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"Learn what we're going through": Attitudes of older powered chair users towards mixed reality games that involve power mobility

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ABSTRACT: Older powered chair users' perceptions on and attitudes towards mixed reality and modern facilitating technologies, such as tablets and smartphones, was explored to inform the design of mixed reality games that involve power mobility. Eleven older powered chair users (aged 55 and over) were interviewed in focus groups about their knowledge of, adoption of, experiences with, attitudes about, preferences for, and interest in these topics. Questionnaire and interview data were analyzed using descriptive statistics and thematic analysis. Findings suggest that community-dwelling older powered chair users are a technologically-forward group that use or are interested in trying new technologies and interaction paradigms, with key barriers being identity mismatch, affordability, and social acceptability. Although they did not see their use of powered chairs, new technologies, and digital entertainment as an integrated system, participants were receptive to the idea of synchronizing assistive and non-assistive technologies for the purpose of social entertainment, advanced training, and/or promoting understanding and empathy in others. In particular, the concept of a game-based mixed reality platform designed around performance mastery for older powered chair users and empathy training for able-bodied friends and family members was well-received. Initial resistance due to identity mismatch or lack of knowledge was mitigated through explanation and examples.

KEYWORDS: Power mobility, older adults, technology use, games and entertainment, social interaction, mixed reality, inclusive design

DEFINITIONS:

Power mobility: Mobility enabled or enhanced by electrically-powered mobility aids, such as electric wheelchairs and mobility scooters.

Mixed reality: An interaction paradigm involving synchronized physical and virtual space facilitated by technology such as head-mounted displays and more recently smartphones and tablets.

1. Introduction

With age come potential declines in physical mobility that can negatively impact an individual's well-being (or quality of life), leading to depression, isolation, loss of independence, lowered activity levels, and early death [6, 24–26]. Power mobility through the use of powered chairs, such as electric wheelchairs and mobility scooters, is an increasingly popular option that provides a means of moving from place to place with little or no physical demands placed on the user. The number of older powered chair users is expected to rise in tandem with the aging of the baby boomer population worldwide [17, 29]. As such, research that explores the impact of these assistive devices on the lives of older adults is necessary and timely.

While adopting a powered chair can improve well-being in a number of ways, including greater activity levels and community participation [3], and social interaction and feelings of autonomy (the ability to be free and independent) [9], it may not be enough, and may even introduce additional issues. For instance, some research has illuminated experienced users' concerns about the safety of the device and a perceived inability to carry out social activities, such as visiting friends and family [3, 8, 15]. Additionally, design research on powered chairs (e.g. [27]) has focused on optimizing the built environment and chair use (impact of the device and/or impact on device use), rather than on other relevant factors, such as social interaction, entertainment, well-being beyond physical and mental health, and the co-impact, if any, of other concurrently used non-assistive technologies.

One potentially relevant option for exploring and enhancing the interaction between well-being and assisted mobility for older powered chair users is mixed reality. Mixed reality is defined as an interaction paradigm in which physical and virtual space are merged [19]. Although conceptualized and explored in the 1990s, mixed reality has only recently gained stead due to the proliferation of affordable, easily available, and less cumbersome technologies to facilitate it: namely, new handheld, mobile technologies such as tablets and smartphones. Mixed reality may be particularly suitable for older powered chair users and the challenges they face for several reasons. By its nature, mixed reality requires the use of physical space in some way, which opens up possibilities for deliberately incorporating powered chair use. In this way, specific device- or mobility-related issues may be tackled through specially-tailored tasks, rules, and environments. Many of the newer handheld, mobile technologies that can facilitate mixed reality (e.g. smartphones and tablets) may already be familiar to older adults. As such, modern mixed reality experiences can be designed to encourage mobility, activity engagement, and social interaction using technology older adults may already have in their possession.

Finally, mixed reality offers a potentially inclusive setup, in which chair users and non-chair users can interact together, face-to-face, in physical space.

The authors are aware of no work to date that has explored mixed reality for older powered or non-powered wheelchair users. However, some work has explored mixed reality for older adults in general. One example is *Age Invaders* [14], an intergenerational mixed reality game that features co-located play in physical space through a room-sized virtually-augmented physical gameboard and virtual play over the Internet. A second example is the *Eldergames Project* [10], which developed a mixed reality tabletop game to help older adults develop cognitive skills in a social, playful setting. However, neither project explored the possible impact of, or on, mobility aid use in terms of, for example, feasibility, inclusivity, training, or increased confidence. Further, while the *Eldergames Project* addressed intergenerational social interaction and entertainment, their approach leaves room for explicit measures of well-being, including social and enjoyment factors, which have a long and rich history in the psychological literature.

Mixed reality can be facilitated in many ways, but not all technologies, contexts, and approaches may be appropriate for older powered chair users. Early work on technology adoption indicated differences among age groups, where older adults, unlike their younger counterparts, were influenced by social pressures based on the subjective norm and perceptions of how easy or difficult the technology is to use [22]. However, more recent research on older adults and engagement with new technologies provides evidence for a disappearing "digital divide." Findings show that an increasing number of older adults are becoming interested in new technologies and reporting more positive than negative experiences with the technologies they use [5, 18, 20], although some contention remains over the importance of perceived ease of use, one of the barriers found earlier by Morris and Venkatesh [22]. Similarly, recent statistics on older adults and ICT use in Canada suggest that older adults' engagement with digital technologies, especially the Internet, is increasing: Internet use for people aged 65-74 increased from less than 10% in 2000 to 60% in 2010 [2]. Further, the nature of this engagement is similar to other age groups, e.g. socializing and entertainment [32]. Even so, this work has focused on now-established forms of ICT, such as email, desktop computers and the Internet generally, and not on newer forms of technology, such as tablets and smartphones, and modes of interaction, such as mixed reality and embodied interaction, defined as interaction facilitated by the use of movement- and/or gesture-based controls. Further, little is known about whether and how specific technologies and interaction styles work with other factors, such as mobility

impairment and assistive device use, to affect the lives, and particularly the well-being, of older adults.

Mixed reality has long-standing ties to digital gaming [21]. Work in digital gaming generally, and embodied gaming in particular, has shown promising, if initial, results for older adults in terms of well-being and mobility. Aarhus *et al.* [1] found that social embodied games had a positive impact on seniors' fitness and self-perceptions of ability. Jung *et al.* [13] found gains in well-being measures for older adults who played the Nintendo Wii gaming system compared to those who played traditional boardgames. Even so, this work has largely overlooked the potential impact of, or on, mobility aids, mobility, and well-being. One project has explored the intersection of movement-based gaming and older mobility aid users: Gerling, Mandryk and Kalyn [11] developed and evaluated an accessible Microsoft Kinect-based toolkit that elicited engagement in older adults using wheelchairs. Work at the intersection of older mobility-restricted users, games, and well-being is nascent; more research is needed in general, particularly for older powered chair users who may already be using ICT that could be harnessed as game-based interfaces and/or displays.

Motivated by the above, the overarching goal of the work presented in this paper is to develop a mixed reality gaming platform that explores the impact of technology and interaction paradigms on older powered chair users' well-being. As a fundamental first step in this inclusive, user-centred design process, the authors conducted a focus group study with older adults at a local community centre to produce a needs analysis informed by data about the intended end-users of the system [4, 28]. The main contributions of this study are twofold. First, empirical data on older powered chair users' interest in, use of, attitudes toward, perceptions of, and/or experiences with mixed reality and related interaction paradigms, newer (e.g. smartphones and tablets) and older (e.g. desktop computers, cell phones, the Internet) forms of ICT that can be used to facilitate modern forms of interaction, including mixed reality, the intersection of assistive and non-assistive technologies, and social interaction, entertainment, and other well-being factors that emerged organically in the focus group sessions, in particular the notion of empathy training. Second, a needs analysis framework informed by a thematic analysis of the data that is underpinned by an inclusive, user-centred design approach.

2. Methods

An exploratory focus group study with older powered chair users was undertaken at an accessible community and athletics center in Scarborough, Ontario, Canada.

Qualitative and quantitative data was collected through a questionnaire and discussion questions. Quantitative data was summarized with descriptive statistics. Qualitative data was thematically analyzed to generate a needs analysis framework. Research ethics board approval and informed consent from participants was acquired prior to beginning the data collection process.

2.1. OBJECTIVES AND RESEARCH QUESTIONS

The objectives and research questions are presented by topic in Table 1. See Table 2 for the focus group questions associated with each topic area.

Table 1. Research questions and objectives by topic area.

Topic Area	**Objectives and Research Questions**
Mixed Reality and Interaction Paradigms	O1. Gather older powered chair users' perceptions of and experiences with new and emerging interaction paradigms, particularly mixed reality.
	RQ1a. How do older powered chair users perceive mixed reality and similar interaction paradigms, especially in the context of powered chair use? RQ1b. What experiences have older powered chair users had with mixed reality and similar interaction paradigms?
Facilitating Technologies	O2. Gain an understanding of older powered chair users' perceptions of and experiences with technologies that can facilitate modern interaction paradigms, such as mixed reality.
	RQ2a. What modern ICTs that may be used to create mixed reality experiences, such as tablets and smartphones, do older powered chair users currently use or would be willing to try? RQ2b. How do they perceive and/or experience these ICTs, particularly in tandem with their powered chair?
Social Interaction, Entertainment, and Well-being Factors	O3. Identify challenges that older powered chair users face that are related to social interaction, entertainment, and other well-being factors that may be explored in a mixed reality platform.
	RQ3a. How do older powered chair users perceive and experience their powered chair with respect to being mobile and engaging in social, entertainment, and other well-being related activities? RQ3b. What kinds of social or entertainment activities do they enjoy or would they be willing to try?

2.1. FOCUS GROUP

Focus groups [16, 30] are used by human factors researchers to gather foundational data on needs and requirements for particular user groups. Three sessions with a unique group of 3-4 participants each session were conducted across three days. All sessions were audio-recorded and written notes were taken by the facilitator. A questionnaire was administered before the start of the main discussion to capture demographic and quantitative use data.

2.2. PARTICIPANTS

Older adults (aged 55+) who use powered chairs, such as electric wheelchairs and mobility scooters, were recruited by the principal investigator in-person at a local community centre. A purposive sampling approach using criterion, opportunistic, and convenience schemes [23] was assisted by members of staff at the community centre, who suggested individuals that met the required age range and mobility device use. The minimum age requirement was lowered from 64 and over to 55 and over to include participants who self-identified as "older adults" but were younger than the 64 and over standard. Exclusion criteria were: presence of non-mild cognitive impairment, e.g. late stage dementia; non-independence, e.g. living in a care home; and inability to travel to the study location. Participants were given $20 CDN for participation and to offset incurred travel expenses.

A total of eleven participants (four women) were recruited. Most participants (six) were aged 55-64, with two aged 65-74, two aged 75-84, and one who did not indicate his/her age. All participants had at least a high school education, with six having attained college or university degrees. In terms of type of powered chair used, seven participants used electric wheelchairs and four used mobility scooters. In terms of duration of powered chair use, one participant had used her/his chair for a month or less, one had used his/her chair for 2-4 months, five had used their chair for 5-12 months, and four had used their chair for a year or more.

Two participants dropped out due to transportation scheduling conflicts: in one session, a participant left at the halfway point, and in another, a participant left about three-quarters of the way through.

2.3. INSTRUMENTS

A 19-item questionnaire was given to participants at the start of the session to capture demographic data and basic technology use data. There were 7 closed-

answer questions on demographic information, such as gender, age, type of powered chair used and how often. There were 2 multiple choice questions on the nature of powered chair use and how participants learned to use their chair. There were 4 questions about whether and how often ICT are used (closed-answer) and for what reason (open-ended). There were 6 closed-answer questions about game use, and 2 questions about whether (closed-answer) and what (open-ended) games they have played while using a powered chair. Questions were drawn from previous studies that looked at powered chair, ICT, and game use, e.g. [7].

The 12 initial focus group questions plus the 3 questions that emerged organically during the focus group sessions are listed in Table 2 along with the questionnaire items associated with each topic area.

Table 2. Questionnaire items and focus group questions grouped by topic area.

Topic	**Instrument**	**Questions**
Mixed Reality and Interaction Paradigms	Questionnaire	What games do you play while on your powered chair? How often do you play games using your powered chair?
	Focus Group	Emergent Question: Do you know what mixed reality is? Can you describe it? Here's an example of a mixed reality game. What do you think about this game? Would you be interested in trying it? Why or why not? Emergent Question: Have you ever experienced mixed reality? Please describe your experience. Would you be interested in playing a game with other people using your powered chair? Why or why not? Here are a number of different interface styles. Which are your favourite three? What do you think of these designs? Can you imagine other kinds of designs that would appeal to you?
Facilitating Technologies	Questionnaire	What hardware do you use most often to play video games?
	Focus Group	Do you use a smartphone? Why or why not? Do you use a tablet? Why or why not? If you use the Internet, what sorts of tasks or activities do you use it for? Do you use any of these technologies with other people, such as friends or family members? If so, who and in what way?

Social Interaction, Entertainment, and Well-being Factors	Questionnaire	How often do you use a computer? How often do you play games (on the computer or otherwise)? What types of video games do you play? How often do you play traditional games, such as cards, board games, pool, etc.? What types of traditional games do you play? Why do you play video or traditional games?
	Focus Group	How does your powered chair affect your social life? How does your powered chair affect your ability to engage with entertainment, such as movies, games, and events? Emergent Question: How else has your powered chair affected you?

2.4. PROCEDURE

At the start of the focus group session, participants filled out the ethics sheet and questionnaire. Once completed, the facilitator asked the first set of discussion questions related to power mobility and communication and entertainment technology. A small break was scheduled at the end of this discussion. The second part of the discussion involved eliciting participants' opinions on and interest in two existing mixed reality (merging physical and virtual space) games for older adults—the *Eldergames Project*, which is a mixed reality tabletop memory game [10], and *Age Invaders*, an embodied mixed reality intergenerational game [14]—that could be modified to include older powered chair users. This involved describing verbally and showing photos of these mixed reality games; it was not possible to have participants experience these games firsthand because the researchers did not have access to them and the mixed reality technology involved was complex and hard to replicate. Participants were then asked about their preferences for game interfaces, interaction styles (e.g. keyboard-and-mouse, touch- or gesture-based, and full body interaction) and visuals. Participants were shown a series of screenshots of existing modern games (e.g. *Angry Birds, Solitaire)* and asked to choose three based on their preference for the visuals and interaction style. Participants were given scratch paper, pens, stickers, and manipulatives, such as Lego and Plasticine, in case they wished to illustrate their preferences; however, no participant made use of these materials. The session was concluded with a

debriefing and compensation, as well as an opportunity for a private conversation with the facilitator.

2.5. THEMATIC ANALYSIS

The interview data were open-coded using a structured thematic analysis method [12] and the QSR international NVivo 10 software. A set of eight themes were identified and defined (see Table 3).

2.5.1. Inter-rater reliability

Using a randomly selected set of data totalling 20% of the total data and covering all themes, two raters, one of which was the first author, refined the coding scheme until a Kappa coefficient of at least 0.66 and percentage agreement of at least 95% was reached for each theme. A Kappa coefficient of 0.66 is considered acceptable in NVivo [12]. The first author then completed the coding.

Table 3. Themes used to code the focus group data; derived from the research questions.

Themes	Definition	Example
Learning experiences and preferences	Participants' comments on what style of learning (e.g. alone, in-person help, help over the phone) works best for them. Includes comments on how they learned and who taught them in the past.	"I prefer to have my son help me learn the smartphone."
Opinions on mixed reality	Participants' comments on what they think about a powered chair game, as well as what experiences, if any, they have playing powered chair games. Includes comments on not knowing what it is.	"I think a powered chair game would be interesting."
Opinions on powered chair games	Participants' comments on the idea of a mixed reality setup. Mixed reality is the synchronous merging of physical and virtual space, for example through heads-up displays (HUDs) or mobile phone screens. Includes comments on not knowing what it is.	"I've never heard of mixed reality."
Perceptions of powered chair use on social, entertainment, and other factors	Participants' comments on their experiences with powered chairs and how their powered chair has affected their life in terms of identity and self-image, entertainment, social interaction, and other factors related to well-being. Includes how they believe others perceive them. Can be positive, negative or neutral (no impact).	"Powered chairs are just to get me from point A to point B."

Perceptions of technology use	Participants' comments on how they perceive their own technology use or reasons for lack of use, as well as how they believe others perceive their technology use. Includes computers, the Internet, and handhelds, such as mobile phones, tablets. Must be an experience or a value statement, not simply a use statement, e.g. "I like my iPhone because ..." rather than "I use an iPhone." Can be positive or negative.	"I'm too old to use a smartphone."
Preferences for game design	Participants' comments on their preferences for types of games (e.g. puzzle games, shooters), graphics (colours, textures, aesthetic style, etc.) theme (e.g. adventure, love story), mechanics (e.g. levelling up, quests) and number of players (single, multiplayer). Includes examples of games they play and enjoy.	"I love puzzle games that make you think."
Preferences for style of interaction	Participants' comments on their preferences for style of interaction, e.g. mouse-and-keyboard, touchscreen, full body interaction. Includes examples of specific interfaces if mentioned with respect to interaction style.	"I love the new full body game controllers."

3. Results

3.1. QUESTIONNAIRE

Responses are grouped by topic area below. Discrepancies in response numbers are due to some respondents not answering certain questions; specifically, the question on age had one missing response; the question "How often do you play games?" had one missing response; and the question "Do you use any of the following [modern technologies, such as smartphones]?" had two missing responses.

3.1.1. Game use

In terms of traditional or computer games, five of the eleven participants played everyday and five never played; one participant did not respond (Table 4). In terms of video games, four played puzzle games (e.g. crosswords, Sudoku, Brain Teasers) and three played casino games (e.g. poker, slots, blackjack) (Figure 1). In terms of traditional games, such as cards, board games or pool, five never played, two did so once a week, and two did so once a month (Table 4). Six played card games (e.g.

bridge, solitaire) and three played board games (e.g. Monopoly, Settlers of Catan, chess). Reasons for playing either traditional or computer games included entertainment (six participants), to pass the time (six participants), to be with friends (five participants), or as a distraction (three participants) (Figure 2). Eight never played games using their powered chair and two played using their powered chair everyday (Table 4).

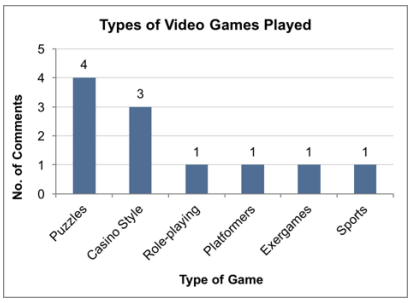

Figure 1. Types of games played.

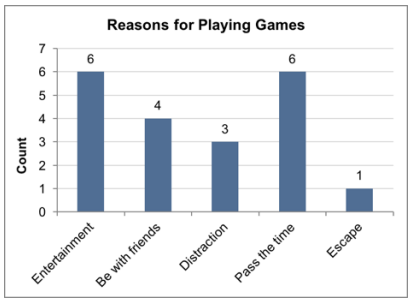

Figure 2. Reasons for playing games.

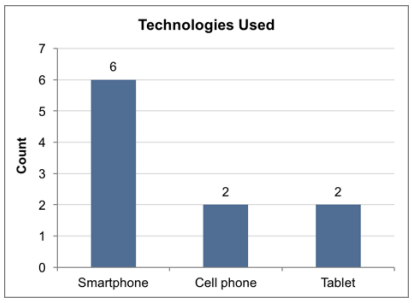

Figure 3. Technologies used.

3.1.2. Technology use

Six participants used a computer everyday, two used a computer once a week, and three never used a computer (Table 4). Six participants used a smartphone (e.g. iPhone, Android smartphone), two used a cell phone with no Internet features, and two used a tablet (e.g. iPad, Microsoft Surface) (Figure 3). Five reported interest in using a smartphone and five reported interest in using a tablet. Reasons for not using smartphones and tablets included: the perception that these devices are for kids; having no one to call; being old-fashioned; and not being able to afford it.

Table 4. Frequency of use for games and computers. Also described in-text.

Question	Everyday	Every 2-3 Days	Once a Week	Once a Month	Never
How often do you play games, computer or otherwise?	5				5
How often do you play traditional games, such as cards and boardgames?			2	2	5
How often do you play games using your powered chair?	2				8

How often do you use a computer?	6		2		3

3.2. THEMATIC ANALYSIS

Participants across the three sessions made a total of 339 comments; the frequency of comments per theme can be found in Figure 4. Analysis will proceed by theme in order of number of comments, starting with the highest.

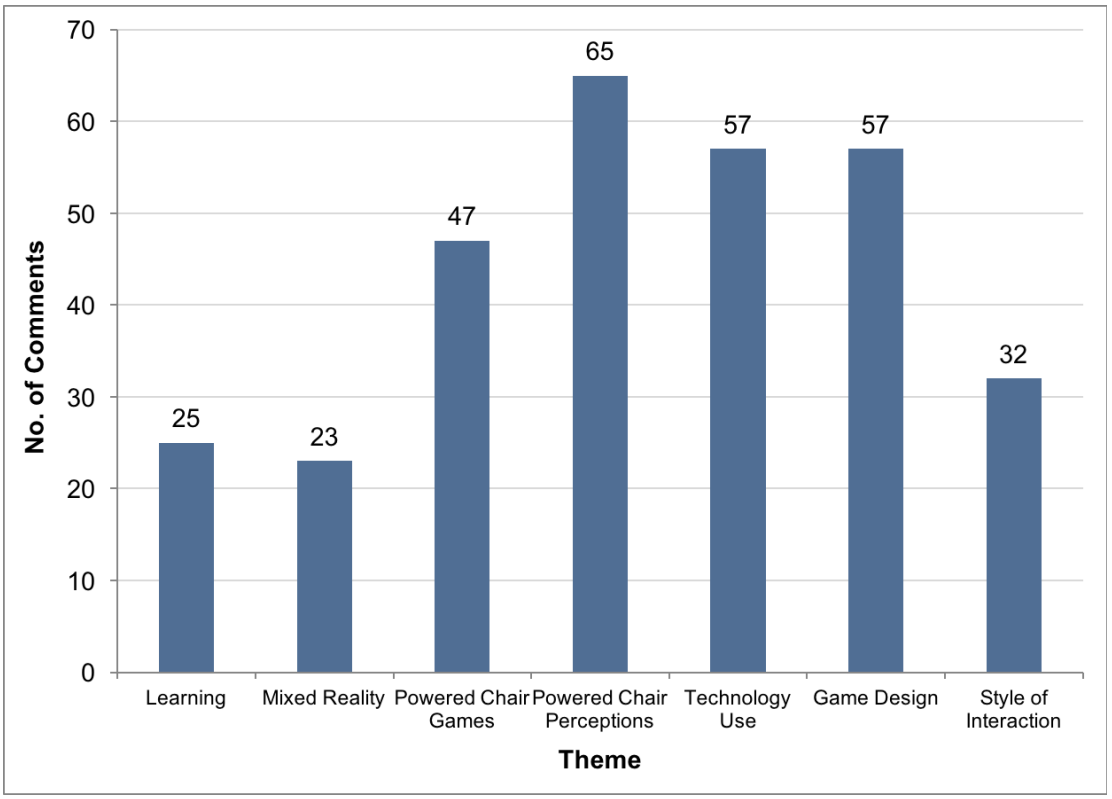

Figure 4. Frequency of comments from thematic analysis.

3.2.1. Perceptions of powered chair use (65 comments)

Participants thought that people in general did not understand why they use a powered chair. Participants suggested that the onus is on other people to understand why people like themselves use powered chairs. Experiences in which they were aggressively questioned by other people, particularly pedestrians, about having to use a powered chair were shared. Some participants expressed concern

about unintentionally driving into other people and the noises their chair makes in certain contexts, such as in a theatre.

> **Participant A:** *"I mean, people look at you in the powered chair, and it's like, they don't understand what you're going through."*
>
> **Participant B:** *"One guy ... a runner ... turns around at me and says, 'Why don't you just get up and walk?'"*
>
> **Participant C:** *"Hello!" [interpreted as an expression of surprise and incredulity]*
>
> **Participant B:** *"The guy shot off before I could answer ... You gotta educate yourself ... We're in it for a reason."*

While participants commented on the ease of use of powered chairs, they also discussed the challenges for new drivers, particularly with respect to the sensitive controls. Participants reported several experiences of unintentional movement, including bumping into objects and features of their environment, such as walls. Safety for self and others during powered chair use was a common concern.

Participants had mixed opinions on how the powered chair affected their social life. Some participants reported that it increased opportunities for social interaction because the powered chair allowed them to travel on their own without assistance. Others commented on being unable to use personal vehicles, the unreliable nature of accessible transit, and being ignored at parties, which they attributed to being the only person in a powered chair. Some commented on the lack of shared social place with friends and family when travelling to and from places or events, because the person in the powered chair must take alternative transit that they cannot share with non-chair users.

3.2.2. Perceptions of technology use (57 comments)

Technology use was largely conceptualized in terms of other people's engagement with and perceptions of technology use. Technology as the domain of younger generations, especially children, was a common perception. Participants talked about noticing other people, especially friends, family, and neighbours, using technology and then desiring to use those technologies themselves. However, in discussions with technology users, especially younger members of the family, participants faced scepticism, if not admonition.

> *"My daughter says, 'Mom, what are you going to do with a smartphone?'"*

Participants had mixed perceptions of their competence with technology. Some reported not knowing how to use ICT, while others conceptualized their use of technology as experimental or proficient. They viewed handheld technologies as

the next generation of personal computers that have a wider range of capabilities than traditional desktop computers, as summed up by the following quote:

> *"Basically ... the tablet is replacing the desktop computer."*

One participant described a situation in which his/her sister asked their brother to fix a broken desktop computer, but quickly realized that s/he could just use his/her smartphone to carry out essential tasks, such as banking activities. Traditional desktop computers and laptops were characterized as old and new handheld technology, particularly smartphones and tablets, were characterized as "do everything" devices. However, while participants conceded that this was the case, some were not happy with this transition. Participants expressed concern about using new handheld technology for tasks such as banking.

Participants who did not use new handheld technology offered several reasons why: not knowing how it was different from older forms of computer technology; being satisfied with the technology they were presently using; believing that the new technology would be too expensive; or believing that the new technology would require learning or be too difficult to learn. One person could not use touchscreens, a common interface in new handheld technology, because of a debilitating hand condition. Another considered her/himself too old-fashioned while also expressing interest in changing his/her viewpoint in the near future.

The Internet was characterized as an information, social, and entertainment tool. Participants used the Internet for interpersonal communication, primarily via email but also via Skype, playing games, and looking up information on a variety of topics, including song lyrics, recipes, news, and health topics. Participants who did not use email said that they did not have people to contact.

> *"We had the Encyclopedia Britannica ... and you were sort of the best kid in the world on the street if you had one of those. Your mother and father paid ... a couple hundred dollars for this bloody bookcase full of books. But now ... Google."*

3.2.3. Preferences for game design (57 comments)

Participants expressed interest in puzzle games, especially Candy Crush, and sports. The concept of a game that would allow non-powered chair users, such as able-bodied friends and family, to understand their perspective better (empathy) was positively received. As expressed in the following quotes:

> *"So they can learn what we're going through."*

> *"It might help people understand what we're going through."*

Preferences for social games was mixed. Many participants spoke of playing single-player games, especially solitaire. Others expressed interest in playing games socially, particularly with friends and family, though some did not think younger members of the family would want to play with them. Participants who preferred social games expressed equal interest in competitive and collaborative styles of play.

> *"They don't want to play with granny."*
>
> *"[The grandchildren are] not sitting there on their computer ... They're looking, actually, at you. And doing things with [us]."*

Participants did not express interest in a basic training game for learning how to drive their powered chair. Conversely, some participants indicated concern over interference of the game with learning how to drive their chair.

> **Participant A:** *"I think it might interfere. With learning."*
>
> **Participant B:** *"It would."*
>
> **Participant A:** *"Yeah, because you have to concentrate on learning first."*
>
> **Participant B:** *"Learn how to drive it."*

3.2.4. Opinions on powered chair games (47 comments)

The majority of participants expressed interest in a game tailored for powered chair users. Participants were not aware of any existing games for powered chair users.

> *"I dreamt I was playing a game. Like tennis ... I was playing tennis with someone, with other people in powered chairs."*

Participants responded positively to the idea of an obstacle course for powered chair users. Ideas for challenges included: narrow doorways; going around pylons; learning how to control other people's powered chairs; timed challenges; and helping novice powered chair users navigate the course.

> *"How long does it take them to make a cup of tea in the chair? You know, little fun things like that."*

Participants were not interested in a training game for themselves, and had mixed opinions on whether or not a training game for new powered chair users would be valuable. Some expressed concern about a training game interfering with learning. Others stated that learning how to drive the powered chair, especially in terms of gaining an understanding of the sensitivity of the controls, was essential. Still

others thought that it would have no effect either way. A few participants were concerned about safety issues in a game that used powered chairs.

3.2.5. Preferences for style of interaction (32 comments)

Participants expressed interest in motion-based and touch-based interaction, such as touchscreens, buttons, and motion-based controllers like the Nintendo Wiimote and Microsoft's Kinect. Participants generally preferred full-body interaction to other interaction paradigms and input methods, such as mouse-and-keyboard.

> **Participant A:** *"... it's not restricted to a particular part of your body. So, while you're doing that, you're engaging your body, a little bit of physical activity, which is beneficial. Secondly, you are not overwhelming any particular part of your body."*
>
> **Participant B:** *"Well, it's just like exercise. Yeah, I'd go for that."*

3.2.6. ICT learning experiences and preferences (25 comments)

Participants characterized their ICT learning experiences in terms of who provided the support. Common sources of aid included family members, especially younger family members, and neighbours. Some participants preferred to experiment on their own.

The preferred manner of aid was being shown, rather than told, what to do. The preferred modality was in-person, rather than over the phone or on the computer. Participants preferred the content to focus on learning the basics, rather than learning advanced or rarely used functionality.

> **Participant A:** *"He showed me the basics. And then I just did play with it."*
>
> **Participant B:** *"Me too. ..."*
>
> **Participant C:** *"... I just play with it until, you know. If it doesn't work, I try the next. And if I really have a hard time, then I call my son. [laughs]"*
>
> **Participant B:** *"Just call the young people."*

3.2.7. Opinions on mixed reality (23 comments)

Participants found the concept of a mixed reality space hard to understand and imagine. Most participants were initially uninterested or unwilling to try such a setup. However, after further explanation and seeing an example, almost all participants expressed interest in trying mixed reality. No participant was aware of or had previously experienced a mixed reality setup.

> *"It's the same as the Planetarium, right? Seeing that projection up there, the stars and that?"*

Participants' concerns centred around practical issues, such as how to create a mixed reality space that could accommodate multiple powered chairs and how to find a physical space large enough to support mixed reality for several concurrent powered chair users. Participants were also concerned about whether or not it was technologically or financially feasible.

> *"That would be expensive, though, for the projector, wouldn't it?"*

> *"Where you going to get a board big enough for a powered chair? [laughs]"*

One participant expressed concerns about safety. These were alleviated by the facilitator, who explained how such a game could be designed to ensure a safe experience for everyone.

4. Discussion

4.1. PERCEPTIONS OF AND EXPERIENCES WITH NEW AND EMERGING INTERACTION PARADIGMS, PARTICULARLY MIXED REALITY

Modern interaction paradigms, particularly full body and touch-based controls, were preferred over traditional methods. However, most participants were initially hesitant about the concept of mixed reality. This was due to: (a) not understanding what mixed reality was, (b) not being able to imagine themselves using their powered chairs for non-driving tasks, and (c) concerns about safety. However, these initial impressions were altered after examples were provided and explained. At the end of each session, the majority of participants expressed interest in the idea of mixed reality and the opportunity to try playing a mixed reality game. Additionally, the participants who were not hesitant about mixed reality were already aware of and/or had already experienced mixed reality or a similar interaction approach, including an interactive display at a local science centre and an embodied exergaming session during physical rehabilitation. These participants expressed keen interest in trying out a mixed reality platform that was designed for powered chair users.

Designing a mixed reality game for older powered chair users will require a careful and thoughtful understanding of their perceptions of mobility and powered chair use. The notion of having the powered chair as a facet of their self-image could lend itself to the use of avatars in gameplay. Taking into account participants'

perceptions of the danger of their device to others (e.g. running into people) as well as their desire for shared social spaces, one is encouraged to consider requiring the non-powered chair users to use powered chairs in the mixed reality game space. This setup also presents an opportunity to tackle the perception of other people, even friends and family members, not understanding or empathizing with the older powered chair user as a powered chair user. Finally, participants found it difficult to imagine use of their powered chair and entertainment—mixed reality or otherwise—in a meaningful way because they only conceptualized their device as a tool for mobility and traversing the built environment. A mixed reality gaming platform may need to consider this in the form of a tutorial or thoughtful advertising of the system that makes use of examples or provides clear description—text, visual, and perhaps video—of the system.

4.2. PERCEPTIONS OF AND EXPERIENCES WITH TECHNOLOGIES THAT CAN FACILITATE MODERN INTERACTION PARADIGMS, SUCH AS MIXED REALITY

This sample of older powered chair users was more technologically-forward than expected from the research on the digital divide. Specifically, participants used a range of ICT more frequently than previously reported. More than half used a computer everyday—an increase compared to the quarter of participants who did so, as reported by Cresci *et al.* [5])—and the same number used a smartphone with some overlap between the two groups. Almost half of those that did not use such technology reported the desire to try using a smartphone and/or tablet. Use of ICTs was not directly linked to powered chair use.

Perception of technology, in terms of being inappropriate for their age and socially-oriented, contributed to lack of device use. Participants were also concerned about the cost of technology. Increasing knowledge in terms of other older adults using this technology—for example, through media representations of older adults using such technology—and being made aware of affordable versions or providing senior discounts, may be key going forward. There was an expressed appetite to embrace ICT for many different reasons, such as communicating with family members and keeping current. Services, technology, and research that has a focus on providing ICT and learning opportunities for older adults using powered chairs seems to be desirable.

4.3. CHALLENGES RELATED TO SOCIAL INTERACTION, ENTERTAINMENT, AND OTHER WELL-BEING FACTORS THAT MAY BE EXPLORED IN A MIXED REALITY PLATFORM

Perceptions around the effect of powered chairs on social interaction was mixed. Participants were upset by the constraints of powered chair use on the manner in which they could participate in social situations. Specifically, even though they could still join others in activities outside of the home, they could not travel with friends and families in accessible transit, as they would have done if driving themselves. Some participants expressed concern about the impact of their powered chair on other people in a shared social setting, including the uncontrollable noises caused by the chair, even when not in motion. Above all, participants were hyperaware of being negatively perceived as a person in a powered chair and reported several experiences in support of this perception. Participants agreed that non-chair users, with the possible exception of trained transit employees, did not understand, believe, and/or empathize with the life experiences of an older person using a powered chair.

In contrast to previous findings (e.g. [8, 15, 31]), participants reported that the built environment was generally accessible, allowing them to engage in entertainment outside the home, such as movies, theatre, and sport events. Problems with entertainment engagement centred on perceived social isolation and some issues with the built environment, notably bathrooms.

While actual gaming activity was polarized, with roughly half who played games every day and half who never played games, the majority of participants played or expressed interest in playing games. As with ICT, results indicate that these older powered chair users were engaging with modern entertainment despite concerns about the digital divide. Participants primarily enjoyed puzzle games over other genres; however, this finding can be explained by the fact that specific puzzle games were trendy at the time this study was conducted.

Participants did not report any specific relationship between entertainment and powered chair use, nor did they know of any entertainment venues for powered chair users of any age and had not considered the possibility of entertainment that directly involved the use of powered chairs. However, participants were open to trying new technologies and interaction paradigms in an entertainment context that involved the use of their powered chair, as long as safety was ensured.

Participants were interested in a game with powered chairs that involved (a) an obstacle course for expert or novice powered chair users, or (b) a game that gave non-powered chair users the opportunity to experience being a powered chair user.

Comments about involving friends and family and ideas about game challenges that require a multiplayer setup suggest that a social gaming context is preferred. A mixed reality game could be designed to require the use of powered chairs as a control mechanism, avatar identity, and narrative element. In such a game, able-bodied players would be required to use powered chairs. Such a setup has the potential to act as an empathy training game by giving able-bodied people the opportunity to experience powered chair use. Additionally, it would be an inclusive, social entertainment opportunity for the older powered chair users that, by virtue of requiring powered chair use, would mitigate or eliminate many of the concerns raised by participants regarding perceived social isolation and socially problematic device issues.

There was some concern about younger family members not being interested in playing a game with their grandparents. Echoing this, recent research that considered the experience of older and younger generations playing a physical game together suggests that intergenerational games need to be carefully developed to accommodate age differences and mitigate perceived competency differences, especially in terms of younger players about older players [26].

4.4. NEEDS ANALYSIS FRAMEWORK

These findings informed the following needs analysis framework for mixed reality gameplay with end-users who are similar to the older community-dwelling powered chair users who participated in this study. The authors' intention is to validate this framework in the design and evaluation of a mixed reality game with this user group.

Technology: There is interest in trying modern ICTs, including smartphones and tablets. Despite popular conceptions of older adults' disinterest in new technologies, most of the older adults in this study were already using, or were interested in learning, these technologies.

Interaction Styles: Participants expressed preference for and interest in a variety of interaction styles, from the traditional desktop computer setup featuring mouse and keyboard interaction to touch-based screens to full body and gestural interaction. However, there was some concern over two aspects of a mixed reality setup: feasibility, e.g. whether or not a space large enough for powered chairs could be found, and the cost of the technology, such as projectors, that would be needed; and safety, based on previous incidents with their chair. The issue of feasibility can be mitigated through

the design and availability of a finished platform. The issue of safety can be mitigated in two ways: through choice of space, i.e. one that accommodates the number of powered chairs needed, and through game design, such as by including rules that discourage close contact between players in powered chairs.

Content: There was interest in a game similar to an obstacle course that offers advanced, rather than basic, training with their powered chair and/or promotes understanding in those who are not powered chair users, especially people with whom they may interact with regularly, e.g. friends and family.

Single or Multiplayer: Participants expressed interest in both single and multiplayer setups that were either collaborative or competitive in nature. Preference was about half and half. Therefore, a variety of social, multiplayer setups are viable.

Learning Styles: There was preference expressed for exploring on their own and/or being shown in-person how to use unfamiliar technologies.

4.5. LIMITATIONS

A few issues limit this work. The small sample size, while appropriate for a focus group, limits the generalizability of the findings. The flexible, improvisatory nature of the focus group method allowed for the emergence of new, relevant questions; however, these could not be asked of participants in previous sessions. Some participant data could not be collected due to blanks on the questionnaires and dropouts. Finally, although a criterion scheme (to ensure that recruited participants matched the desired user population) and an opportunistic scheme (which resulted in the age range flexibility and a broadened understanding of who identifies as a member of the desired user population) was employed in the purposive sampling approach, a convenience scheme was also used: who was available while recruiting on-location at a single venue that was a fitness and social gathering facility. This limits the generalizability of the results because potential recruits from other venues, such as care homes or retirement facilities, may have different attitudes towards the focus group topics. Future work will attempt to recruit more widely at different locations in the city.

5. Conclusion

Older powered chair users conceptualized their powered chair use as a tool and aspect of their identity that increases their freedom and independence while having a minimal effect on their ability to engage socially and with entertainment. Aside from safety, these participants' primary concern was with a perceived lack of understanding on behalf of non-powered chair users. They are an increasingly pro-technology group in terms of ICT use and entertainment. While they did not see their use of powered chairs, ICTs, and entertainment as integrated, participants were open to and interested in the idea of using their powered chairs in a technology-mediated space involving a social game-based activity. Participants were not, however, interested in a training game; instead, they expressed interest in an obstacle course, puzzle, or prosocial game involving non-powered chair users gaining an understanding of the necessity of and challenges associated with powered chair use, if not empathy with those who must use powered chairs. Findings suggest that initial hesitation or lack of interest in technology can be alleviated by describing key concepts and providing examples.

5.1. FUTURE WORK

Findings from this study suggest that barriers to imagining a mixed reality setup may be overcome through explanation and examples. Future work will explore the design of a social, multiplayer, game-based mixed reality platform for older powered chair users and their able-bodied friends and family that seeks to increase empathy for older powered chair users and/or act as an advanced training platform to improve self-confidence and reduce insecurities with the device.

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