From Imagination to Innovation: Using Participatory Design Fiction to Envision the Future of Accessible Gaming Wearables for Players with Upper Limb Motor Disabilities

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The interest in enhancing video game interactions through wearable technology has grown, yet accessible gaming with wearables remains underexplored. This study employs participatory design fiction, enabling disabled gamers to envision a future with tailored gaming wearables while critiquing technology. We conducted a two-phase study. Phase one involved in-depth interviews with upper limb motor disability participants; we developed a fictitious gaming wearable by analyzing the data using reflexive thematic analysis. A smaller group iterated on the wearable in phase two to ideate on ideal futures with accessible gaming wearables. Using data and dialogic/performance analysis, we crafted a design fiction diegetic prototype as a tech review video. This research highlights disabled gamers' unique needs and experiences around gaming wearables. It offers an innovative diegetic prototype for accessible gaming tech. Our methodological contribution merges narrative inquiry and dialogic/performance analysis in participatory design fiction research, providing a valuable approach for future studies.

CCS Concepts: • **Human-centered computing → Accessibility technologies**; *Gestural input*; • **Games/Play, Individuals with Disabilities and Assistive Technologies, Wearable Computers, Qualitative Methodologies**;

Additional Key Words and Phrases: Design Fiction, Accessibility, Video Games, Speculative Design, Electromyography, Movement Based Design, Wearable Technology, Narrative Inquiry, Dialogic Analysis, Performance Analysis

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1 Introduction

Video games are an immensely popular hobby and have additionally been found to provide many benefits to players including positive creative, emotional, and social benefits [65]. Nevertheless, individuals with disabilities may have greater challenges when engaging in video game activities. Assistive technology is frequently utilized by disabled people to facilitate their daily tasks. Assistive technologies encompass a wide range of physical objects, services, and support systems that aid individuals with various impairments in achieving better health, well-being, inclusion, and engagement.

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There has been extensive innovation in accessible technologies for in-game content and adaptive controllers such as the XBox Adaptive Controller [96] and the recently released PlayStation Access Controller [87]. Though these innovations have greatly benefited the disabled gaming community, more variety of accessible interaction options are needed.

HCI researchers have been interested in how wearable technology can give players a new way to interact with each other [24, 25, 66, 99, 110]. Gerling and Spiel [48] identify how technologies at the frontier of innovation often exclude individuals with disabilities in their initial development. They further identify that if disabled bodies are considered, development of these innovative technologies is used for medically corrective or rehabilitative purposes [48]. A valuable aspect to note from critical disability research is the difference between the medical model of disability and the social model. The medical model describes disability as a strictly medical problem "that must be cured, rehabilitated, or eliminated if a person is to achieve full capacity as a human" [70]. The social model of disability "distinguishes between impairment as a biological or physical condition and disability as a social and environmental construction" [70]. When research explores innovative technology as an avenue for rehabilitation and ignores other non-corrective uses of the technology for users with disabilities, this places that research strictly within the medical model of disability. The case of exploring innovative technology such as wearable interaction for users with disabilities is no different, with extensive research focusing on wearables for rehabilitation [3, 47, 54, 75]. There is a distinct lack of research to explore the potential of wearable interaction for entertainment-focused purposes for disabled users. We aim to address this research gap by understanding the lived experiences of gamers with upper-limb mobility disabilities and the future designs of wearable technology to support the hobby of video game play. We utilize the definition of assistive technology as "products, equipment, and systems that enhance learning, working, and daily living for persons with disabilities" [9]. In this study, we explore how to better design assistive technology video game controllers for gamers for entertainment video game play. Video game play for entertainment focuses on playing games for a fun, enjoyable, and entertaining experience. This is in opposition to video game play for rehabilitation. Though games for rehabilitation, such as serious games, are a critical part of HCI and have many health benefits for participants [3, 47, 49, 50, 54, 75, 100], this is not the focus of this paper. To achieve this, we pose the following research questions:

RQ 1. What strategies can be developed to support future wearable assistive technology controllers for players with upper limb motor disabilities?

RQ 2. How can personas as a research activity be used to understand our user group of individuals with upper limb motor disabilities to inform future designs of accessible gaming wearables?

RQ 3. How can a design fiction diegetic prototype be used to represent the future of accessible gaming wearables?

To answer our research questions, we conducted a two-phase study. The first phase explores the user base of gamers with upper limb motor disabilities to understand their lived experience. This study phase utilized the phenomenological data collection method of semi-structured interviews. Eleven participants with upper limb motor disabilities were interviewed. The first phase was analyzed with the reflexive thematic analysis method [18] to develop a set of themes used to design the initial concept of a future wearable controller that was used in the participatory design fiction activity in phase two.

In phase two of the study, we used participatory design fiction to critique our design idea, develop a persona, and give the participants a space to tell us stories of their experiences. Design fiction is a design method that uses diegetic prototypes to visualize future technologies and understand the implications those technologies have on everyday life [14]. At the same time, participatory design is a process where users critique and shape designs to be used within their communities [95].

Combining the two design processes, we collect storied data from the participants' experience and collaboratively build a persona. Then using the narrative inquiry dialogic/performance analysis method, we develop a script and film a video for our dietetic prototype, a video review of our fictional wearable controller.

Through this research project, we provide three main contributions: (1) an exploration into the player experience for players with upper limb motor disabilities through a meaningful understanding of gamers' needs and lived experiences; (2) The application reflexivity-based analysis methods to explore and reflect on the lived experiences of gamers with upper limb motor disabilities, including the detailed exploration of an analysis method novel to the HCI community, dialogic/performance analysis. Through the use of reflexivity we were able to critically reflect on our thoughts and actions as they pertained to the study [68]; Finally (3) An exploration into the implications of accessible gaming wearable interaction through the use of a design fiction diegetic prototype. This is done through the application of participatory design fiction as a way to allow this group to explore their ideal futures in similar ways that have been used with other marginalized communities [17, 20, 53, 57, 58]. Though our focus is on the design for people with upper limb motor disabilities, we hope this work will give other researchers a resource for future projects to use participatory design fiction and to apply dialogic/performance analysis.

2 Related Works

This section covers video games, wearables, and upper limb motor disability terminology. Next, we examine wearable gaming interface research advances. To conclude the section, we discuss participatory design fiction and narrative inquiry HCI research.

2.1 Upper Limb Motor Disabilities

Motor disabilities that affect the upper body are diverse and can interfere with one's sensations, movement, and coordination [93]. This includes neurological conditions like cerebral palsy [90], or physical conditions like limb anomalies [41]. These disabilities can specifically affect fine motor skills, which require "precise, voluntary, and coordinated movements with their hands" [23].

Our user group represents upper limb motor disabilities through conditions including Parkinson's, cerebral palsy, hypermobile type Ehlers-Danlos syndrome (hEDS), limb differences, tremors, difficulty with fine motor movement, muscle weakness, and nerve damage in the hands and fingers. hEDS can cause joint pain, instability, hypermobility, and fatigue in the upper limbs [103]. Parkinson's disease can cause tremors, lowered coordination, and muscle stiffness [33]. Cerebral palsy is a group of disorders that can affect the upper limbs through muscle weakness and coordination limitations, muscle spasms, and reduced range of motion [32]. Though diverse, our participant group represents only a small portion of the full spectrum of disabilities that affect the upper limbs. We recognize there is extensive research done on upper limb motor disabilities and HCI [6, 11, 39, 56, 60, 77, 83, 91, 108, 111] however we aim to specifically focus on this user group and the intersection of wearable interaction and video game interaction.

2.2 Video Game Accessibility

The creation of accessible video game gameplay standards [35] and accessible controllers like the Xbox Adaptive controller [96] and Logitech Adaptive gaming kit [51] indicate progress in video game accessibility. Creating accessible game controllers is a major advancement in controller design, but the solutions are not without criticism. Some criticisms of the Xbox Adaptive include its complicated setup, limited interaction options, and a lack of innovation in accessible devices beyond it [44]. According to Anderson [6], the gaming community views these projects as the final solution to gaming accessibility. Notwithstanding their importance, these advancements should serve as an introduction to addressing accessibility needs in gaming.

Porter and Kientz [84] and Wentzel et al. [109] provide insights into gamers with disabilities, with the latter study focusing on those with limited mobility and physical disabilities. Video game hardware incompatibility with assistive technology is a significant obstacle for disabled gamers [84]. According to Wentzel et al. [109], gamers with limited mobility must configure accessible interaction methods through hardware or software changes. Xbox Adaptive gadgets, which link adaptive switches and other assistive equipment effortlessly help solve this problem. But they are not the only answer. We must study ways to make gaming gear more accessible for upper-limb disabled players.

Many studies suggest novel gadgets for upper limb motor disability interface design. Some examples of hands-free gadgets include eye-gaze, voice control, and biosignal-based interaction [8, 21, 97, 98, 105]. Other research explores touch-based interaction and accessible switches for gaming [4, 45]. In the industry, AbleGamers and SpecialEffect advocate for disabled players and assist in creating accessible interactive gadgets for individuals. On an individual basis, video game accessibility cannot be solved. Users may not, due to a plethora of reasons such as financial or complexity of their disability, be able to buy custom devices. Additionally, disabled gamers' accessibility needs might change during a play session, making the purchase of technology even more expensive. Thus, it is important to consider solutions that work for a wider range of upper limb motor impairment experiences and gaming situations than the current solutions.

2.3 Accessible Wearables in Human-Computer Interaction

Wearables offer a unique platform for creative interaction methods that integrate the body with technology- this can be observed in how smartwatches and fitness wearables integrate heart rates into interactions or how virtual and augmented reality systems utilize body movements for interaction. Research indicates that the use of wearable technology by individuals with physical disabilities differs from those without disabilities due to their unique bodily experiences [27, 104]. For example, Carrington et al. [27] found that users with disabilities who used wheelchairs viewed their assistive technology as an extension of their own body. This concept of assistive technology as bodily extension could furthermore be a valuable aspect to consider when exploring wearable interaction for users with disabilities including upper limb motor disabilities. Vatavu and Ungurean [104] identify how users with motor impairments found unique coping strategies and alternate methods of interaction when wearable interaction posed a barrier to them and were more inclined to explore these alternative interactions than participants without disabilities. This too, provides a valuable perspective on how users with disabilities approach wearable interaction specifically when accessibility barriers exist. This could further provide insight into how to design accessible wearables that allow for and are designed with consideration towards some flexibility in their intended use. Moon et al. [78] proposes that wearable technology has the potential to specifically benefit users with disabilities through increased independence, community and social participation, and increased control in everyday activities. Despite this potential, wearables research for users with motor disabilities still focuses on rehabilitation or therapy applications [2, 3, 7, 69, 107]. Even in video game contexts, researchers preliminary focus on designing games for rehabilitation [10, 12]. Rehabilitation, exercise, and therapy are essential for disabled people, as are hobbies and leisure. Such circumstances require as much investigation as rehab. We address this gap by exploring the use of accessible wearable technology in the context of hobby video game playing.

2.4 Wearables and Creative Interactions for Video Games

Wearable interactivity allows imaginative and interesting interaction. Gaming interaction benefits from enhanced immersion, engagement, and character embodiment [24, 25, 66]. Extensive research has been conducted on designing playful and innovative gaming wearables, as well as enhancing their creativity through costume and customization aspects [24, 64, 66, 99]. The findings demonstrate able-bodied users prefer customization, playfulness, sociality, performance, bioadaptivity, and bodily movement in wearables. However, the inclusion of accessibility is lacking. As Gerling and Spiel point out, when technological innovations are made the first user group to be considered are able-bodied users [48]. Too often technology is designed around the able-bodied user, with accessible adaptations considered as an afterthought [48, 78]. The needs of disabled individuals vary from their able-bodied counterparts [27, 43, 71, 73, 80, 104], and considerations towards this user group needs to take place at the inception of wearable interaction innovation, not only after the technology has become established. This paper seeks to address this gap by engaging gamers with upper limb motor disabilities to understand what their ideal future looks like in terms of accessible wearable interaction.

2.5 Participatory Design Fiction

Design fiction is a design method which combines research, storytelling, and design speculation to create diegetic prototypes of objects that do not exist but could feasibly exist in the future [14]. Design fiction is a highly collaborative design method that thrives on multiple perspectives' input and perspective to contribute to design research [14]. Methods of designing for the future, often categorized as design fiction and speculative design in HCI, have been found to have particularly successful applications in bringing marginalized groups into design research and providing space and opportunity for these groups to design their ideal futures [17]. These methods have been used with the black community [20, 57], the trans community [53], the queer community [17], and in disability studies [38]. However, to our knowledge, there is limited work exploring how design fiction in HCI could be used to envision the future of gaming wearables.

A common way to develop dietetic prototypes alongside design fiction is to use participatory design [42]. Participatory design strives to incorporate users into the design process in subjects that create conflicts or barriers [13]. It is a popular method used in the HCI and disability communities [22, 85, 94]. Unlike traditional design fiction processes, participatory design requires the participation of not just any stakeholders but the would-be users of the design [13].

In HCI research, design fiction and participatory techniques are increasingly used in HCI research, including in wearables, intimate artifacts, and UTI treatment research [67, 79, 81]. Nägele et al. [79] emphasize the need to employ participatory design fiction methodologies with vulnerable users to better represent and value their ideas and experiences beyond the cultural norm. The researchers also emphasize that incorporating the input of those with disabilities in design benefits not only the disabled community but also a more extensive group of users [79]. This study's second phase uses participatory design fiction to explore the design space of accessible gaming wearables by having participants imagine a future. In phase two we also shifted to using a narrative inquiry methodology along with dialogic/performance analysis, which supports the design of our diegetic prototype.

2.6 Narrative Inquiry

Narrative inquiry is a qualitative research method from the humanities [36]. This method emphasizes participants' life experiences through storytelling [88]. Narrative inquiry involves collaboration between participants and researchers, as researchers reframe and retell participants' stories, combining their perspectives with the researcher's [36]. The narratives participants discuss are restored through a chosen framework [31]. Restorying involves retelling participant narratives within the specified framework [37]. According to Clandinin and Connelly, the three-dimensional narrative inquiry space (inward and outward, backward and forward, and situated in place) is a possible framework [31]. However, researchers can also customize their framework to meet their research goals. This use of this framework helps identify key features of participant narratives and contextualizes them within the research [37].

Riessman identifies four narrative inquiry analytical methods: thematic, structural, visual, and dialogic/performance analysis [88]. Dialogic/performance analysis combines the contextual elements of structural analysis with the content focus of thematic analysis [88]. Dialogical/performance analysis examines how speakers engage and perform narratives [88]. This makes dialogic/performance analysis ideal for participatory design fiction research. Participatory design research is conversational and collaborative, which supports the dialogic/performance analysis method in which speakers generate narratives through discussion. Even if participatory design exercises do not ask for narrative stories, they'll emerge through discourse.

Narrative inquiry has been used in HCI participatory design research to examine social stigma, online privacy conflicts, stroke patients, under-resourced communities, knee replacement surgery patients, and video game player experience [26, 52, 63, 82, 89, 106]. Studies employed several methods, including thematic analysis [52, 63, 89], visual analysis [82], affinity mapping [26], and co-analysis [106].

The use of dialogic/performance analysis in speculative and design fiction research is limited [16, 30]. In these instances an analysis method similar to dialogic/performance analysis was used, but valuable details about how analysis was conducted is missing. These details are needed to ensure other researchers may use comparable research approaches since narrative inquiry is less common in HCI than other qualitative methods. Unfortunately, the narrative inquiry processes in the publications above exclude important data, such as defining the frameworks with which the narratives were restoried. Participatory design fiction, narrative inquiry, and dialogic/performative analysis are beneficial, and our study will outline the design and analysis process to help other HCI researchers with future initiatives.

3 Phase One Methodology

In the study's first phase, we aimed to build a base-level understanding of our user group of video game players with upper limb motor disabilities through semi-structured interviews. Specifically, we wanted to understand any barriers they experience while playing video games, and their experiences and preferences around wearable interaction.

3.1 Participants and Procedure

This study included 11 participants (nine male, two female) between the ages of 24 and 58 (average age = 34.6). Specific information on the participants can be found in Table 1. We recruited participants through forums such as Reddit, Facebook, and Discord, through calls for participants distributed through Parkinson Canada and the Multiple Sclerosis Society of Canada, as well as through social media posts and snowballing. Participant inclusion criteria included being able to communicate in English, being at least 18 years of age, self-identifying as having an upper limb motor disability, and having at least one year of experience playing video games for entertainment. Participants were compensated with $25 CAD e-gift cards to their chosen online stores. Ethics board clearance for the study was obtained from the first author's institution. Additional ethical consideration was put towards ensuring participants felt comfortable and that their privacy was respected. Participants were provided with a detailed informed consent form before completing any part of the study (demographic survey or interview) to ensure they understood what was required of them during participation and that they felt comfortable with these requirements. Participants were also assured that they could withdraw from the study if they felt uncomfortable before or after the interview had concluded, and there would be no repercussions for withdrawal. In terms of privacy, participants were assured their responses would be fully anonymized, and they were provided with a participant code in place of their name during the Zoom video conference interviews. Additionally, they were given the option of not having their cameras on for the interviews if they preferred. When conducting research around disability, there can be apprehension by participants towards divulging personal medical information as it pertains to their disability experience. To avoid discussion that would require a participant to provide detailed medical information we avoided interview and survey questions that specifically asked for medical diagnoses, and instead opted for more open ended questions about participants' experience with disability that allowed participants to provide as much or as little specific detail about their medical diagnosis as they felt comfortable.

Participant	**Disability Characteristics**	**Age**	**Gender**	**Years Experiencing Disability**	**Years Playing Video Games**	**Gaming Systems**
P1	Tremors	25	Male	12+	15	PC, Nintendo Switch
P2	Parkinson's, difficulty with coordination, and limited endurance	57	Male	11	3	VR, Oculus
P3	Cerebral Palsy	30	Male	30	10	PC, Nintendo Wii, PlayStation, Mobile, Nintendo GameCube
P4	Fused right-hand fingers, shortened right arm, limited touch sensitivity and movement in the right hand	31	Male	31	26	PC, Xbox
P5	Shoulder laxity, chronic pain, intermittent weakness, tremor	36	Male	5	25	PC, Xbox, Nintendo Switch, Mobile
P6	Missing hand	31	Male	31	24	PC, PlayStation, Nintendo Wii, Nintendo Switch
P7	Musculoskeletal disorder, fatigue in hands/fingers	26	Female	3	2	PC, Mobile
P8	Difficulty with fine motor movement	24	Male	24	14	PC, PlayStation, Nintendo Switch
P9	Hypermobile type Ehlers-Danlos syndrome (hEDS)	35	Female	35	25	PC, Xbox, PlayStation, Nintendo Wii, Nintendo Switch, Mobile
P10	Parkinson's	58	Male	7	40	Nintendo Wii, Mobile
P11	Nerve damage to hands/fingers	25	Male	7	20	PC

Table 1. Participant demographic information.

Though upper limb disabilities were the main inclusion criteria, participants also had other physical disabilities. Symptoms reported by our participants included tremors, touch sensitivity, touch force, response time, touch accuracy, left-handedness, joint instability, dislocation risk, lightheadedness, visual impairments, dizziness, pinched nerves, discomfort, and fatigue.

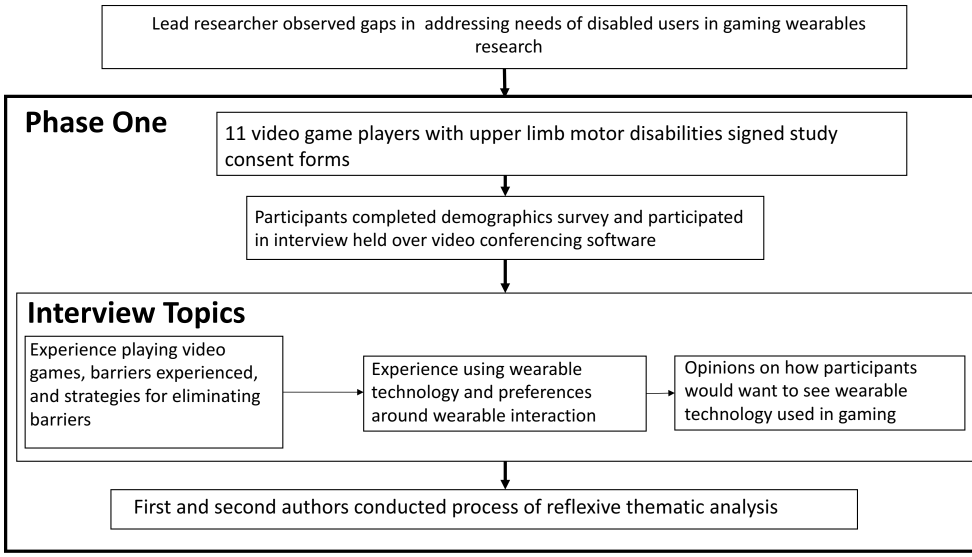


Fig. 1. Diagram of the structure for the first phase of study.

Our participants used phones, tablets, mice, keyboards, and consoles like the Nintendo Switch and Wii to play games. Wearables the used included gaming headphones, microphones, VR/AR devices, smartwatches, phones, and earbuds.

The original demographic survey asked participants to self-declare disabilities, demographics, and game choices. Participants completed a Zoom semi-structured interview after eligibility verification. Audio-recorded 45-minute interviews were used for transcription and data analysis. Interview questions included our participants' video game histories, interaction preferences, opinions, preferences, and experiences using wearable devices for gaming, entertainment, hobbies, and daily activities. At the end of the interview, participants voiced their opinions on future gaming wearables. Questions covered wearable placement, interaction type, appearance and feel. Figure 1 provides and overview of the procedure for the first phase of the study.

3.2 Data Analysis

The first and second authors used reflexive thematic analysis to evaluate participant interview transcripts [18, 19]. Data is parsed to familiarize oneself with the data. Then we coded participant quotes descriptively and latently. Per Braun and Clarke's thematic analysis process, we repeated this five times to standardize the codes. We then organized the codes into themes and subthemes based on participants' gaming and wearable technology values and experiences. After choosing codes, subthemes, and themes, the first two authors met to discuss and reorganize them to be more concise and relevant to inform the design of the future wearable. We discussed how participant quotes were read and resolved conflicts over coding, topic, and subtheme hierarchy.

Because thematic analysis considers the researchers' own experiences, we disclose the following positionality statement: All the authors are educated in accessibility and disability research. Additionally, we each have our own personal lived experiences with disabilities.

4 Phase One Results

We developed three main themes: barriers, disability experience, and designing for disability, which are detailed below.

4.1 Barriers

Aside from financial barriers as a result of the high cost of assistive technology, participants identified unique barriers to wearable and video game interaction including concern for personal safety, and cognitive load barriers.

Regarding personal safety barriers, participants were concerned that gaming interaction might cause pain or injury. Our participants felt a lack of clarity on how new devices like VR might affect their disability, as P1 stated: "With VR, I couldn't use it that long because I found myself getting very lightheaded and dizzy from the visual input. And that is often a trigger for seizures for me." Similarly, P5 said, "I would...like to try that [VR], but that one would be [due to] my lack of coordination. I'm a bit worried to try it [because] there's a good chance that I would fall." Outside of VR, even screen-based video game interaction could cause our participants to experience fatigue. P7 said, "I feel like it's fatigue feeling, and immediately I cannot work anything after playing video games. I need rest after gaming."

In terms of cognitive load, participants reported that barriers such as device sensitivity, and control complexity induced higher cognitive loads. P10 expressed: "I tried the settings even on my PC settings, laptop settings, everything out there is just made for sensitivity [of mouse movement] for a regular user. But not ultrasensitive to do something I need for gaming". Similarly, the complexity of buttons on controllers created a barrier for P5, who said, "With an X-Box controller, it's comfortable to use, but it's too complicated. So there comes a point where I just...can't keep up with the same input requirements...I could when I started."

4.2 Disability Experience

The disability experience theme included the subthemes outcomes of inaccessibility, and current barrier solutions.

The outcomes of inaccessibility subtheme covered aspects such as use of third party devices, physical discomfort, and shortened gaming session length. Our participants rarely used an accessible controller such as the Xbox Adaptive controller. Despite this device being designed for accessible gaming, its lack of use within our participant group shows that there still remains a significant gap in accessible gaming devices. P6 utilized a third-party controller designed to be accessible for one-handed use, but did not find it worked well for them. They explain, "It was [very] confusing. It was a nice thought, but it didn't work." These results show that, despite our participants searching for ways to alleviate inaccessibility, this inaccessibility still results in adverse downstream effects on user experience.

Input device inaccessibility had the effects of physical discomfort for the user, as well as shortened gaming session lengths. P4 used an adapted playing style with an Xbox controller and used their hand and chin to work the controls instead of two hands. This resulted in physical discomfort and a shorter gaming session for them, as they explained, "if I played for too long, I would...get like a rash on my chin from where I was playing the game, using my chin to work like the thumbstick."

In the barrier solutions subtheme, we discuss how participants would create their own solutions to interaction barriers. These solutions included changing the physical way participants were using controllers, or incorporating a social gameplay aspect to alleviate barriers.

Many participants adapted the way they were using a controller or input device to make interaction more accessible. P1 reported holding their controller lighter, P4 used their chin to operate controls, and P6 utilized their knee. P9 found that switching positions often helped them feel better while playing video games, “I fidget a lot. I don’t sit statically when playing due to pain." Our participants moved interactions away from painful areas when they couldn’t modify their posture. P10 said, "I’m right-handed. But I do some left-handed motions to offset the need for the right hand because my left hand is healthy still. My right hand is the one that shakes all the time." Participants also remapped buttons or modified the default controller button-in-game action map. Most video games support button remapping; however, our participants developed workarounds when not. P4 said, "I used to "Joy to Key" ...to custom map [controller] buttons to...keyboard inputs."

Social solutions involved cooperative video game play, or using community or tech support to problem-solve barriers. Friends or family took over control in co-op play. P6 suggested adopting techniques in games where progress often stalled. "I...like Mario Odyssey, but I got stuck on that. So most [of the] time, my brother would play, and I just use the second Wii remote." Its main drawback is that it requires a partner to cooperate. If all else failed, our participants sought community or tech support when issues were more difficult to overcome. P2 said, "I quite often end up on Reddit because that’s where a lot of people are social and interacting about specific questions."

4.3 Designing for Disability

This theme focused primarily on how participants would want accessible gaming wearable interaction to be designed. This included discussion around wearable location, interaction modalities, attributes of the technology participants valued, and motivations they would have for using the technology.

For wearable placement, the extremities (n=9) were most often mentioned, followed by the head (n=5), upper body (n=5), whole body (n=4), and lower body (n=1). Since the hand is already used during gaming, a gaming wearable that enables a more accessible engagement mode for this body component makes sense. The feet extremity was also noted as an underused part of the body in current gaming setups, and could potentially serve as an additional location for interaction.

Participants reported valuing input and output modalities for gaming. They preferred input modalities that promoted gross motor movement over fine motor movement. Gamers with upper limb motor disabilities may struggle with fine motor skills needed to utilize joysticks and keys. “Anything where I could use larger muscle groups rather than my fingertips would make things easier," stated P5. Wearables that provide game feedback were discussed as output modalities because they could boost game immersion. P1 outlined, “If [a gaming wearable] was like output related, like if it was like a haptic thing to help me feel what’s actually in the game or something. Sure. Like that would be cool."

In terms of technology attributes, participants valued technology flexibility. P9 values this in their Nintendo Switch, “I remember being so exuberant when I got the Switch and realizing how many different ways there were to play it, because realizing again with my mobility how much that sets me free. So I’m not limited into only one [use] situation." P6 similarly says, "I want to make sure [a gaming wearable] is not only accessible but is also flexible for [user’s] gaming style and the way that they play their games."

Our participants also considered independence through wearable interaction. P3 adds, “I have to spend a little bit more time and have someone assist me in setting [current gaming interaction] up...But I’d like to be able to set it up by myself, hopefully." Independence was also an attribute participants saw in their current wearables, P5 said their smartwatch provided them freedom: "[my smartwatch] allowed me to go on walks by myself without bringing like a family member just in case this allowed everybody to feel more comfortable with me having a bit more independence."

Participants said they were motivated to play video games for escapism and community. Along with these motives, players emphasized the games’ health benefits. Many of our participants noted

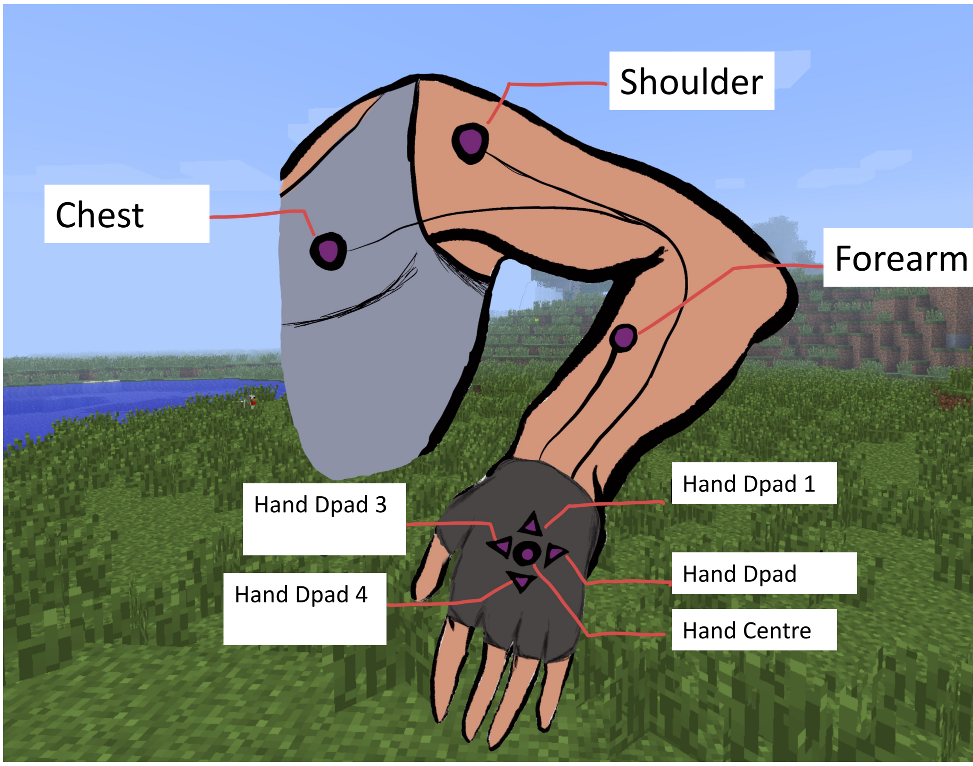


Fig. 2. Electromyography (EMG) Future Wearable, with example game background captured in Minecraft [76]

the added health benefits that video games gave them as a motivation to continue playing. P2 recounts their experience with how playing the virtual reality game Beat Saber provided a source of exercise: "I discovered that...once I started...playing Beat Saber a fair bit, my skills and my movement improved, and my family was shocked that I...saw a big progression."

5 Designing the Future Wearable Game Controller

Phase one provided us with some valuable insights about building accessible gaming wearables, and we utilized this feedback to design ideas for accessible gaming wearables. Aspects we included from participant interviews included placing the wearable on the extremities, using gross motor movement of large muscle groups for interaction, and incorporating some flexibility in where the wearable could be used. Additionally, participants highlighted that wearable interaction may provide game immersion instead of VR, which many found inaccessible.

We envision the first design would use electromyography (EMG) sensors controlled by large muscles and gross motor movements (Figure 2). The future design uses 9 degrees of freedom, including a gyroscope, accelerometer, and magnetometer, allowing gamers to track movement and rotation. The design would encourage flexibility and modularity, which were also requested by participants in phase one to give participants the ability to move the device to alternate body parts. The pieces would be intended to be used with the Xbox Adaptive in an effort to expand the options for accessible gaming that this device offers.

Phase one revealed participants' choices for building an accessible wearable controller. The data did not reveal how to use the device in games. In phase two, we use participatory design fiction workshops to iterate the future wearables and how gamers with upper limb motor disabilities would ideally want to use them.

6 Phase Two Methodology

In the study's second phase, we aimed to imagine how gaming wearables would be implemented into future disabled gamers' lives. Four individuals participated in participatory design fiction sessions. The sessions sought participant feedback on how gaming wearables would be used in their gaming experience to inform the design fiction diegetic prototype. We used a tech review YouTube video to symbolize future gaming wearables in the diegetic prototype.

6.1 Participants

This study included four participants (one female, three male) between the ages of 25 and 58 (average age 36.3). Table 2 shows the participants' demographic for this study phase. According to Bleecker et al. [14], the ideal number of participants for a design fiction session is three to six. Other research that conducts design fiction sessions with participants have used a similarly low number of participants [57, 79]. Inclusion criteria included being able to communicate in English, being at least 18 years of age, having at least one year of experience playing video games for entertainment, and self-identifying as having an upper limb motor disability that results in the characteristics of fatigue in the hands/fingers, lowered finger response time, and difficulty with fine motor movement of the hands/fingers. We chose to define inclusion criteria by disability characteristics rather than specific disability because we still wanted to have a variety of different types of disability represented in our participant pool as in phase one, however, we still wanted to narrow the scope of the types of disability characteristics we would focus on exploring in the second phase. We recruited participants from the participant pool from study one. Participants were contacted only if they consented to be contacted for follow-up studies. Participants were compensated with $20CAD e-giftcards to online stores of their choosing. Ethics board clearance for the study was obtained from the author's institution. As with the study's first phase, specific ethical consideration was put towards ensuring participants felt comfortable and that their privacy was respected. Participants were provided with a detailed informed consent form before completing any part of the study (demographic survey or interview) to ensure they understood what was required during participation and felt comfortable with these requirements. Participants were also assured that they could withdraw from the study if they felt uncomfortable before or after the participatory design fiction sessions had concluded. There would be no repercussions for withdrawal. In terms of privacy, participants were assured their responses would be fully anonymized. Because sessions were in groups, we also considered ensuring privacy between participants within the sessions. Before joining the Zoom call, participants were put into a waiting room, and the first author manually changed their screen names to their participant codes before exiting the waiting room and joining the Zoom call. Participants were also allowed to leave their cameras off during the call if they preferred. As with the study's first phase, the questions and activities in the participatory design fiction sessions avoided requiring participants to provide personal medical diagnoses or private medical information and instead focused on their experiences with disability.

Participant	Participant Code from Phase 1	Disability Characteristics	Age	Gender	Years Experiencing Disability	Years Playing Video Games	Gaming Systems
DP1	P1	Tremors	25	Male	12+	15	PC, Nintendo Switch
DP2	P5	Shoulder laxity, chronic pain, intermittent weakness, tremor	37	Male	5	25	PC, Xbox, Nintendo Switch, Mobile
DP3	P10	Parkinson's	58	Male	7	40	Nintendo Wii, Mobile
DP4	P7	Musculoskeletal disorder, fatigue in hands/fingers	26	Female	3	2	PC, Mobile

Table 2. Participant demographics for the second phase of the study.

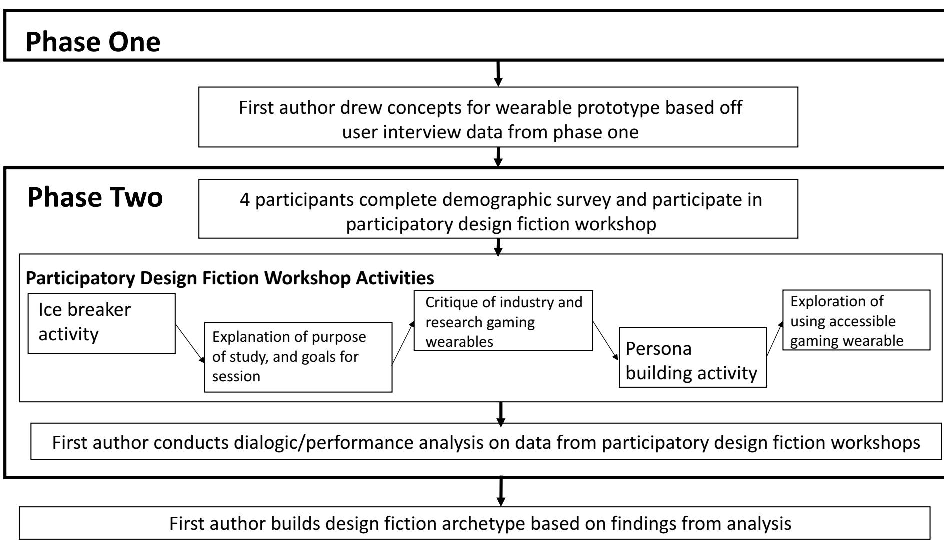


Fig. 3. Diagram of the structure for the second phase of study.

6.2 Procedure

A detail of the phase two study can be found in Figure 3. Two Zoom participatory design fiction sessions allowed participants to turn on or off their cameras and alter their names to their participation codes for anonymity. Participatory design fiction sessions averaged 90 minutes and were audio and video filmed for transcription.

Participatory design fiction sessions explored accessible gaming wearable design space and gathered feedback to create a diegetic prototype based on Bleecker et al. [14]. This fictional technology was based on YouTube gaming tech review videos by YouTubers like Linus Tech Tips [101]. Each session featured five activities, as shown in Figure 3. A Miro board (see Appendix A) described and illustrated each session activity for our attendees.

First, participants met during an icebreaker. Next, design fiction was defined, and the participatory design fiction sessions' goals were explained. Participants were shown a portion of a Linus Tech Tips video reviewing the Xbox Adaptive controller [101] to demonstrate the type of tech review video to be made from their input during sessions. Participants were then shown industry and research gaming wearables and asked to evaluate their accessibility. The three industrial examples were a Wiimote, a bionic prosthetic arm, and a KOR FX haptic gaming vest. Three research examples from Jung et al.'s study [66] demonstrate their "inputs," "gaming cloth," and wig head-worn gaming

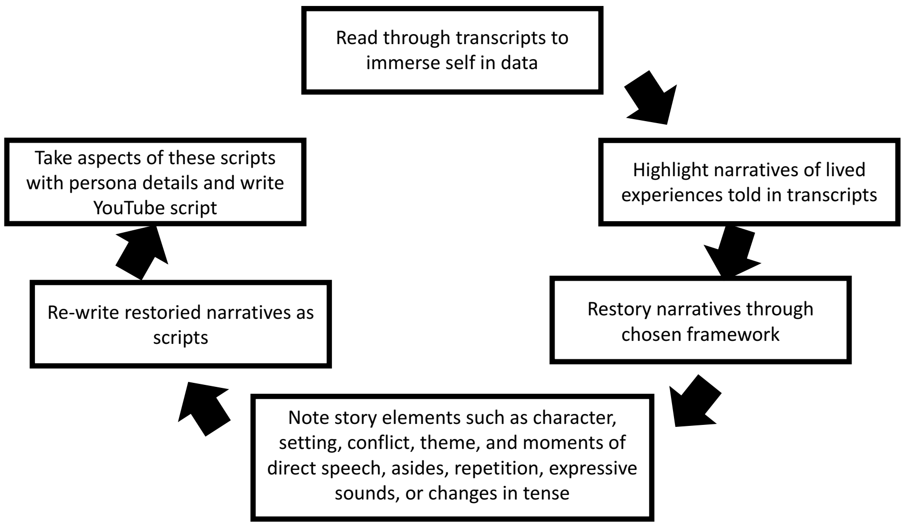


Fig. 4. Diagram of the process used for dialogic/performance analysis on the data from the second study phase

wearable notions. A persona-building exercise followed. Participants were presented with a persona outline and asked to construct one to depict an individual who they think would use a gaming wearable. This persona activity was a character in the diegetic prototype YouTube video that participants could relate to and speak through. Finally, in the design fiction exercise we presented the future wearable concept detailed in section 5 and asked them to critique the wearable, and list the pros and cons of using one for interaction.

6.3 Data Analysis

We used narrative inquiry methodology and utilized the method of dialogic/performance analysis to analyze the data. The narrative inquiry methodology process and dialogic/performance analysis was informed by Creswell [36], Clandinin and Connelly [31], and Riessman [88]. Our analysis was completed in six steps outlined in Figure 4.

We adopted Garland-Thomson's [46] framework for feminist disability studies. According to Garland-Thomson's paradigm, marginalized groups like the disability community experience fit vs. misfit and dependence vs. vulnerability [46]. The range of fit vs. misfit shows how a disabled body and the environment can coexist (fit) or create a barrier (misfit). The spectrum of dependency vs. vulnerability shows how humans want to fit in and how body-environment misfits produce vulnerability—in applying this approach to our participants' actual experiences, the fit vs. misfit spectrum illustrated how physical interaction features created or removed barriers. These barriers or their removal altered the individual's emotional experience (i.e., feeling supported/dependable or unsupported/vulnerable). The participant quotes on lived experience were restoried to emphasize fit vs. misfit and dependence vs. vulnerability. We provided each restoried statement with a numerical number between -5 and 5 to visualize its placement in the framework. Positive numbers represented quotations in the fit and dependency axes, whereas negative values showed misfit or vulnerability. This resulted in the four framework quadrants in Figure 5. As instructed by Riessman [88], contextual characteristics of lived experience quotations were also evaluated. Characters, scenes, conflicts, audience asides, repetitions, emotive sounds, and verb tenses were noted for each lived experience

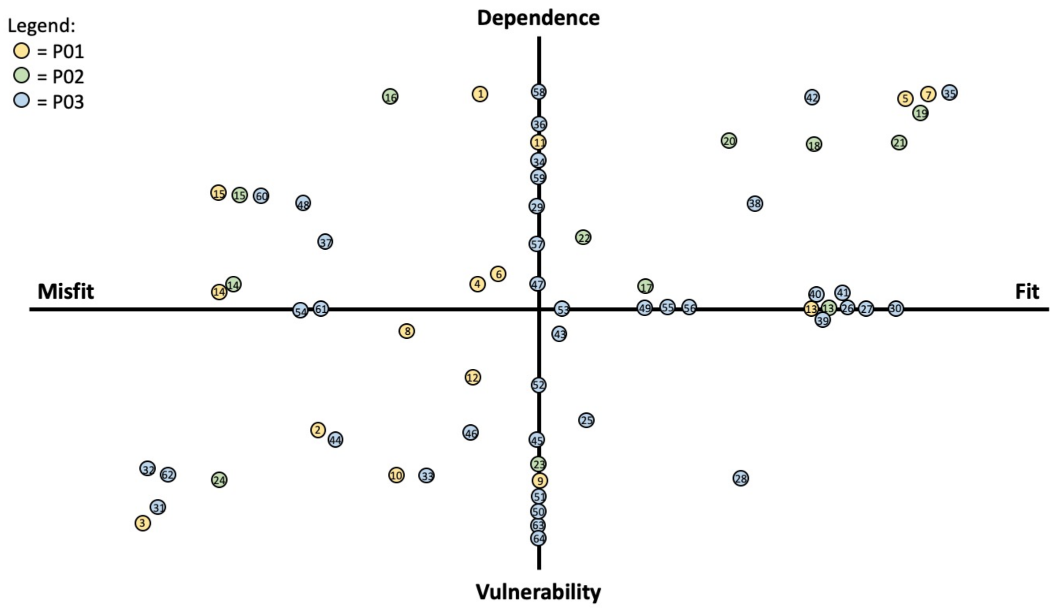


Fig. 5. Visualization of the quotes pulled from participant quotes and where they fit on the Fit vs Misfit and Dependence vs Vulnerability spectrums.

quote pulled from the data. These factors contextualized the lived experience quotation. We included all the quotes in an analysis chart in Appendix B.

After data analysis of the chosen framework and story elements were noted, alternative scripts of the participatory design fiction sessions were created, including lived experience quotations as the framework and contextual notes. These scripts focused on our participants' real experiences from participatory design fiction sessions. These framework scripts made data relating to study questions easy to find. The data then efficiently generated the design fiction diegetic prototype.

The dialogic/performance analysis procedure ended with employing framework scripts to create the diegetic prototype YouTube tech review video script. The YouTube reviewer was based on our participants' personas made through participatory design fiction. The content in the script was influenced by the persona's likes, dislikes, and personality traits and the framework script quotes. The script and video showed the possibilities for accessible gaming wearable and critiqued its implementation in real gaming applications.

7 Phase Two Results

In this section, we present the results of phase two.

7.1 Narrative Inquiry and Dialogic/Performance Analysis

Our data demonstrates that participants described several fit-and-misfit and dependence-vulnerability events. Many of our participants' experiences fall in the misfit and vulnerability, fit and dependence, or both quadrants (Figure 5). The misfit and dependence quadrant commonly featured stories of participants overcoming difficulties or how different interactions could hinder them but they offer ways to design around those obstacles.

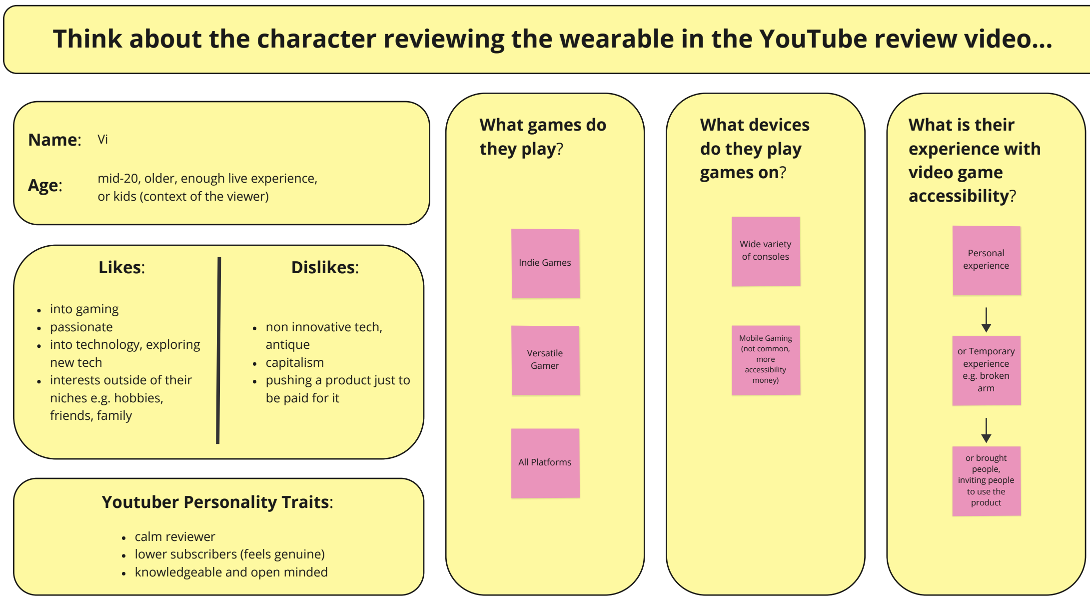


Fig. 6. Completed persona description. This persona compiles different elements proposed by participants during the two participatory design fiction workshop sessions.

The interactive design fiction workshop persona activity shaped the YouTube review video character. According to the data collected in the workshop, the character appears to have first-hand experience with an upper limb motor disability, fatigue and difficulty with fine motor movements. The YouTube character is non-binary, has fewer subscribers, speaks calmly, and is aware of other disabilities. Their interests include Indie games, small enterprises, innovative technology, and accessibility. The participants in the study wanted the character not to use complex jargon. They dislike deception and being paid to promote a product. Therefore, we developed a script for a non-binary disabled YouTuber reviewing a product they supported on a Kickstarter campaign. Figure 6 shows the completed persona which takes elements from the persona activity from both of the participatory design fiction workshop sessions.

The YouTube review video has four parts: the introduction to the product and how the reviewer found the company, an overview of how the product works in practice, a discussion of the benefits and drawbacks of the device, and their conclusive thoughts on the device. Our participants' lived experiences influence the video reviewer's evaluation of the accessible wearable. Table 3 shows some of the restoried participant quotes and how they were translated into the YouTube video script. Appendix C shows additional participant quotes and their adapted quotes in the YouTube script.

7.1.1 Feedback on Using Accessible Gaming Wearables. We presented a proposal for an accessible gaming wearable to get comments on how it might be used in practical gaming sessions. These comments cover the design of the suggested wearable, how it represented accessible features, how accessibility may be enhanced, and the pros and cons of using gaming wearables over a traditional controller.

Participant Quote		Youtube Script Quote
DP2	“The Wiimote I struggled with a bit because it required some bigger movements. That tired me out quicker."	“I did always struggle a bit when using the Wiimote and having to have my arm extended for long periods of time and feeling very fatigued, so I'm hoping I don't have that issue with this device."
DP1	"I also had issues with the Wiimote. Growing up, it was a big source of frustration because particularly with pointing and having to remain steady is not something I can do with my upper limbs."	
DP2	“For me, hand rotation would be like holding up my arm to use as a pointer also wouldn't work, but like to have my hand on my lap and then just be able to sort of bend my wrist to down to move forward, for example. That would be a lot easier for me."	“Okay, so it's nice that it works when I just need to rest my hand on my lap, or even my desk between movements so that does eliminate some fatigue concern I had."
DP1	“My initial thought would be like hesitant to use it as like a main interaction technique as something you have to kind of like consciously do. And I don't know why, but I would I would get kind of like, wrapped up in trying to flex something or contract a muscle to try to do something important in a game."	“Let's try out the muscle sensor part, I feel like this part is a bit more intimidating and maybe a little less natural. Like my initial reaction is how much like mental effort am I going to have to put towards moving individual muscles?"
DP2	“I was just sitting here trying to flex various muscles to see how easy it would be to do."	
DP2	“If you sort of tied them to the motions, that would make sense in the game. Like, like a jump would be like lift lifting your heel off the ground. So like contracting your calve or whatever."	“I've configured [the wearable] so clenching my hand is my item action like punching or hitting with my pickaxe, lifting my ankle off the ground is jump, and moving my shoulder is selecting different items in my hot bar."
DP2	“I think it would be cool if you had a device that was sort of like you could you could put it on whatever part of your body best works for you, but that the controls would be. Like you could, like, sort of customize the controls."	“I do kinda like that you can choose which muscle groups you want to use in games and map them to different actions.", “I really like that it is customizable to whatever part of the body you feel you have the most control of."

Table 3. Restoried participant quotes from participatory design fiction sessions and accompanying quotes derived from them in the YouTube script.

Design. Our participants liked that the gaming wearable's pleasant, accessible features broadened interaction beyond the hands and fingers. DP3 said, "So...this would be exactly what I was...visualizing you're sharing the load with other parts of the arm." Our participants also suggested using the same movement interaction on additional body parts to make it more adjustable and adaptive to more people. DP2 suggested, "If you had a like, a motion sensor that could be controlled by hand rotation...It could also be worn on your chest in a vertical orientation so that you could go with your torso or put it on your leg if that's what you have...[It] seems like it would be adaptable to a wider range of disabilities."

Our participants were more hesitant about the muscular contraction interaction in the proposed wearable, although they recommended ways to make it more accessible. DP1 said, “But my initial thought would be hesitant to use it as a main interaction technique as something you have to like consciously do...I would get caught up in attempting to flex or contract a muscle to do something vital in a game." Even for bigger muscle groups, the mental effort necessary to engage specific muscles was a major obstacle for our participants. Instead, DP2 recommended relating muscular contraction to a muscle movement, saying, "if you sort of tied them to the motions, that would make sense in the game. Like a jump would be like lifting your heel off the ground." Our participants stressed having a wearable's sensitivity customized to their needs. Parkinson's can create muscle excitation when playing video games, according to DP3. Thus, a wearable must account for impairment changes throughout gaming. They added, “When we are in the game and getting excited for the game. I get more...shaking than when I'm not in the game. So again, during the experience, it'd be cool if it was configurable enough to tone it down or turn it up a notch, depending on where I am in the game.

Benefits. The accessible gaming wearable allowed participants to adapt engagement to the body parts they had the most control over. As DP2 stated, "The benefit for me getting a wearable like this would be to utilize muscles that aren't as easily fatigued." According to DP3, a gaming wearable would allow him to work out body areas not currently worked through gaming. As DP3 used gaming for fitness and physical therapy, this was crucial.

Wearable interaction also offered a modular approach, whether adjusting the wearable's location on the body or replacing it with a controller as weariness set in. DP1 said, "If I was playing a game where this wearable was used and after a while, I got really tired because it required a lot of physical activity, how easy it would be just to drop the wearable from use and pick up like a standard handheld controller or something."

The unique interaction with a wearable may also give existing games a fresh experience, according to DP1. "It would make me want to revisit many games that I've already played and experience them for the first time all over again." This unique connection could also bridge the gap between VR and regular gaming immersion. DP1 said, "It would be a cool way [for me] to bridge the gap... to experience a certain level of immersion like virtual reality." VR can be inaccessible to those with disabilities, although using more body parts in video game interaction, like in VR games, increases immersion without the accessibility issues.

Drawbacks. A notable drawback raised was the cognitive effort needed to don and doff a wearable, DP1 described, “I would also imagine...like having to take it off and store it. It would have to be very cognitive to be like okay, I am blocking off X amount of time today to use this." Similarly, the presented proposed wearable was noted as taking more space to use which would make it difficult to multitask; DP1 described, “I tend to look at it like I'll eat while I play video games, just like I'll have my hand one hand on the controller and do something with the other. So now I would feel like I [could not] pick up and drop the game...quickly. I would have to be committed to that play session."

Wearable interaction's novelty, adoption potential, and game integration were drawbacks brought up by the participants. From DP4, "How many games you can play with this wearable... Will people buy it? What's the future of this?" DP2 suggested building games for the device since "sort of adapting anything, you're already at a disadvantage unless somebody is developing the game specifically for use with this system or wearable." Our participants worried that gaming wearables would focus too much on exergames. If it were advertised for exergames, DP1 explained, "I would be less willing to purchase that. I would want it to be something I could make and use in whatever context made the most sense." DP3 mentioned the device's energy for exercising. Wii boxing was DP3's main game and workout. They said, "If I'm [going to] box, I'm doing it not only because I enjoy it, but because it helps me. I'm not able to do anything else that day if I boxed. So if I spend 20 to 30 minutes on that, it's got to be the right thing for me to spend my exercise money on..it better be the right activities to keep me, to give the best return on my investments, my time investment." Participants noted it is essential to consider how fatigue affects their gaming sessions and potentially their energy distribution for the rest of the day.

The cost was the final drawback participants noted. Wearables' increased expense was questioned. DP1 stated, “It seems like it would have to be something additional that was purchased. So there's a financial requirement there." However, DP3 stated they would buy an accessible gaming wearable if they knew it would improve their performance. "I'm not a big spender, but if [something out there] would give me an ounce of improvement, I'd spend it in a moment." There must be a balance between guaranteeing such a technology improves the user experience and how much it will cost.

8 Discussion

We examined the needs of video game players with upper limb motor disabilities for accessible gaming wearables in two phases. In the first phase, we interviewed eleven participants about wearable technology and video game engagement barriers. The second study uses participatory design fiction sessions with four participants to imagine how gaming wearables would change their gameplay.

8.0.1 Strategies for Accessible Gaming Technology. Our participants used customized play styles, which use controllers and input devices differently to make interaction easier. These included using body parts other than the hands and fingers or often shifting their interaction to avoid discomfort. Participants without adaptive play styles used consoles or systems with the fewest barriers. The gaming experience and the ways that users choose to interact with video games differ greatly among users with upper limb motor disabilities. Organizations like Makers Making Change aim to create affordable modifications to video game controllers, such as their one-handed Xbox controller modification [29] and PlayStation 4 controller case [28], to address the high preference and persistent interaction barriers. They are limited because volunteer designers must design these adjustments individually. This suggests that video game players with upper limb motor disabilities should be allowed to personalize and DIY their game engagement. DIY culture and disability are extensively studied in HCI research [1, 34, 55, 86]. DIY tactics could help gamers with disabilities design interaction solutions instead of waiting for organizations like Makers Making Change to help. Xbox Adaptive gadgets can also aid DIY projects. Any 3.5mm mono jack interactive device is compatible with the Xbox Adaptive controller. Thus, it has great promise as a link between DIY interface gear and video game software and should be researched.

8.0.2 Strategies for Accessible Gaming Wearables. Research on gaming wearable design emphasizes interactivity, socialization, and performance [24, 25, 66]. Our participants valued wearables that allowed involvement and socializing but not performativity. Our participants preferred interaction that allowed movement. The use of movement in video games has been extensively studied in rehabilitation and exercise applications [2, 3, 62, 109]. Some research aim to develop new exergames for people with disabilities [2, 62, 107]. It is also valuable to explore how to add a high level of physical movement to interact with games that users already own or non-exergames they are interested in purchasing. This was explored by Ahmetovic et al. [3] in a rehabilitative/exergame context, as well as Hassan et al. [59] for esports applications. However, Ahmetovic et al. [3] focused on rehabilitative and exergame applications of physical movement for game interaction, which our study shows not all video game players with upper limb motor disabilities are interested in. Though incorporating physical movement in video game interaction is beneficial to users with disabilities, focusing game interaction entirely on rehabilitative purposes does not fulfill the needs of gamers with disabilities and should be balanced with game interaction for entertainment purposes. This concept was explored by Hassan et al. [59] for users with limb differences who played esports. This is one disability demographic and video game genre. There is a need for HCI researchers to investigate this further.

8.1 Participatory Design Fiction: Workshop and Tools

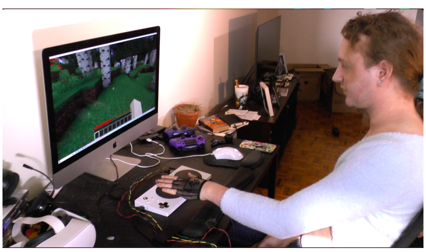
Phase two employed personas to help participants identify with a user during the participatory design fiction session and data from the sessions to inform the design fiction diegetic prototype.

8.1.1 Personas. The study's first phase revealed that some participants were uncomfortable discussing personal gaming experiences or wished to discuss the needs of other people with disabilities. In the second phase, we introduced a persona-making activity to focus the conversation on lived experiences and users with upper limb motor disabilities. Our YouTube video design fiction diegetic prototype involves this persona reviewing and streamlining dialogue. Our participants desired the persona to be non-binary and depict a user with upper limb motor disabilities. This emphasizes intersectionality in disability design. This intersectionality may be represented by multiple disabilities or marginalized identities (like the persona's non-binary identification). Because the study did not ask individuals about their identities beyond disability, this value toward intersectionality would likely not have developed without a persona. Personas helped participants streamline input to users with upper limb motor disabilities while emphasizing intersectionality. This provided more information to construct a prototype of an accessible gaming wearable for this user group. Our participants shared more about their experiences and preferences through the character.

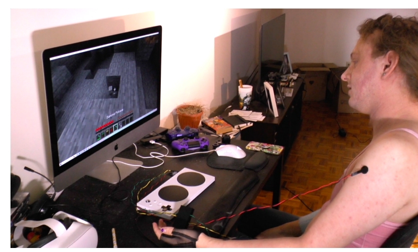
Using personas in HCI research helps designers and researchers understand the demands of certain user groups [40]. HCI research highlights the limitations of personas, including reinforcing stereotypes [61, 72, 102]. This potential was not taken lightly, and to avoid any possibility of stereotypes being implemented, we let our participants— all of whom had upper limb motor disabilities—lead the conversation about the persona's traits. A challenge with personas is that designers typically create them but rarely use them [61]. Through the YouTube reviewer character, we incorporated the participant persona into the design fiction diegetic prototype to guarantee it informed future designs. Marsden and Haag [72] and Hill et al. [61] emphasize the importance of personas in promoting personal reflection. We found this helpful for participants to reflect on their personal experiences when creating the persona. This let participants tell their stories through the identity. The persona also helped us appropriately cast the actor in the review video who had an upper limb motor disability and was part of the non-binary community. The actor was also given space to improvise lines from their own lived experience in the video.

8.1.2 Design Fiction Diegetic Prototype. Design fiction is a common method in HCI to inform designers and researchers about future implications of adopting new technology [14]. The diegetic prototype [14] represents this implication, and aims to realistically reflect future technology in a media where it would fit now. The goal of our diegetic prototype was to authentically represent the experience of using an accessible gaming wearable as described by participants during the participatory design fiction sessions. In HCI research, there are many examples using design fiction diegetic prototypes to represent future concepts through different mediums. These mediums include posters [67], storyboards [57, 79], physical prototypes [15, 74, 79, 81], work booklets [5], and body maps [17]. As a research team we considered these different mediums, but decided to explore a video format instead and modelled this video after tech review videos by YouTubers like Linus Tech Tips [101]. Tech review videos are commonly used in gaming communities to explore positive and negative attributes of technology, and therefore would present a natural fit for our goals of representing the experience of using an accessible gaming wearable better than through mediums like posters or physical prototypes. The tech review video can give a more detailed visual representation of the community to inform the design of future wearables. In the video we witness a gamer with an upper limb motor disability using a gaming wearable and hear our participants' stories. This visual and audio narrative immerses viewers in a fictitious world with accessible gaming wearables and shows us what it might be like. Figure 7 shows different scenes from the video. We also liked that design fiction did not require participants to imagine future technology. Their ideas could be realized with present technology. Still, understanding how these technologies can enable idealistic futures for upper limb motor-disabled video game players was valuable.

Our chosen analysis method of dialogic/performance analysis also greatly supported the process of creating the design fiction diegetic prototype. The two aspects of dialogic/performance analysis that we employed that particularly assisted the diegetic prototype creation were the use of restorying participant quotes using the fit vs. misfit and dependence vs. vulnerability framework, as well as creating scripts of these restoried quotes for each of the two sessions. The framework allowed participant voiced experiences and opinions data to be contextualized. Additionally, these restoried quotes when put together as a script helped us identify specific aspects of participants' experiences that were particularly relevant and informative about the design and practical use of an accessible gaming wearable. These quotes could then be picked out and placed within the script for the diegetic prototype YouTube video as talking points for the reviewer character. Due to both the analysis method of dialogic/performance analysis and the diegetic protoype medium requiring the creation and use of a script these methods were a natural fit. However, valuable future research using dialogic/performance analysis and design fiction could show how alternate diegetic prototype mediums could also fit with the analysis method.



(a) Scene showing how a gaming wearable could use hand movement to play a video game.



(b) : Scene showing how shoulder movement could translate to in-game action in a video game.

Fig. 7. Two scenes from the YouTube video diegetic prototype that represent how the different aspects of the future wearable concept could be used with a video game.

8.2 Reflecting on Reflexive Thematic Analysis and Dialogic/Performance Analysis

This study let us try several data analysis strategies. We value thinking on each analysis method and how we used it in each study phase. After using the qualitative methodology phenomenology and reflexive thematic analysis, we employed narrative inquiry and dialogic/performance analysis. This latter method is innovative for participatory design fiction HCI research. It was worthwhile to illustrate how each method differs and how they benefit analysis.

8.2.1 Reflexive Thematic Analysis. Phase one began with reflexive thematic analysis based on Braun and Clarke's work [18]. This qualitative data analysis method is applied in numerous research fields. Braun and Clarke write that their thematic analysis method is often misused, which motivated their 2019 paper clarifying the method and its applications [18]. This was the primary writing about reflexive thematic analysis that we followed to analyze the study's first phase.

The core of the thematic analysis is in the themes that the data is described through. These themes represent "interpretive stories about the data, produced at the intersection of the researcher's theoretical assumptions, their analytic resources and skill, and the data themselves" [18]. It considers the researcher's perspective, data substance, and participants' perspectives. This method is beneficial since it utilizes the researcher's subjectivity to improve data rather than threatening objectivity [18]. Keeping participants' words in context was a drawback of this analysis strategy. Reflexive thematic analysis uses themes and codes to express participants' thoughts and experiences. Reducing a complete representation of lived experience to a subject or code and focusing on how they interact can eliminate some nuances in participant quotes.

Finally, we produced many codes using thematic analysis of interview data. However, some participants were not as talkative during the one-on-one interviews which required the interviewer to try their best to elicit opinions with follow-up questions. This is a barrier we attempted to alleviate by using personas in the second phase of the study, as discussed previously.

8.2.2 Dialogic/Performance Analysis. The study's second phase uses the narrative inquiry method of dialogic/performance analysis. This study explores a novel use of this narrative inquiry method for participatory design fiction-based HCI research, as this approach is only sometimes employed in HCI research. Here, we discuss the advantages of this narrative inquiry method for participatory design fiction research and how it was used overall.

According to Smith-Chandler and Swart [92], narrative-based methodologies are crucial for disability studies. In narrative inquiry, persons with lived experience with disability can "challenge static beliefs etched in impairment stereotypes." [92]. They also note that "alternative voices of disability can be heard from the unique perspectives of the individuals themselves." [92]. Our participatory design fiction research shows the value of various voices to understand lived experiences and perspectives and identify commonalities or barriers. Participants with various upper-limb motor disabilities shared barriers and thoughts on the usefulness of an accessible gaming wearable. Finding connections and reflecting on comparable experiences let participants share and build on each other's narratives.

Similarly, Vyas et al. [106] explored the lived experiences of persons in under-resourced communities through narrative inquiry. We likewise discovered that hearing other participants' stories helped our participants open up about their experiences. Participants could also communicate their experiences and beliefs through the design fiction activity of building a persona for our YouTube video diegetic prototype. Design fiction and persona building strengthen narratives and help us understand future prototype design for the community.

8.2.3 Differences in Processes. The primary difference we observed between the two data analysis methods was the level of context kept intact. Reflexive thematic analysis, like narrative, is focused solely on the content of what participants say. During reflexive thematic analysis, sentences or expressions from participants are whittled down to one or two words that encompass the meaning of what was said in a code. In organizing these individual codes into more significant themes and subthemes, keeping the context of how each participant voiced each code was challenging. This resulted in some repetitions of codes in different themes and subthemes. With dialogic/performance analysis, the context of how participants voice their lived experiences is kept intact more than reflexive thematic analysis. Furthermore, the narratives analyzed with dialogic/performance analysis could still be reduced to establish the narratives concerning the framework while retaining the context that participants established while voicing their narratives.

Finally, the conversational nature of the research during the two stages and how it affects data analysis should be discussed. Dialogic/performance analysis explicitly involves the researcher. This encourages narratives through dialogue and is useful when the researcher shares their personal experiences. In our research, the first author leading participatory design fiction sessions is neurodivergent and struggles with video game controllers. Reflexive analysis simply evaluates participants' input, excluding the conversational aspect that enriches lived experience research. In disability research, diverse lived experiences enrich data [92]. Dialogic/performance analysis can better value these voices.

Reflexive thematic and dialogic/performance analysis are more useful and yield distinct outcomes. In our reflexive thematic analysis of interview data, we retained a lot of material from a small sample. We described the participants' needs and experiences. Dialogic/performance analysis of participatory design fiction sessions revealed participants' narratives of their lives, which helped inform the design of the diegetic prototype.

9 Limitations and Future Works

Regarding limitations, we acknowledge that participants recruited for this study are exclusively representative of Western, educated, industrialized, rich, and democratic (WEIRD) societies. Additionally, this study was limited in the spectrum of disability characteristics. Upper limb motor disabilities are extensively diverse, and we recognize that it would be impossible to generalize our findings to all users with upper limb motor disabilities. We also note the importance of including researchers in these projects who have upper limb motor disabilities. We hope others will run similar studies to gain even stronger insights into understanding the lived experiences of gamers with upper limb motor disabilities. We also acknowledge the specific ethical considerations around including participants with disabilities, and have outlined in this paper the precautions we took to ensure a comfortable, safe, and respectful environment for our participants. We encourage future researchers to similarly consider how their research can be more ethical for participants with disabilities. This includes ensuring research is conducted in a respectful manner, and we especially encourage researchers to consider whether collecting personal medical information (e.g. medical diagnoses, medical treatment information) is strictly necessary. Disclosing such personal information may be uncomfortable for participants with disabilities, and may in certain cases be traumatic for participants.

Future work on accessible gaming wearables should similarly explore different types of disabilities beyond just upper limb motor disabilities. There are diverse disabilities represented in the disabled gamer community, and similar studies to explore how gaming wearables should be designed for these groups should be explored. Our research presented an idea for an accessible gaming wearable and represented its use through a design fiction diegetic prototype. Our next step in this research is to create a working prototype of an accessible gaming wearable and evaluate it at the low-fidelity and mid-fidelity levels.

Future work on dialogic/performance analysis should explore other examples of how this analysis method can be applied to other types of participatory design fiction research. Our research presented a natural fit for dialogic/performance analysis as our chosen design fiction diegetic prototype was a script and accompanying video for a tech review YouTube video. Design fiction diegetic prototypes can represent a diverse number of artifacts, and exploration into how dialogic/performance analysis can support other types of design fiction diegetic prototypes is valuable. Future applications of dialogic/performance analysis with disability research should also strive to create a framework specifically for disability research in HCI.

10 Conclusion

This study aimed to explore the design space of accessible gaming wearables for players with upper limb motor disabilities. Through eleven semi-structured interviews and two participatory design fiction sessions, we explored the lived experiences of gamers with upper limb motor disabilities, the barriers they experience, their strategies for overcoming barriers, and their feedback on proposed and existing gaming wearables. Additionally, we reflect on reflexive thematic analysis and dialogic/performance analysis performed on the qualitative data collected through the study.

Through the first phase of the study, we identified the different strategies that players with upper limb motor disabilities use to circumvent accessibility barriers, as well as different aspects that would be valuable in accessible gaming wearables. We furthered this exploration with participatory design fiction sessions to envision what gaming interaction would look like for players with upper limb motor disabilities if they used wearable interaction. We represented this envisioned future through a design fiction diegetic prototype, which we chose to show through a tech review YouTube video. Our research additionally utilized personas.

We found some participants in the study's first phase less eager to provide stories of lived experiences to identify their needs and experiences and alleviating interaction barriers, so personas were used in the second phase as a conduit to generate a deeper understanding of the user group. This helped participants tell their narratives of lived experience through the persona. Additionally, this persona served as the character in the tech review YouTube video.

Lastly, we present a detailed explanation of how we applied dialogic/performance analysis to our participatory design fiction sessions. This method of data analysis is seldom used in HCI research and lacks clear examples of how to apply this method to HCI research. We hope future researchers find value in our detailed example of how this analysis method can benefit HCI research.

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