USERS' PERSPECTIVES OF INTELLIGENT POWER WHEELCHAIR USE FOR SOCIAL PARTICIPATION

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ABSTRACT

The objective of this study was to understand: (1) the current difficulties encountered by power wheelchair (PW) users and (2) potential barriers and facilitators to using an intelligent PW (IPW) for community participation, such as in a shopping mall. Twelve PW users were interviewed using a semi-structured interview guide. The main IPW features were demonstrated to the participants using a 4-minute video. Findings highlighted three main themes related to current difficulties encountered by PW users: maneuvering the PW or performing an activity in a restricted space, driving the PW in the presence of environmental barriers, and driving the PW in temporary or unforeseen circumstances. In terms of the perceived use of the IPW, participants anticipated both benefits (e.g., obstacle avoidance) and challenges (e.g., relevance of particular features and reliability of the system). These findings will inform future development of this IPW.

INTRODUCTION

Statistics Canada estimated that in 2000/2001 there were approximately 155,000 home dwelling Canadians and approximately 109,000 residing in healthcare institutions using wheelchairs as their primary means of mobility (Shields, 2004). According to the Canadian PALS Survey (Participation and Activity Limitation Survey (PALS), 2006), there were 175,180 people who used a manual wheelchair, 36,293 who used a powered wheelchair (PW), and 66,080 who used a scooter. As our population ages, the number of older Canadians living with mobility disability is expected to grow over the next 40 years. In 2002 in the United States, there were 2.7 million non-institutionalized users of wheeled mobility devices, approximately 30% of which used powered wheelchairs or scooters. This number was estimated to have risen to 3.86 million by 2009 (Flagg, 2009).

The benefits of power mobility are well documented for the elderly (Auger et al., 2010), but it has been reported that users PW are afraid to use them in crowded places (Evans, Frank, Neophytou, & de Souza, 2007), and many prescribers of these wheelchairs report that they regularly see clients who cannot use PW safely because of visual, motor and cognitive deficits (Fehr, Langbein, & Skaar, 2000; Mortenson, Clarke, & Best, 2013; Simpson, 2005). In a review of studies looking at PW that provide navigation assistance to the user, Simpson (2005) reports that such technologies could benefit people with severe motor, sensory or cognitive limitations, allowing them to carry out their everyday activities. However, few studies have involved people with disabilities in their evaluation and these types of PW have not become commercially available for use outside the lab.

A recent collaborative initiative between researchers, technicians and clinicians from the fields of computer science, engineering and rehabilitation has resulted in the creation of a prototype intelligent power wheelchair (IPW) with autonomous navigation functions which brings together robotic and artificial intelligence technologies. Built on a commercially-available PW, the proposed IPW (Figure 1), which can be controlled by a variety of interfaces (speech recognition, joystick, tactile display) and has numerous navigation sensors, can determine and follow a planned path, avoid static and dynamic obstacles, pass through doorways and in between obstacles, and follow a given object such as a wall or a person/group of people. During the development process, potential IPW users' perceptions were assessed in order ensure that the IPW corresponds to users' needs.

Figure 1: Example of the IPW navigating autonomously in a mall.

PURPOSE

The objective of this study was to understand (1) the difficulties encountered by PW users with their PW and (2) potential barriers and facilitators to using an IPW for participation in the community, such as in a shopping mall.

METHOD

Design

A qualitative exploratory study using semi-structured interviews was conducted.

Subjects

Using purposive sampling, twelve PW users were recruited from the wheelchair and seating departments of two rehabilitation centers in Montreal. Inclusion criteria were (1) using a PW in the community for at least one year, (2) being 18 years of age or older, (3) being able to express themselves in French or English, and (4) having any musculoskeletal or neurological diagnosis resulting in a long-term severe mobility limitation. Participants were excluded if (1) they had a dysarthria diagnosis and/or a hearing or vision deficit significantly limiting their ability to participate in the interviews, and (2) if they presented with emotional or psychiatric problems or cognitive disabilities that could limit their participation in the study, according to the health care professional.

Data collection and analysis

PW user participant demographics were collected. A semi-structured interview guide with open-ended questions and probes was developed for this research. The guide addressed participants' past and present uses of PW, needs and difficulties related to using their PW, as well as the perceived barriers and facilitators to using our IPW prototype. To facilitate informed discussion regarding the prototype, a four-minute explanatory video was shown to the participants demonstrating the main features of the IPW within the environment of a major shopping center in downtown Montreal (Québec, Canada). Example interview questions included asking participants to comment on the various technical capabilities of the IPW, such as obstacle avoidance, path planning, and following a person or group of people. All interviews were conducted face-to-face at the participants' residence in English or French (based on the participants' preference). Interviews were audio recorded and transcribed verbatim in the language of origin. Each interview lasted approximately 40 minutes and each participant was interviewed once.

Data collection and preliminary analysis was conducted concurrently in order to facilitate ongoing refinement of the interview guide and gather pertinent data. Each interview was analyzed for general impressions, emerging themes, and coded by at least two members of the research team using QSR NVivo 8 software. The Consortium on Assistive Technology Outcomes Research taxonomic framework (Jutai, Fuhrer, Demers, Scherer, & DeRuyter, 2005) and assistive technology adoption literature informed the data collection and analysis.

The study was approved by the Centre for Interdisciplinary Research in Rehabilitation of Greater Montreal (CRIR) Research Ethics Committee.

RESULTS

Participants

Participant demographics are presented in Table 1 (n=12). Our sample consisted of twice as many men as women with ages ranging from 22-88 years. The primary diagnoses were neurological in nature.

Table 1: Participant characteristics

PW users (n=12)		
Sex (n)	men	8
	women	4
Age (years)	mean ± SD	55 ± 21
	range (min-max)	22-88
Primary diagnosis (%)	musculoskeletal	33
	neurological	67
	• injury	8
	• degenerative	50
	• congenital	8
Duration of PW use (years)	mean ± SD	14 ± 12
	range (min-max)	3-39

Key themes regarding current PW use

With regards to current PW use and challenges, 3 main themes and 11 sub-themes emerged from the data (Table 2).

Table 2. Current challenges experienced by PW users

Theme 1: Manoeuvring PW or performing activity in a restricted space	Theme 2: Environmental barriers	Theme 3: Temporary or unforeseen circumstances
Sub-themes: • Entering/exiting • Transferring • Avoiding obstacles • Driving through a narrow space • Controlling the joystick	Sub-themes: • Static obstacles • Moving obstacles • Uneven surfaces • Lack of accessibility	Sub-themes: • Presence of extra or unforeseen obstacles • Broken equipment

In Theme 1, challenging situations are related to activities and tasks which require manoeuvring the PW in a small or restricted space, or performing an activity in such a space. Examples that the participants provided included entering, exiting or driving in relatively narrow spaces. The context of such driving activities was generally well identified, and often included spaces that were too narrow for the participants to comfortably enter or drive through, such as elevators and public washrooms. For example, it was described as "sometimes having difficulty driving through narrow store aisles so that objects don't fall off the shelves". Participants also discussed the challenge of

entering or exiting an adapted transport vehicle (taxi or van) when trying to get to a mall, a situation that can be even more difficult if another wheelchair is already present in the vehicle.

"Well I just found it difficult to manoeuvre it through like small doors, like doors that are not wide enough, that, that was very challenging, and also getting into adapted taxis. Cause sometimes there is two of you in the van, so to negotiate turns was extremely difficult when I first started because I didn't know my dimensions of my chair well enough".

Theme 2 involved driving the PW in the presence of environmental barriers. The presence of obstacles hindering the movement of the PW was identified by almost all participants. The presence of dense crowds, or of other people within a smaller space, such as elevators, was described as challenging not only due to the skill required to manoeuver the PW in such circumstances, but also because people don't always look where there going, and the added stress that one may inadvertently cause injury to someone else. Participants also described driving challenges created by static obstacles. These could require more precise manoeuvring, such as driving in stores with too many shelves or avoiding potholes; or they could limit access, such as the presence of stairs in a corridor or an elevator that may be too small for the PW.

The third theme involved situations that are unforeseen, temporary, or very circumstantial. In the words of one participant:

"I don't have so many difficulties, but when driving backwards a lot of things can happen. For example, if you have shopping bags on either side of your wheelchair. Well, sometimes you back off from an elevator and the doorway is not wide enough. And then you crush all your groceries. That has happened to me."

This theme described situations that are normally not challenging, but that become challenging due to temporary circumstances, such as driving in a store filled with extra displays that take up more space than usual, entering a crowded elevator or malfunctioning equipment such as an out-of-order automatic door system.

Key themes regarding IPW use

Two main themes emerged regarding perceived use of the IPW, namely perceived benefits of and challenges to using the IPW (Table 3).

Table 3. Perceived use of the IPW

Theme 1: Perceived benefits of using IPW	Theme 2: Perceived challenges to using IPW
Sub-themes: • Benefits to them today • Benefits to them in the future • Relevance to their activities	Sub-themes: • Not perceived as relevant for them • Perceived relevance for others • Establishing reliability

Regarding perceived benefits of the IPW, half of the participants would be interested in the wheelchair as a whole if it were available today. However, not all capabilities of the IPW were viewed in the same way. Features which were viewed as most beneficial to them today were obstacle avoidance, driving through doorways and following walls. Most participants mentioned scraping doorways and having trouble in crowds as current problems they experience with their current PW and they felt that these IPW functions could help them avoid this. One participant stated:

"*It would allow me to relax & look around instead of having to concentrate on my driving".*

Being able to follow a person or a group of people was viewed by some as beneficial as they find it hard to adjust their speed to that of the person walking next to them.

Participants' comments suggest that the technology is viewed as relevant if it coincides with their current activities. For example, the IPW could follow a group of people. However, this was only viewed as useful if the PW user participated in activities which involved groups of people. Similarly, path planning was viewed as interesting by most participants, but only a few found it relevant. It was not felt to be useful if, for example, the participant relied on a caregiver to accompany them in their activities, as the caregiver could assist them with this task. Participants did not report that it would allow them to do new activities.

Participants stated repeatedly that they would not use a technology which they did not feel was relevant for them due to their current functional level. For example, if they do not perceive that they need assistance to get through a doorway or to find their way around, they do not want to have a technology assist them with this task. However, even when not viewed as relevant for them, participants identified acquaintances who they felt would benefit from the IPW. In addition, several participants suggested that it could be relevant to them in the future should their condition deteriorate.

Participants stated they would have confidence in the IPW technology. However, several participants identified ways in which they would want to see the reliability of the IPW demonstrated before choosing to give up the manual control of the PW. For example, they proposed having an adaptation period during which to get use to the IPW reaction time for or having a mechanism to prevent or alert the user of a malfunction.

DISCUSSION

This study examined current challenges in using PWs, and explored the possible benefits and challenges to using an IPW. Participants in this study experience common difficulties with PW driving as has been reported in the literature (Evans, et al., 2007; Simpson, 2005). While the IPW affords a number of new capabilities, it is clear that not all functions are viewed in the same way by all participants.

Previous experiences and challenges with current PW, current and future anticipated functional level and current activities appear to impact on the participants' perception of the usefulness and relevance of each function.

All the participants in our study indicated that they would be confident in using the technology. They did however provide examples of how they could be made to feel that the IPW is in fact reliable, such as having an adaptation period or an alert system to indicate a malfunction, in order to be sufficiently confident to allow the IPW to navigate autonomously. Interestingly, a recent qualitative investigation into PW users', caregivers', and therapists' perceptions of collision avoidance found that while the majority of participants supported an IPW technology, there were concerns regarding the power mobility technology's safety and reliability (Wang, Korotchenko, Hurd Clarke, Mortenson, & Mihailidis, 2012, in review). They were concerned with the potential to injure others, and described specific problems, including driving backwards, avoiding dynamic obstacles, and negotiating outdoor barriers. Differences in the studies may in part arise from the strategies used to elicit the participants' perspective. In our study, a 4-minute video demonstrating actual use of the IPW was used during the interviews with the participants, perhaps allowing them to view the IPW's capabilities in a real environment, while in the Wang study the IPW was described to the users and a very short video (13 seconds) was shown only to caregivers.

As demonstrated in this study, feedback from potential IPW users is essential to develop a wheelchair that best meets the users' needs, the ultimate users of the wheelchair. More in-depth analysis of the reasons for using or not using an IPW as well as understanding the caregivers and clinicians' perspectives are essential as they can greatly impact actual use of the IPW.

CONCLUSION

Collaborative research between fields such as rehabilitation, engineering and computer science encourages the development of novel assistive devices. Furthermore, taking into account key perspectives, such as that of the PW user, in the design and development of these technologies allows potential challenges to use to be identified and addressed early on.

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