A Diary Study in Social Virtual Reality: Impact of Avatars with Disability Signifiers on the Social Experiences of People with Disabilities

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ABSTRACT

People with disabilities (PWD) have shown a growing presence in the emerging social virtual reality (VR). To support disability representation, some social VR platforms start to involve disability features in avatar design. However, it is unclear how disability disclosure via avatars (and the way to present it) would affect PWD's social experiences and interaction dynamics with others. To fill this gap, we conducted a diary study with 10 PWD who freely explored VRChat—a popular commercial social VR platform—for two weeks, comparing their experiences between using regular avatars and avatars with disability signifiers (i.e., avatar features that indicate the user's disability in real life). We found that PWD preferred using avatars with disability signifiers and wanted to further enhance their aesthetics and interactivity. However, such avatars also caused embodied, explicit harassment targeting PWD. We revealed the unique factors that led to such harassment and derived design implications and protection mechanisms to inspire more safe and inclusive social VR.

CCS CONCEPTS

• **Human-centered computing** → **Virtual reality**; **Accessibility technologies**.

KEYWORDS

Social virtual reality, avatar, disability disclosure, harassment, diary study, protection mechanisms

1 INTRODUCTION

Social Virtual Reality (VR) is a simulated virtual space where multiple users meet and interact with others in the form of avatars [24]. Through the full-body tracking avatars, kinesthetic interactions, and synchronous voice chat, social VR enables embodied social experience that simulates the "face-to-face" communication in real life [23]. The COVID-19 pandemic has further promoted the adoption of social VR, making it an important social platform. However, the embodied nature and the lack of established norms in social VR bring high social risks, such as inappropriate behaviors, cyberbullying, and heightened privacy concerns [5, 23, 47, 65]. The term *embodied harassment* is thus coined to characterize the harassing behaviors conducted and experienced through the embodied avatar bodies [23]. Prior research shows that the sense of embodiment can exaggerate the negative feelings from harassment [5].

Compared to general users, the historically underrepresented communities (e.g., LGBTQ, ethnic minorities, and women) face an higher amount of and more disruptive risks when disclosing their identities in social VR [23]. For example, female users report more harassment than male users in social VR [21, 65], and non-white avatars are more likely to attract social stigma and become victims of racial discrimination [21]. However, little research has focused on the social VR experiences of people with disabilities.

As an important marginalized community with 1.3 billion people worldwide [52], people with disabilities (PWD) have shown increasing presence in social VR. Prior research has explored PWD's identity disclosure preferences in social VR and found that many PWD are willing to disclose their disability via avatar design [45, 74]. Zhang et al. have also revealed PWD's concerns about the potential risks caused by disability disclosure in social VR using avatars, such as being treated unequally and exposing vulnerability to strangers [74]. Yet, no research has deeply explored PWD's experiences in social VR and the impact of disability disclosure via avatars. Many important socio-technical questions remain unaddressed. For example, how will social VR users react to an avatar that indicates

disability? Will such avatars trigger more harassment and cyber-bullying? What technologies can be designed to support PWD in disability disclosure and protect them from potential risks?

To fill this gap, we conduct a diary study to explore the impact of avatars with disability signifiers on PWD's experiences and derive implications to inspire inclusive avatar design as well as protection mechanisms against harassment in social VR. We adopt the term "**Disability Signifier (DS)**" to describe any features on avatars that could signify a user's disability in real life, such as a sign, a symbol, or a piece of assistive technology [74]. We recruited ten PWD who freely explored a widely-used commercial social VR platform—VRChat—for two weeks. We observed and compared their social VR experiences when using two types of avatars (one avatar per week): (1) a regular avatar without DS, (2) and the same avatar with DS (e.g., a virtual wheelchair) to reflect their disability.

Contextualized in the unique avatar-centered culture of VRChat, we found that avatars with DS became an attention grabber that attracted more social interactions but also triggered more harassment. We identified six types of harassment triggered by avatars with DS, including ableist language, teasing, physical harassment targeting DS, mimicking one's disability, discrimination in group activities, and being treated as inferior. We further revealed the perception gap between PWD who used avatars with DS and other users in VRChat—PWD perceived avatars with DS as a self-presentation strategy while other users without disabilities perceived avatars with DS as trolling or meme avatars. Surprisingly, despite the harassment experiences, most participants indicated the willingness to continue using avatars with DS in the future and suggested various technologies to mitigate potential harassment.

Our research makes three contributions to the ASSETS community. First, to the best of our knowledge, this is the first research that studies the impact of disability disclosure on PWD's social VR experiences via an observational study. Second, we identify the unique types of harassment targeting PWD in social VR, the factors that lead to such harassment, and the strategies adopted by PWD to cope with the harassment. Third, we derive design implications to support more inclusive and safe social VR for PWD.

2 RELATED WORK

2.1 Social Barriers and Stigma Faced by PWD

Participating social activities and building connections with others contribute to personal well-being. However, PWD face multiple barriers (e.g., mobility issues, communication issues) that largely restrict their involvement in social activities [55, 70], leading to social isolation and loneliness [18, 28, 44]. The social stigma caused by the use of assistive technologies [34], separation from peers while growing up [14], and discrimination and bullying that targets disabilities further prevent PWD from actively engaging in social activities and being socially accepted by their peer community who do not experience disabilities [17]. As a result, PWD are more likely to spend long time alone, not cohabit with a partner, have limited contacts with family and friends, and be unemployed for an extended period of time [44].

With the rise of social media, PWD could better connect and interact with others online without being limited by physical obstacles. However, a myriad of HCI research shows that PWD still experience cyberbullying and online discrimination [2, 9, 31, 32, 41, 42]. For example, Burch [9] collected and analyzed 24 Reddit threads and 16,908 comments to study the hate speech targeting disabilities, revealing the widespread use of ableist language and the portrayal of PWD as the burden and waste of public resources. Heung et al. [32] conducted interviews with 20 PWD to investigate ableist microaggression on social media. They uncovered 12 archetypes of microaggressions, such as questioning PWD's ability to contribute to society, accusing the authenticity of disability, and asking invasive privacy questions. Moreover, compared to real-world social settings, the anonymity of interactions on social media posed extra threats to PWD. Both studies from Alhaboby et al. [2] and Burch [9] found that some users created backup social media accounts with fake information to post hate speech to PWD, not worrying about the consequences due to the anonymity of Internet.

PC-based virtual worlds (e.g., Second Life, Minecraft) present another form of social media, where users can interact with each other via avatars rendered on a 2D screen. This medium presents new social opportunities for PWD [7, 68, 69] but also introduces new online risks and barriers to PWD [11, 56, 68]. For example, Ringland [56] observed 200 hours of social activities in Autcraft, a Minecraft server designed for children with autism. The study highlighted the safety issues faced by autistic children in virtual worlds, where their autistic identities caused online harassment and violence from both their peers and strangers. Beyond safety concerns, the inaccessibility of virtual worlds also prevents PWD from engaging in social activities [11, 68]. For instance, Carr et al. [11] designed four teaching forums in the Second Life to investigate students' learning experiences in virtual worlds. They found that the synchronous voice chat feature was inaccessible to deaf students, which excluded them from participating in group discussions.

Although prior work has discussed PWD's social barriers in various social context, ranging from real life social activities to conventional social media to PC-based virtual worlds, little research has investigated the experiences and stigma that PWD may face in the emerging social VR.

2.2 Avatar-mediated Interaction and Identity Representation in Social VR

In recent years, VR has gained increasing popularity and promoted a new social format—Social VR [21, 73]. Unlike the PC-based virtual worlds where users rely on a mouse and a keyboard to manipulate their avatars on a 2D screen [40], social VR affords embodied first-person avatar experience and simulates "face-to-face" interactions via full-body tracking and synchronous verbal communications [47, 51, 73]. Researchers have studied the uniqueness of avatar-mediated interactions in social VR [21, 39, 48, 51, 73]. For example, McVeigh-Schultz et al. [48] found that the full-body tracking avatars enabled physical gestures in communication (e.g., hand shake) and led to more embodied interactions.

Beyond the embodied avatar experience, social VR also offers high flexibility in avatar customization, allowing users to curate

their social images via avatar design. A myriad of research has investigated how users craft their avatars in PC-based virtual worlds, including both 3D video games [16, 25] and social virtual worlds (e.g., Second Life) [16, 38, 62, 71]. Some recent efforts have been made to investigate how people present their identities via avatars in the more embodied social VR [21, 24]. For example, Freeman et al. [21] interviewed 30 social VR users, revealing that the avatar embodiment make people consider avatars to be themselves and create avatars that are similar to their physical appearances.

Beyond the general users, researchers also start investigating the experiences and avatar design choices of marginalized groups in social VR, such as children [46], women [58, 66], older adults [3], LGBTQ [20, 22, 23], and racial minorities [6, 21, 23]. For instance, Freeman et al. [22] interviewed 59 participants to explore the non-cisgender's experiences and avatar choices in social VR, finding that they used avatars with different genders to signify their flexible and fluid gender identities and carefully customized their avatar accessories and clothing to present the non-cisgender identity. Moreover, Baker et al. [3] conducted a five-month study with 16 older adults to explore their identity construction via avatars, revealing participants' strong desires to adjust their avatar appearances to fit different social contexts, such as a male user designing a female avatar to better communicate with female users.

However, little research has focused on PWD in social VR, a large and historically marginalized community. To our knowledge, only two recent projects explored PWD's avatar design choices. Zhang et al. [74] interviewed 19 participants who had visual and hearing impairments and revealed that PWD preferred disclosing their disabilities via avatars and adopted a spectrum of strategies to curate their images in social VR, such as revealing selective disabilities and indicating ability changes via avatars. The other work by Mack et al. focused on PWD with invisible disabilities and how they managed multiple identities via avatar design [45]. They found that participants with multiple, intersecting minoritized identities needed to make trade-offs when deciding which identities to present via avatars, especially when the expression of one identity conflicted with the other (e.g., a South Asian person with albinism had difficulty presenting their race and disability at the same time). Despite the investigation in PWD's identity representation preferences via avatars, no research has explored how presenting disabilities via avatars would affect PWD's social VR experiences and what potential risks it may bring.

2.3 Harassment and Stigma in Social VR

Prior research has investigated harassment experiences and privacy issues in social VR [5, 6, 23, 47, 66]. For instance, a survey study from Shriram and Schwartz [66] indicated an increasing presence of harassment in social VR: 21 out of 99 male participants and 2 out of 7 female participants encountered harassment, and 42% participants reported experiences of witnessing someone else being harassed. Freeman et al. [23] further defined harassment in social VR as *"embodied harassment"* and identified four key characteristics, including physical behaviors that aimed to disturb others, forced attention through voice chat, invasion of personal spaces, and unequal social dynamics between adults and minors. Yet, governing

harassment in social VR remains challenging. Through interviewing 25 VR users, Blackwell et al. [5] found that the embodiment and sense of presence of social VR intensified harassment feelings, and the lack of social norms in defining appropriate behaviors and the highly subjective perception of harassment made the enforcement of platform-based regulations very challenging.

The risks in social VR could become more severe for people in the underrepresented groups [6, 21, 24, 30, 46, 47]. For example, non-white avatars were found to more easily attract social stigma and become victims of racial discrimination, and female avatars were more susceptible to sexual harassment in certain circumstances [21]. The voice chat feature of social VR further exacerbated the problem since it revealed a user's identity (e.g., gender, linguistic background) regardless of their willingness of identity disclosure [47]. Prior research has shown that some users have been forced by others to speak in social VR to reveal their true identity [23].

Limited efforts have been made to mitigate harmful behaviors. Typical harassment combating mechanisms in current social VR platforms are predominantly post-hoc and reactive methods, allowing users to block, mute, or report a perpetrator after an incident has occurred with harmful impacts [23, 61]. Kelsea et al. has investigated the potential of AI-based moderation and found that the embodied, real-time nature of social VR makes the effectiveness of this method questionable [60]. Meanwhile, some platforms (e.g., Horizon Worlds, AltspaceVR, Rec Room) adopt more proactive protection methods, such as the "Safe/Personal Bubble," making any avatar fully invisible if they get too close to a user and thus preventing physical harassment between avatars [49]. However, such proactive mechanisms often undermine a user's immersive experiences in social VR, because no one, including their friends, can get close to a user when the bubble feature is activated [61].

Despite the prior work on harassment and combating methods in social VR for diverse population, no study has deeply explored what unique risks PWD may face if they disclose their disabilities via avatars and what coping strategies they use to protect themselves. Our research aims to fill this gap by conducting a two-week diary study to compare PWD's social VR experiences and behaviors when using avatars with and without DS. We seek to identify the unique risks targeting PWD in social VR and derive design implications for effective protection mechanisms.

3 METHOD

To deeply explore how avatars with DS influence PWD's social VR experiences, we conducted a two-week diary study with 10 PWD who freely explored VRChat using avatars with and without DS. The study was approved by the Institutional Review Board (IRB).

3.1 Participants

To comprehensively understand the impact of different DS on PWD's experiences, we broadly recruited PWD without restricting the disability type. We leveraged various channels for the recruitment, including the mailing lists of non-profit disability organizations (e.g., the United Spinal Association, the National Federation of the Blind), the disability and VR communities on mainstream social media platforms (e.g., DisabiliTEA on Discord, r/CerebralPalsy and r/amputee on Reddit), referrals from recruited participants, and our

university's student job forum. Interested participants would fill out a survey with screening questions, in which we asked about participants' age, disability conditions, and general experiences with VR and social VR. Eligible participants must (1) be over 18 years old, (2) have at least one disability, and (3) have access to a device that supports social VR applications (i.e., a VR headset or a Windows computer). We limited our recruitment to individuals who spoke English. If selected, participants were asked to complete an oral consent at the beginning of the study.

We recruited 10 participants (4 female, 5 male, 1 non-binary) with ages ranging from 18 to 61 ($mean = 34.1, SD = 13.39$). Our participants had diverse disabilities, including mobility disabilities (e.g, amputee, cerebral palsy, spinal cord injury, genetic brittle bone condition), chronic health issues (e.g., PoTS), and neurodiversity (e.g., autism, ADHD, asperger). Four (P1, P2, P7, P9) had invisible disabilities, meaning that they experienced physical and psychological conditions that had no visible manifestation or had visible features that were not clearly connected to a disability [19, 36, 59]. However, except for P2 who used arm braces and compression gloves to deal with repetitive strain disorder, the other three participants (P1, P7, P9) used visible assistive technologies that could easily reveal their disabilities (e.g., a wheelchair) in daily life. The remaining six participants had visible disabilities and used visible assistive technologies (e.g., prosthetics, walking cane, wheelchair).

Seven participants had used VRChat to socialize with others or play games, and four of them (P1, P3, P4, P5) had used VRChat for at least a year. The other three participants (P6, P7, P10) had experiences with Second Life. No participants had created an avatar with DS before due to the lack of DS options in existing avatar systems and the technical and financial challenges in creating fully customized avatars. Seven participants used VR headsets (i.e., Oculus Quest 2, HTC Vive Pro, Valve Index) to complete the study, while three participants (P6, P9, P10) had to use VRChat through Windows computers due to the inaccessibility of VR headsets. For example, P6 had a C-4 to 5 spinal cord injury and needed the keyboard remapping function on a computer to experience VRChat. Table 1 shows participants' information. Participants received a compensation of $125 upon the completion of the study.

3.2 Apparatus

Our study was conducted in VRChat[1]. We selected VRChat as our study platform since it was one of the most popular social VR platforms—VRChat had the largest number of daily active users (22,000) and a total user amount that exceeded 4 million [15, 67, 72]. Moreover, VRChat relied heavily on user-generated content and allowed users to design and upload customized avatars [15], which gave us the freedom to design avatars with DS for the participants. VRChat consisted of many virtual worlds with different themes (e.g., Rooftop Bars, Black Cat, Chess, No Time Two Talk), in which users could explore and participate in various social activities or games [43]. For instance, users could watch a movie with friends in a virtual theater or join a party in a virtual house.

During the study, participants freely explored VRChat with two types of avatars: (1) a regular avatar of their choice, and (2) the same avatar with DS that reflected their disability (e.g., a virtual

wheelchair, a virtual cane). We created custom avatars for each participant. We generated the regular avatars using *Ready Player Me*[2], a commercial 3D avatar platform that was compatible with VRChat and provided hundreds of avatar customization options (e.g., facial features, skin tone, outfit styles). We crafted the avatar appearance based on participants' preferences in the initial interview (Section 3.3.1)[3]. We then designed the DS based on each participant's preferences and added them to the regular avatars using Blender[4]. We finally imported the avatars with DS to Unity and made them compatible with VRChat using the Avatars SDK[5].

We solicited participants' feedback on the avatar and DS design and iterated on them until they were satisfied with the avatars. As a result, our study involved various DS across participants, including wheelchairs (P4, P6, P7, P9, P10), walking canes (P1, P8), bandaged hands (P2), prosthetic arms (P3, P5), and an electric stimulation device on the knee (P5). While most participants only adopted one DS, P5 used multiple DS—a prosthetic arm and an electric stimulation device on the left knee—to express his disabilities. Figure 1 shows the avatars with and without DS used by each participant. To assign the custom avatars to participants, we created a new VRChat account for each participant and set up the avatars to be ready to use for them before the diary study.

3.3 Procedure

The study consisted of three phases: an initial introduction phase, a diary study phase, and an exit interview phase.

3.3.1 Initial Introduction. We first conducted a one-hour initial interview over Zoom, asking about participants' demographics (i.e., age, gender), disability conditions, prior experiences with VR and social VR, their avatar customization experiences (if any), and their willingness of disclosing their disabilities via avatars. The initial interview protocol is listed in Appendix A.1.

We then discussed with participants about their avatar design preferences to create avatars and DS for them (Section 3.2). We explained the two types of avatars they would use in the study and asked about their design preferences, including how they wanted their avatars to look like (e.g., gender, skin tone, facial features, and outfits), what disability they wanted to present via their avatars, how they wanted to present their disability on the avatars, and why they wanted to present their disability in this way. To eliminate potential confounding factors (e.g., mismatch between avatar appearance and the user's voice) and focus on the impact of DS on people's experiences, we encouraged participants to customize their regular avatars to reflect their physical appearance in real life.

Lastly, we went over the logistics of the diary study with the participants, including the requirements of using both types of avatars, the data they needed to upload everyday, and the milestone interview. Details of the diary study are included in Section 3.3.2. To help participants set up the study, we provided both verbal and video tutorials to instruct participants to download and use VRChat,

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[1]VRChat. https://hello.vrchat.com/

[2]Ready Player Me: https://readyplayer.me/vrchat
[3]Only P1's avatar was generated through a self-developed avatar template as we have not discovered the Ready Player Me avatar yet.
[4]Blender is a 3D computer graphics software toolset used for creating virtual reality, animated films, 3D-printed models, motion graphics, etc. https://www.blender.org/
[5]VRChat guides for Avatars SDK: https://docs.vrchat.com/docs/setting-up-the-sdk

Table 1: Participants' demographics (ID, age, gender, self-reported disability, assistive technology usage, prior experience with VRChat) and study logistics (disability signifiers on their avatars, VR device usage, the time spent in VRChat in the study).

ID	Age/Gender	Self-reported Disability	Assistive Technology in Daily Life	Experience with VRChat	DS on Avatars	VR Device	Time in VR-Chat
P1	27/X	Chronic pain in limbs, autism	Walking cane	4 years	Walking cane	Oculus Quest 2	8 hrs 48 mins
P2	31/M	Repetitive strain disorder on both forearms; ADHD; Asperger	Arm braces; compression gloves	1 month	Bandage on both hands	Oculus Quest 2	7 hrs 30 mins
P3	29/M	Congenital amputee: born without right hand	A prosthetic right forearm	1 year	A prosthetic arm	Oculus Quest 2	11 hrs
P4	30/M	Osteogenesis Imperfecta Type III: Genetic brittle bone condition		3 years	Wheelchair	Wheelchair	Oculus Quest 2	15 hrs
P5	18/M	Cerebral Palsy: left hemiplegia	WalkAide II: A functional electronic stimulation device	1 year	A prosthetic left arm; WalkAide II on lower left knee	Oculus Quest 2	8 hrs
P6	35/F	Spinal cord injury: quadriplegia C4-C5	Power wheelchair	N/A	Wheelchair	Windows PC	13 hrs
P7	55/F	Multiple sclerosis	Wheelchair; cane; walker	N/A	Wheelchair	HTC Vive Pro	8 hrs 42 mins
P8	29/M	Severe neuropathy below the left knee due to bone cancer	Crutch; cane	2 months	Walking cane	Valve Index	9 hrs
P9	26/F	Postural tachycardia syndrome (PoTS); Ehlers-Danlos syndromes (EDS)	Cane; walker	Multiple times	Wheelchair	Windows PC	9 hrs 48 mins
P10	61/F	Incomplete spinal cord injury at C6-C7	Electric wheelchair	N/A	Wheelchair	Windows PC	9 hrs 24 mins

Figure 1: Design of avatars with DS (left) and avatars without DS (right) for each participant.

record screens while using VRChat on their devices, and upload their recordings appropriately.

3.3.2 Diary Study. Participants conducted a two-week diary study in VRChat with one week using a regular avatar and the other week using an avatar with DS. We counterbalanced the order of avatar conditions across participants, so that five participants (P1, P3, P4, P5, P10) started with avatars with DS, and the other five started with regular avatars. While asking participants to freely explore VRChat in each week, we set some minimal time requirements for the participants to ensure sufficient social interactions, thus collecting rich data for the study. The requirements included: (1)

each participant needed to explore VRChat for at least four days per week; (2) the total time in VRChat should be no shorter than 4 hours per week; (3) each exploration should be no shorter than 30 minutes with at least 10 minutes of verbal communication with other avatars. We also encouraged participants to visit different virtual worlds in VRChat to trigger diverse social dynamics.

Across the two weeks, we sent participants a daily survey to track their use and experiences in VRChat. The survey contained 10 short questions, asking participants about whether they used VRChat today, which virtual worlds they visited, the number of people they interacted with, the topics they talked about, whether they talked about disability-related topics, and their general feelings

in VRChat on that day. All daily survey questions are detailed in Appendix A.2. Participants were required to fill out the survey every day, including the days they did not use VRChat. We also asked participants to record all their experiences in VRChat by using the screen recording function on their devices (e.g., Oculus screen recording, Windows built-in screen recorder). Participants uploaded their recordings to a secure cloud storage by clicking a link provided in the daily survey.

To facilitate the study progress, an email reminder was sent to participants every day at 5 P.M. CST to remind them of the study and check in with them in case they had questions. A researcher also monitored the daily survey data everyday to check the number of days that participants used VRChat and the length of each recording they uploaded. As a result, nine out of ten participants met all study requirements. Only P2's recordings of using avatars with DS were 30-minute shorter than the requirement due to a technical issue in screen recording, however, he confirmed that he fulfilled the minimal requirements. The total time recorded by each participant in VRChat can be found in Table 1.

Due to the length of the study, we conducted a 30-minute milestone interview right after the first week to collect some immediate information. We went over participants' social VR experience in the first week and asked questions about interesting scenarios we observed and anything that needed further clarification. For instance, we asked P1 about a scenario happened in the second day, *"In day two when you were using the avatar with a cane, we observed that another user in VRChat switched their avatar from a mushroom to a penguin sitting in a wheelchair after seeing your avatar. How did you feel about this?"* We also used the milestone interview to address participants' questions and technical issues and help them switch avatars for the next week of study.

3.3.3 Final Interview. We ended the study with a one-hour final interview via Zoom. We first asked participants to compare their two weeks of experiences when using avatars with and without DS. Specifically, we asked about how DS influenced the participants' behaviors, others' reactions, conversation contents, and the participants' willingness to build social interactions and participate in social activities. We further asked about the benefits and drawbacks of using avatars with DS, and whether participants' willingness of disability disclosure had changed after the two-week experience. Lastly, participants suggested technologies to better support disability representation and mitigate discriminations in social VR. The final interview protocol is detailed in Appendix A.3.

3.4 Data Analysis

We transcribed all interviews and screen recordings (with audio) uploaded by the participants using an online automatic transcription service. Two researchers went through the transcripts and manually corrected all transcription errors. We also watched the recordings of participants' VRChat experiences and took notes of their social contexts (e.g., the virtual worlds they visited, the activities they participated in, the number of people in the virtual worlds), the avatars they interacted with, and the behaviors of both the participants and other avatars they interacted with. We then merged our notes with the video transcripts by matching the timestamp.

We used the method of thematic analysis [8, 13] to identify repetitive patterns and themes from our data. Two researchers first coded two participants' data independently at the sentence level via open coding. They then discussed and reconciled their codes to resolve any differences, and developed an initial codebook upon agreement. Next, two researchers divided the rest of the transcripts and coded them independently. During this process, the two researchers regularly checked each other's codes and discussed them as needed to ensure consistency. New codes were added to the codebook based on the agreement between the two researchers. In the meantime, a third researcher oversaw all these activities to ensure a high-level agreement. We categorized all the codes into high-level themes and subthemes using axial coding and affinity diagram. After the initial themes were identified, researchers cross-referenced the original data, the codebook, and the themes, to make final adjustments, ensuring that all codes fell in the correct themes. Our analysis resulted in 296 codes and seven themes.

We also analyzed participant responses in the daily survey via both descriptive and inferential statistical analysis. For example, we recorded the number of days that participants used VRChat with each type of avatar, the virtual worlds they visited, the activities they conducted, and the feelings they had after experiencing VRChat. We also used Wilcoxon rank-sum tests to compare participants' experiences when using avatars with and without DS, such as the number of days that they had disability-related conversations with others. The answers to open-ended questions were analyzed via thematic analysis.

3.5 Ethical Considerations

Since our research involved PWD and required them to use avatars with DS in a virtual social environment, we paid particular attention to research ethics and ensured participants' physical safety and mental health. We deliberately took the following measures as we conducted the research: (1) Before starting the study, we worked closely with the IRB office in our university to make sure all study materials were framed appropriately to set the accurate expectations for the participants and reduce any potential risks. (2) In the consent phase, we made it clear to our participants that their participation was completely voluntary, and they were able to quit the study anytime without any penalty. (3) The research team checked on participants' survey responses and recordings on a daily basis to check for any potential ethical issues. (4) In the final interviews, we asked our participants to elaborate on their concerns regarding their safety and privacy during the study. (5) Lastly, since the recordings provided by our participants may contain other VRChat users, we removed the usernames that appeared in the videos and changed the tone of the audio using a voice changer to de-identify all VRChat users before further analyzing the videos.

4 FINDINGS

4.1 Use of VRChat in the Diary Study

During the two weeks, each participant spent 5.25 hours ($SD = 1.62$, ranged from 4 to 9 hours) across 5.3 days on average ($SD = 1.25$, ranged from 4 to 7 days) exploring VRChat using avatars with DS, and 4.65 hours ($SD = 1.23$, ranged from 3 to 7.5 hours) across 4.1 days on average ($SD = 0.74$, ranged from 3 to 6 days) using

avatars without DS. The longer time using avatars with DS may indicate participants' higher interest in using such avatars for social activities. Based on the daily survey entries, we found that participants visited various virtual worlds in VRChat and mostly preferred virtual worlds where they could build conversations with others. The five virtual worlds visited the most by participants included: *Udon Bird Sanctuary* (25 visits mentioned across all participants), *Chess* (24), *The Black Cat* (21), *No Time Two Talk* (16), and *Midnight Rooftop* (12). Three of the virtual worlds (*Udon Bird Sanctuary*, *Black Cat*, and *Midnight Rooftop*) provided spaces with themes for users to chat and hang out, *No Time Two Talk* was an emerging world where users were randomly paired for one-on-one conversations, and *Chess* was the only game room among the five worlds for users to play chess.

Participants also reported activities they attended, including playing multiplayer games (e.g., board games, racing games, recorded 44 times across all participants in the daily entries), chatting with other users (22), hanging out and exploring different VRChat worlds (16), joining a house party (11), and watching a movie (11). Notably, unlike most participants who joined multi-user activities or explored multiple worlds, P6 watched the same movie nine times because many worlds and activities were inaccessible to her as a person with quadriplegia and watching a movie posed relatively fewer accessibility barriers. Moreover, P9 exclusively went to the *Chess* world to sit and talk in a quiet environment because she was easily overstimulated by noisy crowds in other worlds.

During the two weeks, participants reported different experiences when using avatars with and without DS. With a paired Wilcoxon rank-sum test, we found that avatars with DS led to significantly more disability-related conversations than regular avatars ($V = 55$, $p = 0.005$), which was confirmed by participants' comments that avatars with DS triggered more meaningful conversations (Section 4.5). Participants also reported their feelings during the study. Although they felt *"happy"* on most days regardless of the type of avatars, we found that social VR triggered various emotions from the participants. In the daily survey, participants reported 25 different feelings, from positive (e.g., intrigued, excited), to neutral (e.g., ok, so-so, curious), to negative (e.g., disgusted, frustrated, sad) emotions. Some participants even felt surprised due to some remarkably friendly or rude experiences. We explain these different feelings in later sections by discussing participants' positive and negative experiences in social VR. However, we did not observe any significant emotion differences caused by DS.

4.2 Uniqueness of Disability Signifiers in an Avatar-centered Social Culture

We found that VRChat afforded a unique *avatar-centered* culture due to its high flexibility in avatar customization. All participants acknowledged that their conversations and interactions in VRChat usually started with avatars. For example, we observed that VRChat users often initiated conversations by asking *"what is your avatar,"* commenting on others' avatar appearances, or showing off the fancy animations of their own avatars. Five participants pointed out that only avatars with distinguished features were able to stand out in VRChat and triggered more conversations. As P1 mentioned, *"The VRChat culture is very much [like], 'Oh, that avatar has something*

unique, I'm gonna go look at it and possibly talk to the person.'" Such unique culture drew more attention to the avatars with DS used by our participants, leading to unique social dynamics.

Avatars with DS as an Attention Grabber. Seven out of 10 participants believed that their avatars with DS could be easily distinguished from other types of avatars and received more attention in VRChat. They described their DS as *"an attention grabber"* (P4), which was rarely seen in VRChat and aroused other users' curiosity. Four participants (P2, P7, P8, P9) reported that using avatars with DS encouraged both themselves and other VRChat users to initiate conversations. As P7 mentioned, *"When I [used an avatar] without the [wheel]chair, I was ignored. But when I was in the [wheel]chair, people would actually come around and talk to me [... and] you want to talk to somebody who wants to talk to you. There was a lot more of that in the wheelchair [avatar] than there was just a normal [avatar]."* While attracting more attention and social interactions to the participants, these rarely-seen avatars with DS also indicated the lack of adequate disability representation in social VR [74].

DS not Standing Out among Wildly-Designed Avatars. Unlike most other participants, three participants (P2, P3, P9) mentioned that avatars with DS were not drastic enough to be noticed among the various avatars with wild designs in VRChat. As a result, they reported similar experiences when using avatars with and without DS. For example, P9 described her avatar in a wheelchair as *"mundane"* and explained, *"I had a conversation with Spiderman, a Penguin from Madagascar, Nemo from Finding Nemo swimming around in the air, [and] a bunch of Pokemon. Me, just being a person in a wheelchair, is the most normal thing there [...] I don't feel like I'm out of place when everyone else is already so wild."* Moreover, P8 was commented as *"looking too human"* by other users when using his avatar with a walking cane. P2 also emphasized the fact that DS may not attract sufficient attention in this unique avatar-centered social culture, *"The disability doesn't make a difference. You have to try something a lot more dramatic. Everyone in the room [saw you] and like 'wowww', then maybe you see something."*

Desire for Cool, Interactive DS. To better fit in the avatar-centered culture in VRChat, participants wanted to adopt cool DS with an appealing look. For example, P2 wished to use a pair of mechanical arms to represent his repetitive strain injury on his forearms, instead of the bandage on his hands used in the study. He complained that the bandage was neither noticeable to others nor good in appearance, *"I'd [like my future avatar to be] swapped to having some cool-looking mechanical arms on there. I want [my avatar] to look really cool and can do all sorts of fancy things."*

Moreover, four participants (P4, P6, P7, P10) wanted their DS to be more interactive to facilitate the social dynamics. For instance, P4 wanted to have a wheelchair that other users could push around or ride together with him (only with his consent), *"[It] would be really cool if you could have a toggleable option to have somebody sit in your lap or sit on your foot pedals if they're little, so they can ride around with you. And then maybe having a push option, [...] it would look like they're pushing you around in the wheelchair, they have control over your movement. That would be a cool thing to do."* P4 and P6 also suggested other interactions for a virtual wheelchair, such as a *"Pop-a-Wheelie"* option—a maneuver to lift the front wheels and ride only on the rear wheels [53].

4.3 Explicit, Embodied Harassment Targeting Avatars with DS

Besides the attention and interactions, avatars with DS in social VR also received more harassment and discrimination that specifically targeted disabilities. In our study, six participants (P1, P4, P6, P7, P9, P10) experienced harassment when using avatars with DS, while no participant experienced harassment when using avatars without DS. Due to the immersion, the harassment in social VR came in both verbally and physically and tended to be explicit and embodied. Having experienced the harassment and stigma in both real life and social VR, P6 and P9 concluded that the harassment in VRChat was more aggressive and straightforward. As P6 explained, *"People have filters on their mouths in real life [... which] is extremely different from VRChat. Even if people do have those negative and extreme opinions, [...] they tend to keep it to themselves. And also in real life, people are more hesitant to approach [me]."* We describe the different types of harassment and participants' reactions in this section.

Being Addressed by Ableist Language Repeatedly. The most common form of harassment our participants experienced was being referred to by ableist terms, such as *"cripple"* (P4, P6, P9, P10), *"handicapped"* (P4, P6), *"wheelie"* (P10), and *"paralyzed"* (P1, P9). P6 recalled how her avatar in a wheelchair was harassed by a group of VRChat users, *"They detected my avatar's presence in the space. So they [were] following me around, harass[ing] me [while] going, 'hey there was a cripple, there's a cripple!'"* Participants felt deeply frustrated since such harassment happened repeatedly. P6 shared her exhaustion when dealing with the unstoppable, aggressive comments from others, *"It's not even invented. They don't try anything new, it's always the same, 'Hey, there's a cripple here.' It will be a lot appreciated even [if] it varies a little bit, but [I] saw the same thing."*

Even the participants who responded positively in the first place became impatient (P4, P6) after being constantly addressed with these ableist terms. For example, P4 used to educate and correct others to call him by his nickname instead of "cripple." However, after a few days of using avatars with DS and being called "cripple" repeatedly, he eventually gave up, sighed, and muttered, *"Omg, uhhh. It's gonna be one of those nights, isn't it?"* P6 had a similar experience. When using the avatar with DS in the first two days, she just felt surprised and somewhat amused about the cripple comment. However, on the fourth day, she indicated in the daily survey, *"[I am] tired of the overall toxicity and having to deal with the same old cripple comments constantly."*

It is worth noting that some terms were considered to be ableist if they were not used by people from certain communities [37]. For example, P10 only felt comfortable being addressed as "wheelie" by her fellow wheelchair users, *"[Calling someone 'wheelie'] only happens when you're with another group of people who are in [wheel]chairs. You are familiar with each other because you have that linking common of being in a [wheel]chair. But for somebody just popped into a world, [I wonder] why do [they] say that."*

Being Teased for Using Avatars with DS. Six participants (P1, P4, P6, P7, P9, P10) reported being teased about their DS. For example, P6 encountered a VRChat user who laughed at her avatar: *"Look at this! There is a wheelchair [avatar], which actually has no legs!"* Some users even asked the participants to do things that were physically impossible in real life due to their disabilities. For

example, when exploring the bakery counter in a virtual coffee shop, another user asked P6 to stand up when seeing her avatar, *"[You] want a cake bro? Push it up, man! You are in a wheelchair, I'll get you."* P6 felt offended by this joke and replied, *"So rude!"*

Some explicit aggression frustrated our participants so much that a confrontation was aroused. For example, after P4 informed another user of his disability, the user made a burst of laughter and said, *"You shouldn't let people talk to you like that, you should stand up for yourself...sorry hahaha (long and offensive laugh)...I'm trying to make fun of a cripple."* While P4 did not show much emotion at the moment, he later joined a game with that user and shouted with anger to that user after winning the game, *"Hey! Cripple has beaten you in that race, so just say, just say!"* P4's frustration was confirmed by his daily survey where he reported feeling *"annoyed."*

Physical Harassment towards DS. Four participants (P1, P4, P6, P8) experienced physical harassment targeting their DS. Both P4 and P6 were forced to stand up from their wheelchairs. One user even grabbed P4's arm and asked, *"Stand up! I'll help you, give me your arm!"* Unwanted *"help"* and unconsented interactions with PWD's assistive technology is a typical type of harassment against PWD in real life, considering that many PWD view their assistive technology as an extension of their body [10, 57]. We found that such harassment had transferred to social VR due to its embodied nature, appearing in a more aggressive form that went beyond "trying to help." For example, P8 encountered a user who kept trying to snatch the cane out of his hand.

Mimicking One's Disability. We also observed that some VRChat users tried to mimic our participants' disabilities by switching their own avatars to the ones with DS (P1, P9). For example, a VRChat user switched their avatar from a mushroom to a penguin in a wheelchair when they noticed P1's avatar using a cane (Figure 2A). Moreover, after seeing P9's avatar in a wheelchair, another user switched their avatar to the character of Buzz Lightyear in a wheelchair (Figure 2B) and suggested all other users copy this avatar, *"Everyone [copy] my avatar, and it will be hilarious! [...] this is my favorite avatar, paraplegic Buzz Lightyear!"* As a result, other users in the room found this behavior funny and laughed, and one user even asked whether they could copy this avatar. P9 felt a bit uncomfortable about this and believed that the Buzz Lightyear avatar was clearly designed as *"a mocking image of someone who has a stroke or has Parkinson's [disease]."*
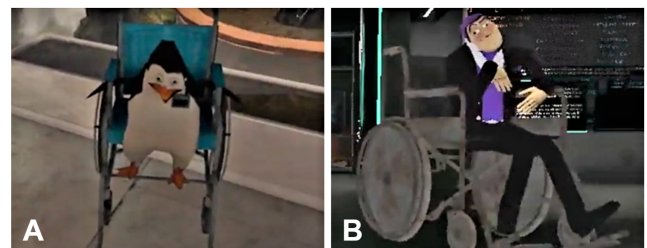

Figure 2: (A) A penguin avatar in a wheelchair; (B) A Buzz Lightyear avatar in a wheelchair.

Discrimination in Group Activities. With avatars with DS, some participants were excluded and discriminated against in group

activities (P4, P6). P6 once entered a virtual room where several people were chatting in a circle and there was another avatar in a wheelchair (not our participants) in that room. P6 was questioned immediately, *"Ah what happened to it? Why do we get more disabled people?"* They asked P6 to *"go sit down there with your disabled friends"* and referred them as *"cripple gang."* Such experience echos the *"othering"* that PWD often face in real life [19, 50]. People without disabilities may view PWD to be different and not fitting in their social group. This social otherness can be exacerbated in social VR, leading to more explicit and aggressive exclusion behaviors, such as directly asking PWD to leave the social group.

Being Treated as Inferior. In addition to conversations, avatars with DS were also discriminated against and bullied explicitly in multiplayer games. For example, in a racing game, one user verbally insulted P4 and interrupted him when he was still talking, *"Hey shut up Hot Wheels! [...] I'm beating the cripple and that is all that matters to me!"* When P4 won the race, they refused to admit his capability and responded with superiority, *"I'll let you [win] bro, I feel sorry [for you]."* Being treated as dependent and incapable is one typical stigma faced by PWD in both real world [4, 33] and other social media [32]. Such a stereotype has transferred to social VR and is even magnified, resulting in others' explicit insults and denial of failure in the competition with PWD.

Noticeable DS Aggravating the Harassment. The appearance of assistive technology plays a significant role in shaping PWD's social experiences in everyday life, especially when interacting with non-disabled people who often form opinions and make judgments on PWD's assistive technology (e.g., visibility, appearances, functionalities) [64]. In our study, we observed similar patterns in social VR that different DS may lead to different social experiences. We found that participants who used more noticeable DS (e.g., wheelchair) tended to attract more attention but also more frequent harassment than participants who used relatively subtle DS (e.g., walking aid, prosthetic limb): all five participants who used avatars with wheelchairs encountered harassment, ranging from two to six times; the two participants who used avatars with a walking cane were harassed once and twice respectively; and the three participants who used avatars with prosthetic arms or bandaged hands were not harassed at all. P8 attributed this phenomenon to the different levels of social stigma caused by different assistive technologies and the corresponding disability severity indicated by the technology. He explained that canes were associated with a relatively lower level of social stigma compared to wheelchairs, *"Because I just had a cane. [When] someone sees a cane, they might think, 'Oh, this person is just older,' or 'this person reminds me of my grandparents,' compared to seeing someone that might be [...] having a crutch [or] in a wheelchair[...] I feel like there might have been a [stronger] stigma against [wheelchairs], and people might have interacted [in] a much more overwhelmingly negative way."*

4.4 Misconceptions about Avatars with DS

We looked into the reasons that caused explicit aggression towards avatars with DS. Besides the anonymity of avatars and the lack of social norms discovered by prior research [5], we identified a unique factor in the avatar-centered VRChat—the *perception gap* on the use of avatars with DS between PWD and other VRChat users.

While our participants used avatars with DS to disclose their disabilities, we found that, due to the avatar-centered culture in VRChat, many users without disabilities treated avatars with DS simply as a character or meme designed by the avatar owners. They did not associate the DS with the owners' real-life identities. In contrast, they tended to arbitrarily assume that VR was a place where PWD escaped from their disability identity. For example, when P6 told a VRChat user that her avatar with DS was meant to represent her disability in real life, the user was surprised, *"It's interesting that somebody would actively choose to be cripple."* P9 echoed this perception, *"In VRChat, I feel like a lot of people who aren't disabled have this idea of like, 'why would you be in a wheelchair when you could not be?' [They believe that] rather than seeing it as a way to reflect your real-life experience to them, it's more of a matter of using the fantastical nature of it to escape from [the reality]."*

Therefore, many users subconsciously omitted the possibility that the DS was reflecting the owner's disability. Instead, they treated avatars with DS the same as other dramatic avatars that were designed for trolling and gaining attention (P3, P4, P6, P8). For instance, P8's avatar with a cane was recognized as *"Mark Zuckerberg"* multiple times due to the similar appearance, and other VRChat users often thought that he was mocking the celebrity with a cane. As P8 recalled, *"the first interaction [from others] is seeing what the face looks like. Then [they] look down and see that I have a cane, and the only thing that can pop into my mind is they're not thinking about disability. They're thinking [that] this dude is trying to walk around with a pimp cane as Mark Zuckerberg or something like that."* This phenomenon is further confirmed by a VRChat user encountered by P7, who mentioned that most avatars he had seen were unserious meme, *"the only ones I see that are in wheelchairs are typically meme avatars. People [are] not really being serious [...] we try to make them look really silly. "*

Interestingly, we found that some VRChat users changed their attitudes after knowing that the avatar owner had a disability in real life (P4, P6, P7, P8, P9). For instance, P8 described how some people shifted their attitudes from making jokes about the DS to being curious about his disability in real life, *"When they found out that I had an actual disability, they weren't making jokes about either the avatar looks or [what] they might say 'a pimp cane.' It seemed to be curious about why I had it and what my disability was. So it turned away from my avatar and to what about me."* Moreover, P4 recalled other users apologizing for their offensive behaviors early on, and P6 noticed one user *"seemed a bit abashed about how he behaved initially"* after knowing P6 was in a wheelchair in real life. The perception gap on avatars with DS between PWD and other users could thus be one major reason that caused explicit harassment in VRChat. These evidences also indicate that while people conduct aggressive behaviors in social VR, they start applying the social norms in the real world to social VR when realizing the association between the avatars and the owner's real identity.

4.5 Desire to Continue Using Avatars with DS

At the beginning of our study, all participants showed an initial willingness to disclose their disabilities on avatars. Three participants (P1, P4, P5) mentioned that their disability was *"an important part of my identity"* (P5) and wanted their avatars to look like themselves

in real life as much as possible, which confirmed the insight from prior research [45, 74]. Additionally, P1 believed that avatars with DS consolidated his disability identity, *"Having similar limitations [via my avatar in social VR] is really helpful for me and my comfort [...] it makes me feel more comfortable in what I need to do for myself [and] taking care of myself."*

Interestingly, after the diary study, nine out of 10 participants expressed their willingness to continue using avatars with DS in the future even having experienced the harassment in VRChat. Three participants (P1, P4, P9) mentioned that the two-week experience solidified their willingness of using DS since *"the positive feeling [of using avatars with DS] outweighs any risk of harassment"* (P9). Some participants also expressed the desire of expanding their avatars with DS to other social VR platforms. As P4 indicated, *"A realistic avatar with me in a wheelchair...definitely has made me see how much more of a positive experience he can give me. So I definitely want to do this in the future. Maybe not even just within VRChat, but with other [platforms] too."* Only P8 expressed hesitation in using an avatar with a cane due to its lack of interactivity, *"I think motion tracking for VR would need to be a little bit better for me to use [the avatar with DS], because I do want to be able to have a [virtual] cane that I'm able to manipulate in real time."*

Below we summarize the key reasons that motivated our participants to use avatars with DS in social VR.

Stimulating Meaningful Conversations. Participants believed that avatars with DS prompted more meaningful conversations about disability (P1, P2, P4, P7) and helped them discover people who were kind and open-minded (P1, P5, P7). As P2 shared, *"We have a strong talking point, rather than just 'how was your day?' They're interested in something about me, so that is a lot easier for me to talk about or to joke about something."* P7 developed *"a sense of hope"* when a group of young individuals protected her from being bullied by another rude user, *"Young generations [are] open to talk about disabilities and all the curiosity [made me feel] hopeful."*

We also observed participants' attitudes change after some in-depth disability-related conversations in social VR. For example, P1 used to walk away from other users' questions about their disability or respond by making simple jokes, such as *"just [having] broken [legs]."* However, after a emotionally fulfilling conversation with a group of users, they became more patient and serious when explaining their disability to other users. As P1 said, *"I got to talk about myself and how I view my limits, and it was well received."*

Enabling More Socially Acceptable Disability Disclosure. P5 felt that the DS in VR did not cause the stigma that he suffered in real life due to his disability. In real life, P5's disability could be uncontrollably identified from his movements and people can easily tell that *"something went wrong."* However, in social VR, P5 had the power to control how he presented his disabilities, which allowed him to design his avatar as *"something looking like a normal person, but then having some kind of difference, such as adding a prosthetic arm to the avatar."* He explained that using prosthetic arm to represent his left hemiplegia made him look cooler and more unique, which enabled a better social experience than in real life.

Promoting Connections with Minority Communities. Two participants (P4, P6) believed that avatars with DS helped them connect with other users with disabilities. For example, P4's wheelchair avatar attracted a user with ADHD (A1) to talk to him. They shared

experiences of growing up without friends, being bullied by peers at schools, suffering from *"social malnourishment"* (A1), and becoming *"socially awkward"* (P4). Similarly, P6's avatar drew attention of a user with Spina Bifida (A2), *"Oh my god, you are just like me! I am in a wheelchair in real life!"*

Interestingly, we observed that the disability-related conversations between our participants and VRChat users without disabilities usually tended to be short, lasting only about two minutes on average. However, P4 and P6's conversations with users with disabilities (A1, A2) lasted 17 and 13 minutes respectively. The shared experiences between PWD evoked connection and empathy, motivating our participants to continue using avatars with DS as a key to identifying peers.

Increasing Awareness of Disability. Four participants (P1, P4, P7, P9) believed that using avatars with DS was an efficient way to educate people about disabilities and normalize PWD's presence in social VR. The experiences of using avatars with DS made our participants realize that the general users in VRChat had limited understanding of disabilities. As P4 indicated, *"It kind of blows my mind how many people just... don't know how to react to someone who is disabled."* We also observed the misconceptions about DS from the general users, such as using a cane meaning a person was *"paralyzed."* P1 was surprised and amused when a user asked if they were "paralyzed" after seeing the cane, *"How does [a paralyzed person using a cane] make sense? Because cane isn't really the kind of mobility aid that makes sense for paralysis. It's just funny how [paralysis is] the disability they go for when they see a cane."*

As a result, participants expressed interests in using avatars with DS to increase PWD's representation in social VR and educate the general public about disabilities. As P1 said, *"Because [avatar with DS] gets the conversation [about disabilities] out there and [makes] people all thinking about it, even if they're the ones who actually put any effort into thinking aren't the ones I'm talking to, there's more than just one person in the room hearing me."*

Filtering out Harmful Interactions. Similar to PWD's strategy on online dating platforms [54], participants used avatars with DS to filter out ableist VRChat users (P1, P6, P8). For example, P6 indicated that the DS helped her identify people who were willing to interact with her regardless of her disability, *"The wheelchair [avatar] puts my disability out there. It tells me who's willing to interact with a person with disability, and the fact that I am still able to have positive interactions shows that, there are people out there who don't mind disability [and] who are accepting of this disability."*

4.6 Coping Strategies against Harassment

To better use avatars with DS in social VR, participants developed several coping strategies to deal with the harassment behaviors targeting disability. We detail them below.

Confronting the Harassment Directly. Four participants (P4, P6, P7, P9) chose to verbally confront the ableist users since they did not want to show any weakness to the bullies and felt the necessity to correct the negative views. As P6 highlighted, *"I could just ignore them but it's really annoying that people think it's okay to say those things. So, I feel compelled to react [and] to say something back to them. Just to strike back at them, because it's such a backward view."*

Engaging in Selective Virtual Worlds Only. Some participants noted that the social contexts and user groups varied drastically in different virtual worlds in VRChat. For example, both P2 and P8 reflected that the *Black Cat* world had more minor users. Four participants (P2, P4, P6, and P9) were not willing to engage in virtual worlds with many minors because they could be *"loud and obnoxious"* (P4), misusing ableist language (P6), and lack of knowledge of how to interact with PWD (P2).

As a result, three participants (P7, P8, P9) chose to only visit virtual worlds that they felt safe in. For instance, P7 only went to worlds with no more than 15 users because she believed that *"the more people that would be in a world, [...] the more chances that there would be negativity."* Moreover, after the first day of exploring VRChat using an avatar with DS, P9 was sure that her virtual wheelchair would attract harassment. She thus only went to the quiet *Chess* world for the rest of the study to avoid potential harm.

Avoiding Disclosing Mental and Cognitive Disabilities. Two participants (P1, P2) decided to disclose their disabilities selectively to avoid potential harassment. P1 and P2 experienced both physical disabilities and mental/cognitive disabilities (i.e., autism for P1, ADHD and Asperger for P2). When designing avatars, both of them chose not to disclose any mental/cognitive disabilities due to the more entrenched stereotypes towards such disabilities. As P1 explained, *"I have complicated feelings about the mental [disabilities]. It's a hugely important part of me, but also a lot of them are things that have been used to portray [us as] monsters. So it's hard to even be willing to mention it to people who don't have it."*

Moreover, due to the invisible nature of mental/cognitive disabilities, P2 felt there was no appropriate way to present such disabilities on avatars unless a stereotypical portrait was used since that was the only impression many people had about these invisible disabilities. P2 used depression as an example, *"Some think that depression is just being really sad, which is ironic because depression is the absence of emotions. [So] the only way to [present mental disabilities] is by using the things people know about it [...] which represented us [wrongly via] stereotypes."*

Adopting Protection Mechanisms on the Platform. Two participants (P4, P8) were aware of the blocking, muting, and reporting methods in VRChat and used them for self-protection. For example, when a VRChat user tried to drag P4's avatar out of his wheelchair, P4 blocked that user to avoid more physical harassment. Not knowing any protection mechanisms in VRChat, P7 learned the blocking feature during the diary study. When encountering a user who directed a derogatory slur at her, P7 blocked them right away.

4.7 Towards a Safer Social VR Environment

Participants suggested approaches to facilitating a safer and more inclusive social VR environment, including representing disabilities properly and regulating other users' behaviors.

Improving the Design of DS. Two participants (P2, P4) believed that the aesthetics of the avatars with DS would directly influence how other users perceived and interacted with them. If the avatars and the DS did not have a high quality, such as high resolution and polished details, people may perceive them as a meme and not treat the DS seriously. As P4 highlighted, *"I have met a couple [of] wheelchair avatars that were meant just for laughs. So, I want to*

make sure that [my avatar] is a high-quality avatar. I want it to be high quality enough to come across as intentional and not a meme avatar, that's important."

The relationship between avatars and their DS was another factor that could affect people's perception (P4, P10). P10 indicated that DS should be designed to see *"person first"* rather than *"DS first."* She pointed out that her virtual wheelchair was too big and overshadowed her avatar, *"The wheelchair that you have is that the person is literally sitting inside the wheelchair, and the wheelchair is encompassing around them. You see more of the wheelchair and less of the person. [But] the modern wheelchair is [that] you see the person's full body [first], and then you see [wheelchairs]."*

Adding Protection Mechanisms. While desiring for more polished and unbiased avatars and DS, participants admitted that it was difficult to set restraints on avatar design in a free-form, avatar-centered social environment. As P6 noted, *"No censorship is one of the key advantages of [VRChat]. We can't curtail those [features that] really keep the spirit of the platform alive."*

Participants thus suggested work-around methods to regulate users' behaviors in social VR. P8 suggested setting up criteria to determine whether a user was qualified to enter a specific virtual world, such as a minimal usage hours in VRChat without being reported. Additionally, P10 suggested adding slogans or signs in different virtual worlds to remind users to be respectful of diversity in VRChat, *"In the 'Udon Bird Sanctuary' world, there are picnic tables and trash cans, and maybe you can have a little signpost [saying] 'Be Respectful' to remind people [...] maybe put it on the back of a duck, because everybody [is] feeding ducks."*

5 DISCUSSION

We present the first observational study that explores how disability disclosure via avatars (i.e., disability signifiers on avatars) impact PWD's experiences in social VR. Contextualized in the avatar-centered social culture in VRChat, we found that the DS (e.g., virtual cane, wheelchair) on avatars became an attention grabber and many PWD wanted to further enhance these signifiers, making them more appealing and interactive, to stand out among the various wildly-designed avatars (Section 4.2).

However, avatars with DS also caused more harassment and risks than avatars without DS. We summarized six types of harassment targeting PWD (Section 4.3) and the unique perception gap between PWD and other users that may lead to harassment in social VR (Section 4.4). Despite the harassment, PWD believed the benefits of DS outweighed the risks it may bring, highlighting their willingness to continue using avatars with DS in social VR (Section 4.5). As a result, our participants developed a series of coping strategies to combat the harassment (Section 4.6) and suggested potential DS improvements and protection mechanisms to ensure a safe social VR environment for PWD (Section 4.7).

In this section, we discuss the unique harassment targeting PWD in social VR as well as the design implications to facilitate a safe and inclusive social VR environment.

5.1 Unique Harassment Faced by PWD

Harassment is no novel topic in social activities, especially for marginalized groups. Prior research has investigated the stigma

and aggression faced by PWD in different contexts, ranging from real life [28, 34, 44] to conventional social media [2, 31, 41]. In the social VR context, researchers have studied the harassment encountered by various groups, including the general users [5], women [58], children [46], and LGBTQ [1, 5, 20]. Situated in prior work, our study focuses on the lens of disability and highlights the risks faced by PWD in the avatar-centered social VR context. We discuss the uniqueness of the harassment targeting PWD in social VR by comparing to other user groups and non-VR social contexts.

5.1.1 Embodied Harassment targeting DS. Our findings expand the "embodied harassment" in social VR [23] via the lens of disability. Such harassment has been categorized into three types by Blackwell et al. [5]: (1) *verbal harassment*, including personal insults, hate speech, and sexualized language; (2) *physical harassment*, referring to behaviors of unwanted touching, standing too close to another user, obstructing movement, and visible sexual gestures; and (3) *environmental harassment*, which is defined as abuse committed through violations of the technical environment, such as displaying sexual or violent content, drawing sexual images, and throwing objects. Our research confirms that PWD have encountered all three types of harassment in social VR. More importantly, we expand each category by identifying new forms of harassment behaviors that target the avatars with DS.

Verbal harassment. The verbal harassment towards PWD is reflected in highly repetitive ableist language, being teased, and being described as inferior or incapable in competition. Such harassment comes from not only individuals but also groups of users, such as an avatar with DS being asked to leave a social group.

Physical harassment. We expand the physical harassment by revealing inappropriate physical behaviors that target the DS on avatars. The DS gives perpetrators a concrete target to conduct physical harassment, resulting in various non-consensual interactions with the DS, such as pushing the virtual wheelchair, pulling an avatar out of the wheelchair, and snatching the walking cane.

Environmental harassment. We identify a new form of environmental harassment targeting DS casued by the unique interactions in social VR—mimicking one's disability through avatars with stereotypical portraits of disabilities. This harassment results from the highly flexible avatar customization in VRChat, which enables PWD to curate their social image but also allows others to easily create and abuse an avatar with DS. The avatar cloning feature in VRChat can exacerbate this issue, aggravating the spread and misuse of inappropriate avatars with DS (e.g., a meme avatar).

5.1.2 Prevalent, Explicit Harassment casued by Misconception. As opposed to online social media, we found that the harassment forms in social VR are more similar to those in real life since social VR simulates "face-to-face" interactions. Prior research [33, 50, 63] has identified various harassment targeting PWD in real world, such as *Epithets*, *Slurs*, *Mockery*, *Mimicking*, and *Ostracism* or *Othering Effects*. Our findings indicate that all these types of harassment in real world have been transferred to social VR; but they are expressed more explicitly and happen more frequently in social VR. Participants (P4, P6, and P9) who rarely encountered overt harassment in their daily life were surprised about how rudely people behaved towards their avatars with DS.

Our study identifies the factors that cause such magnified harassment. Besides the anonymity [47] and lack of social norms [5] in social VR, the avatar-centered culture results in a perception gap between PWD and other social VR users—while PWD use avatars with DS to disclose their disability identity, other users see the avatars as a meme, thus not treating them seriously or respectfully. This misunderstanding leads to the inappropriate behaviors that target the avatars with DS only instead of the avatar owners with disabilities behind the scene. We observed that some users restored social norms from the real world when realizing the association between the avatars and the owner's disability.

To mitigate such misconception and reduce the harassment in social VR, it is important to consider how to suitably indicate the potential association between avatars and their owners (Section 5.2.1) and how to design effective protection mechanisms to prevent the harmful experience for PWD (Section 5.2.2 and 5.2.3).

5.2 Design Implications towards More Safe and Inclusive Social VR

With PWD's strong desire to present their disabilities and the potential harassment they face, how to suitably support disability representation and how to prevent aggression becomes critical directions for VR and accessibility researchers. We derive design implications to inspire safer and more inclusive social VR for PWD.

5.2.1 Improving Avatar Design to Reduce Misconception. The avatar-centered culture in VRChat can easily confuse users in determining whether the DS is a meme or used to represent a real disability. As such, how to better design avatars to present disability and avoid misconception becomes an important research question. Both explicit and implicit solutions could be considered. Explicitly, particular virtual labels could be added to avatars with DS to notify other users of the purpose of the avatar design. One participant (P4) has already adopted a similar technique by adding a line in his bio: *"A nerd on wheels."* However, this method is not effective enough because the bio information is hidden by default and needs additional steps to be revealed. In VRChat, the users need to click the menu button on the left controller, move the cursor/laser onto an avatar, and select that avatar to see the profile that contains the bio information. More explicit and easy-to-access indicators are needed to declare the purpose of an avatar with DS, such as a virtual tag floating on top of the avatar.

Implicitly, high-quality DS with polished details are suggested by our participants since high avatar quality can indicate authority and potentially reduce the possibility of being seen as a meme. However, given the technical and accessibility challenges that PWD face in avatar design and creation [74], we suggest that other stakeholders, such as the disability organizations, avatar design experts, and social VR platforms, would work together to design a set of polished and customizable avatars with DS that can be easily adopted by PWD. The authoritative DS set can also be extended and used as icons that represent PWD for broader scenarios (e.g., real-world usage), serving as a standard framework for disability representation.

5.2.2 Consent Mechanisms to Interact with Avatars with DS. Our study shows that some social VR users may approach the PWD and interact with their DS without consent, such as snatching their cane

or pulling their avatars off the wheelchair. On the one hand, interacting with others' DS without consent could become problematic and cause discomfort and stress for PWD. On the other hand, some participants (e.g., P4, P10) want their DS to be more interactive, such as allowing other people to sit in their wheelchair. As such, it is necessary to design suitable mechanisms for PWD to determine who can interact with their DS and how they can interact with it. Some participants (e.g., P2, P4, P5) have emphasized that the interactions with DS should be fully controllable and built upon mutually agreed norms. We thus recommend integrating proactive consent mechanisms for avatars with DS. For example, when other users show the intent to interact with the DS (e.g., pushing the wheelchair), the PWD will be alerted with a message that asks for their consent and interaction preferences; other users would not be able to interact with the DS until receiving the owners' consent. We believe that such consent mechanisms will provide PWD more control of their avatars and help reduce potential physical harassment targeting the DS.

5.2.3 Implementing Moderation Mechanisms. Incorporating moderation mechanisms is another approach to facilitating a safe social environment. Building upon the moderation strategies in conventional social media [26], we recommend adjusting these strategies to fit the social VR context, for example, setting up entering criteria for particular virtual worlds, and blocking aggressive avatar behaviors (P8). Current social VR platforms have started involving human moderators, and some platforms (e.g., RecRoom) also allow users to mute, block, and report particular users. To mitigate the concerns about moderators' personal bias in defining and detecting harassment behaviors [23], we suggest involving PWD as moderators for disability-related harassment moderation.

However, moderation in social VR can be more challenging than conventional social media since its interactions (e.g., voice chat, avatar behaviors) mostly happen in real-time without permanent records. It is thus unrealistic for human moderators to constantly visit all virtual spaces and monitor each avatar's behaviors. As such, AI technologies could be considered to recognize aggressive language and inappropriate behaviors automatically. For example, start-of-the-art large language models [12] and large-scale toxic language datasets [29] have been created to facilitate hate speech recognition. Meanwhile, more attention needs to be drawn to the potential bias brought by AI itself [26].

5.2.4 Suggestion Mechanisms to Facilitate Positive Interactions with DS. Besides harassment, avatars with DS also bring various positive social experiences to PWD, motivating them to continue using the DS regardless the risks. As such, social VR platforms should also consider involving mechanisms to promote positive experiences associated with DS. For example, as DS may trigger meaningful conversations, a topic suggestion mechanism could be designed (e.g., a text label on the DS saying *"ask me about my disability"*) to further prompt such conversations. Moreover, to facilitate community building, a friend recommendation system could also be incorporated into social VR platforms to connect users who adopt DS on their avatars.

5.3 Limitations and Future Work

Our study have limitations. First, we focus on VRChat, one of the most commonly used social VR platforms. However, its unique avatar-centered culture may apply to other social VR platforms, such as Rec Room and Horizon World. Future work should investigate other social VR platforms and explore how different platform cultures may affect PWD's experience and use of avatars with DS.

Second, although we broadly recruit people with diverse disabilities, all participants end up choosing to only present the more "physical" disabilities (e.g., mobility disabilities, chronic pain) as opposed to mental/cognitive disabilities due to the concerns about certain stigma associated with these disabilities (Section 4.6). Future work should investigate how to suitably reflect mental or cognitive disabilities without causing social stigma and how the representation of such disabilities may affect PWD's social VR experiences.

Third, due to VR headset accessibility issues, three participants have to use a Windows computer for the study, despite our focus on immersive headset experiences. Moreover, we are unable to identify the device usage (headset vs. computer) of other users encountered by our participants, although the data from VRChat in 2020 indicates that over 50% of VRChat users are in VR headsets [27]. We acknowledge that computer-based social VR is not fully immersive and may result in different user behaviors. Future research should build techniques to make VR headsets and social VR more accessible to PWD [35, 75], building upon which, we could further expand our study to more PWD who experience immersive social VR.

Last, we acknowledge that participants' behaviors in the study may differ from their real social VR behaviors. For example, P1 reported being more inclined to confront the harassment in the study but not willing to spend effort dealing with harassment during personal use. A less intrusive observational method should be considered in the future to reduce the impact of the observer effect.

6 CONCLUSION

In this paper, we conducted a two-week diary study with PWD who explored VRChat using avatars with and without disability signifiers to examine the impact of disability disclosure on PWD's social VR experiences. Our findings revealed the various types of harassment that PWD face. Despite the harassment, PWD were willing to continue using avatars with DS and adopted several coping strategies to mitigate the potential risks. Finally, we discussed the uniqueness of harassment targeting PWD in social VR and derived design implications to support safe and inclusive social VR.

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A APPENDIX

A.1 Initial interview

(1) What's your age?

(2) How would you identify your gender?

(3) How would you describe your disabilities?
  - What types of disabilities have you been diagnosed with?
  - How long have you been experiencing this disability?
  - Do you use any assistive technologies in daily life? What are they?

(4) What devices do you use for social VR applications?

(5) What social VR applications have you used before?

(6) What is your most commonly used social VR application?
  - How long have you been using it?
  - What are you using it for?
  - Who do you usually socialize with on this platform?
  - Have you ever used VRChat before?

(7) Have you ever involved any features in your avatar to reflect your disability on social VR applications?
  - If yes,
    – What social VR applications?
    – What features did you involve in your avatar to represent your disability?
    – What did you use this feature to show your disability?
    – With an avatar that has a disability feature, what's your experiences in social VR applications? Any positive/negative experiences?

(8) Do you want to disclose your disability on social VR avatar?
  - Why do want/don't want to disclose it?
  - How do you want to show your disability via avatar? Why do you want to show it in this way?

A.2 Daily survey

(1) Did you use the VRChat today?
  - Yes
  - No

(2) Please upload your screen recordings of your today's experience in VRChat through this link: https://uwmadison.app.box.com/f/450d32f321194eb69a603a27a397ecc7

(3) What's your name?

(4) Which VRChat world(s) did you go to?

(5) How many people have you encountered in VRChat?
  - 0—5
  - 5—10
  - 10—15
  - 15—20
  - more than 20

(6) How many people have you talked to?
  - 0—3
  - 3—5
  - 5—7
  - 7—10
  - more than 10

(7) What topics did you talk about?

(8) What activities did you do? (Select all that apply)
  - Playing a single-player game
  - Playing a multiplayer game
  - Doing a meditation/sleeping
  - Drawing
  - Joining a dance session
  - Joining a house party
  - Watching a movie
  - Others, please specify:

(9) Are any of your conversations today relevant to your disability or the disability features of your avatar? Please describe:

(10) How do you feel about today's experience in VRChat? (Select all that apply)
  - Sad
  - Happy
  - Fear
  - Angry
  - Surprising
  - Disgusted
  - Others, please specify:

(11) Could you please explain why you have such feelings?

A.3 Final interview

(1) Recalling the week that you used the avatar with disability features, how did people react to your avatar?

(2) What are people's attitudes towards the disability feature on your avatar?

(3) Comparing the two weeks' experience, do you think the disability feature on your avatar affects your social experience?
  - If yes, how do you think it affects your social experience?
  - If not, why?

(4) Do you think the disability feature affects people's willingness to interact with you in social VR?
  - If yes, how? Why do you think it impacted?
  - If not, why?

(5) Comparing your two weeks' experience, does the disability feature affect people's behaviors when interacting with you?
  - How do you think it affects people's behaviors?
  - Why do you think they behave in that way?
  - Have you experienced any attitude or behavior changes of other people after they noticed your disability feature?
    – How did their attitudes change?

– In your opinion, why did they change their attitudes?

(6) Do you think the avatar's disability features affect others' conversation with you?
  - How did it impact the conversation content?
  - Did the avatar disability feature trigger any unique conversations? What are they?

(7) Have you had any conversations about disability features that bring a positive impact or feeling on you?
  - What are those conversations?
  - Why did these conversations make you feel positively?

(8) Have you had any conversations about disability features that bring a negative impact or feeling on you?
  - What are those conversations?
  - Why did these conversations make you feel negatively?
  - What did you do after you heard these negative conversations?
  - How do you think the platform can potentially help protect you from these harassment or other types of negative experiences?

(9) In general, do you think the disability feature on your avatar brings any impact on you? Behaviorally? Psychologically?
  - How does it impact you?
  - Why does it impact you?

(10) Does the disability feature impact your willingness to actively initiate conversation with others?
  - How does it impact?
  - Why does the disability feature have such an impact on you?

(11) Does the disability feature affect your willingness to be in a crowd of people in social VR?
  - How does it affect your willingness?
  - Why does it have such an effect on you?

(12) Does the disability feature impact your participation in doing group activities (e.g., play multiplayer games) in social VR?
  - How does it impact? Does it encourage or discourage your participation in group activities?
  - Why does the disability feature have such an impact on you?

(13) Comparing these two weeks, do you think there are any benefits of having a disability feature on your avatar?
  - What are the benefits?

(14) Do you have any concerns about the disability features on avatars?
  - What are your concerns?
  - What made you have such concerns?

(15) Would you have disability features on your avatars in future?
  - Why/Why not?
  - How does the two-week experience influence your choice?
  - What made you decide to have/not have the disability feature on your avatar?

(16) How do you think the disability features on your avatars effectively reflect your disability?

(17) Does the design of the disability feature fulfill all your needs for disability disclosure?
  - Are there other disabilities that you want to disclose but you haven't designed for it in this study? What are they? How do you want to present them?

(18) Do you have any suggestions on how to improve the design of disability features?

(19) What's the ideal disability feature you want to have on your avatars?

(20) Have you ever disclosed your disability in real life?
- If so, how do you disclose your disability in real life?

(21) Do you think the disability signifiers have different impacts on your experience in the real world versus the virtual world?
- What are the differences? Your behaviors or people's reactions?
- What causes the differences?