demonstrated several examples of other contact-based interactions, made possible by the Makey Makey board. These concrete interaction examples helped participants expand their perception of reachable areas for inputs on their wheelchairs. The demonstration also helped participants conceptualize the differences between physical interactions and the resulting output possibilities. This helped us explore form-factor possibilities since participants could focus on designing physical layouts to meet their motor abilities without worrying about the software.

Ability is Nuanced

We worked with participants to identify ways to leverage their capabilities to support interaction with information technology. During the formative interviews, participants identified under-utilized space on their wheelchairs that they believed could be used as additional storage or to mount devices. To further explore the placement possibilities and form-factor requirements we asked participants to identify all the areas on their wheelchairs that they could reach. For example, one of our interview participants has severely restricted upper body mobility. As a result, he uses an array of controls around his head to operate the driving functions of his wheelchair. During our design session, we identified a small area on his armrest that he could reliably touch with his elbow and therefore began thinking about the possibility of motion tracking and touch interfaces for that area of the wheelchair.

Device Use Impacts Other Activities

Many of the existing assistive solutions for people using power wheelchairs involve driving the wheelchair. Through our exploration of participants' technology use we identified several issues regarding mobile device use that stemmed from upper body mobility impairments and the wheelchair's frame. One common solution that has seen success for people with difficulty holding devices is to mount the device to the wheelchair however, this doesn't work for everyone. Two of the three participants in our initial design sessions had used mounts previously but had abandoned them because they got in the way when not being used and made it more difficult to move through tight spaces.

Technological Dependence is a Risk

Not surprisingly, we found that users strongly desired independence from caregivers. However, we also encountered cases where participants desired independence from technology. One participant expressed a very strong opinion about his independence:

"Without my wheelchair I probably wouldn't be able to get around but I don't think that you should just keep adding technology for the sake of technology."

He cautioned us against adding technology to do things for him and encouraged us to consider potentially negative outcomes.

"Where is the incentive for us to work harder and get better if we can just have technology do it for us? If I have the technology to do everything that I would need to walk for, I may never walk again."

The same participant also expressed concern that the addition of mounted technologies and robotic components would make him "stand out" or seem "more disabled". These valuable statements bring to light considerations that may be overlooked by designers and engineers. Involving users throughout the design process can help us maintain perspective on ethical and social issues surrounding technology use and adoption. These examples add to the challenge of developing technical solutions that assist a user while maintaining their sense of independence. Our aim should be to augment their abilities not replace them.

Conclusion

Our findings were obtained through a user-centered, participatory approach to designing interactive systems for power wheelchair users. Complex individual differences in perception and ability contribute to the challenge of designing assistive solutions. We were able to gather specific feedback from power wheelchair users regarding underused space on their wheelchairs, recommendations for how to use this space, preferred form-factors for devices, and the potential impact new technology may have on their lives. Designers and engineers can use this feedback to build future wheelchair-based interactive systems.

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