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HISTORY 44Q – Final Paper

When Worlds Collide: Challenges and Opportunities in Virtual Reality

In October 2016, a visceral account of online sexual harassment shook the Internet. A female gamer, under the pseudonym Jordan Belamire, detailed her experience being groped in the virtual reality (VR) game QuiVR (Belamire, 2016). At first, she was enthralled by the virtual world and described herself walking off the game's highest tower despite her fear of heights: "I didn't fall, and I was walking on air. I was a god." However, within minutes of activating QuiVR's multiplayer mode, everything changed. A player with the username BigBro442 entered the game, and upon hearing Belamire's voice, "[h]is floating hand approached my body, and he started to virtually rub my chest." Despite Belamire's cries for him to stop, BigBro442's avatar continued to grab and pinch her chest, and even rub her virtual crotch. Just like that, Belamire's feelings of invincibility quickly turned to helplessness, "from the god who couldn't fall off a ledge to a powerless woman being chased by an avatar named BigBro442." Feeling shocked and violated, Belamire noted her brother-in-law had played multiplayer VR games numerous times without issues, but her female voice almost instantly elicited harassment.

Belamire is not alone in having problematic experiences with VR. While her encounter pertained to applications developed on VR hardware, others have also reported negative experiences with the VR hardware itself. danah boyd, a female computer graphics programmer and researcher at Microsoft, described her first experience with 3D immersive technologies in 1997 (boyd, 2016). Her excitement about being immersed in the Metaverse, the virtual world imagined in Neal Stevenson's *Snow Crash*, soon gave way to nausea, causing her to vomit. Her female peers had similar experiences, while her male colleagues had no problems with the system. Though VR technology has improved leaps and bounds since then, boyd's research has revealed nausea and simulator sickness in VR are still prevalent, more so amongst females than males. Unfortunately, despite significant investment and advancements in recent years, VR technology still creates a comparatively negative experience for half the population.

Taken together, these accounts illustrate two main challenges in VR technology: first, immersive VR applications promote harassment towards women, racial minorities, and LGBTQ+ individuals, and

second, VR hardware is better suited to males than females. Analyzing VR technology design using sex and gender analysis can significantly improve VR experiences for a wider audience, enabling us to leverage VR's uniquely immersive capabilities to promote social equality. Two gendered innovations can address these challenges: first, VR applications can help develop empathy towards traditionally marginalized communities, and second VR headsets can be more sex-inclusive.

This paper first explores VR software applications that contain discriminatory content and promote harassment behaviors towards historically underrepresented communities. Using gender as an analysis framework for VR software innovation processes facilitates reframing VR applications to promote gender and social equality. Next, this paper confronts design choices in VR hardware that tend to exclude females. Utilizing sex as a lens to analyze these biases, a better sex balance in research participants is needed to rethink reference models for VR hardware, leading to more sex-sensitive VR headsets. Finally, this paper concludes by highlighting the interactions between VR software and hardware, emphasizing that improving both elements in parallel is essential in making the technology more inclusive.

Part I. Addressing Discriminatory Content and Behavior in VR Applications

VR applications hinder gender and social equality by including discriminatory content and facilitating harassment behaviors. Research studies have demonstrated video games, especially interactive role-playing games, promote online harassment (Tang et al., 2019) and physical sexual violence towards women (Afaq et al., 2019), attributable to both the video games' content and the harmful behavior they elicit (Gutiérrez, 2014). Such video games also facilitate discrimination against minorities and LGBTQ+ individuals: 53% of individuals harassed in video games were discriminated against based on their racial identity, and among LGBTQ+ players, 35% were targeted for their sexual orientation or gender identity ("Free to Play?", 2019). Other studies have found VR leads to greater presence (Lemmens et al., 2021) (Pallavicini et al., 2019) and more intense negative emotional expression (Lavoie et al., 2020) than screen-based, non-immersive video games. While research into

discrimination in VR applications is nascent ("Fast rise in social virtual reality", 2021), these trends collectively suggest VR applications, especially social VR, may facilitate harmful behaviors more traumatic than those on traditional platforms. Even in this early stage, disturbing VR games have already been released allowing players to sexually assault women (Buxton, 2016) or containing racist and sexist elements (Feltham, 2021). Female gamers, like Belamire, have also reported harassment encounters in VR environments (Buchleitner, 2018) (Westervelt, 2016). The decisions behind VR application content and design will be influential in ensuring the field moves towards gender and social equality.

The potential for women, racial minorities, and LGBTQ+ individuals to experience harassment through VR applications indicates concepts such as gender, sexual orientation, and race should be integrated into engineering innovation processes behind VR technology. Several problematic VR applications mentioned above are designed for white, cisgender, and heterosexual males as the target audience. Such applications may reinforce gender and racial stereotypes or simulate violent behaviors unacceptable in real-world contexts. This may have dangerous spillover effects into how players interact with others in social VR, or how they behave in the real world. Analyzing assumptions about gender, race, and sexuality embedded in these applications can facilitate designing virtual spaces that are not only inclusive, but also actively promote social equality, rather than perpetuate stereotypes.

Potential solutions to address discriminatory content and behavior in VR technology may involve engineering VR applications that develop empathy towards traditionally marginalized communities. A necessary first step is to cultivate a diverse VR developer community, so communities that get less visibility in VR applications are adequately and authentically represented. White male producers dominate VR application development, and their innovations feature a similarly homogeneous demographic ("The lack of female representation in VR", 2016; Winston, 2020; De Leon, 2020). They even dominate in producing VR content intended to represent women and racial minorities (Nakamura, 2020), creating a spurious empathy for white viewers, and potentially misrepresenting these communities. At the first ever Black VR Creators event, the panel speakers unanimously agreed that

hiring and mentoring more aspiring black VR developers are crucial to improving representation in the space (Winston, 2020). Similar arguments can be made for women and LGBTQ+ individuals. While authentic representation should not be a responsibility that falls solely on underrepresented groups, communities like Women in VR and Black VR Creators indicate developers in these groups want to be more involved in content creation. Hence, having VR content creators from diverse backgrounds can help appropriately represent individuals from across different genders, sexualities, and racial identities.

Beyond workforce representation, VR content can be developed to challenge stereotypes and help develop empathy towards women, racial minorities, and LGBTQ+ individuals. Immersive VR provides the unique opportunity for embodiment, which can promote identification and empathy towards traditionally marginalized groups. Neyret et al. (2020) placed male participants in a VR scenario where a woman is sexually harassed by several men. Participants who embodied a man and the woman empathized with the woman more than those who only embodied a man. Banakou et al. (2016) conducted a similar study with White people embodying an African American virtual body, and virtual embodiment led to a sustained reduction in implicit racial bias against African Americans. VR applications have also been developed to enhance empathy for LGBTQ+ individuals, allowing users to interact with LGBTQ+ narratives in VR ("Gather around a virtual campfire", 2018) and caregivers to undergo immersive training to care for elderly LGBTQ+ adults ("New Virtual Reality Immersive Learning Lab", 2020). Besides developing empathy through embodiment, VR applications can challenge stereotypes by immersing users in situations that reveal and correct implicit biases. Such approaches have been used in various settings, from de-escalation training in law enforcement (Kim, 2018) to reducing gender and racial bias in classrooms (Gordon, 2020). The latter approach yielded statistically significant correlations between users' empathy towards female and minority students and their awareness of implicit biases. These examples illustrate how VR applications provide valuable feedback to individuals about their internalized biases to overcome deep-rooted stereotypes about gender, sexuality, and race.

Overall, leveraging VR's unique capability to provide embodiment and simulate immersive

interactions can challenge implicit biases and develop empathy towards women, racial minorities, and LGBTQ+ individuals. Stanford's Virtual Human Interaction Lab director Jeremy Bailenson believes immersive VR technology "takes the cognitive effort out of" perspective-taking exercises employed to build empathy ("How Experiencing Discrimination in VR", 2018). That said, whether VR can enable effective perspective taking is highly contingent on how immersive it is. The ability to establish a strong presence where users "feel like they are there" is crucial for them to genuinely adopt the perspective simulated by VR technology. Ill-fitting VR hardware may create overwhelmingly negative physical sensations like what boyd experienced, hindering users from gaining deeper insights and causing this solution to ultimately lose its efficacy. It is essential for improvements to VR hardware and software to be made in parallel, with the overarching goal to increase inclusivity in VR technology.

Part II. Addressing Sex-Based Biases in VR Hardware

Sex-based biases exist in modern VR hardware, specifically in VR head-mounted display (HMD) design. In one study, females and males used the popular Oculus Rift DK-1 and DK-2 HMDs to play the game *Minecraft* (Shafer et al., 2017). They were asked to complete the Simulator Sickness Questionnaire (Kennedy et al., 1993) after twenty minutes of gameplay. For both HMDs, females experienced more severe cybersickness symptoms than men, with negligible improvement from the older HMD to the newer version. In Grassini et al. (2021), females also reported more severe nausea-related simulator sickness than males using the Oculus GO HMD. Recent research has discovered interpupillary distance (IPD) non-fit is the primary reason for differences in cybersickness symptoms (Stanney et al., 2020). Substantially more females cannot achieve a good fit to their IPD with modern VR HMDs. Fulvio et al. (2021) found the average male's IPD is 63.7mm, which closely matches the Oculus Rift DK-2's default IPD of 64mm. However, the average female's IPD is 59.4mm, and approximately 90% of females have pupils closer together than the default headset setting. Furthermore, 27% of females have an IPD beyond the adjustable IPD range, as compared to only 5% of men. Using the incorrect IPD setting introduces

conflicts in the visual cues specifying object motion. These conflicts contribute to cybersickness, and evidently, such occurrences are much more likely for females.

The disparities in the experiences using VR HMDs between males and females suggest sex differences should be considered more thoroughly when developing VR technology prototypes. Fulvio et al. (2021) makes clear that VR HMD design choices – both the default IPD setting and adjustability range – are geared towards the average male. From the empirical studies cited above, one can infer the participants involved in preliminary research leading to these design choices were likely predominantly male. Research teams should ensure a better sex balance in research participants to determine the appropriate default IPD setting and adjustability range for males and females separately. Companies developing VR hardware can then create more equitable technology by rethinking the standard reference models for their products. This will likely require having two reference models for prototype testing – one for males and one for females – accounting for the difference in average IPD between sexes.

Considering these analyses, developing more sex-sensitive VR HMDs can address these biases. This could mean VR HMDs are engineered to have a wider IPD adjustability range that accommodates more females (ideally a similar percentage to males). Alternatively, if hardware constraints prevent the adjustability range from being sufficiently large, separate VR HMDs can be developed with a narrower default IPD setting and the appropriate adjustability range for females, which should both be determined through additional research. To avoid further perpetuating gender assumptions, the headsets should be identical in aesthetic design and differentiated using gender-neutral terms like “small”, “medium”, and “large”, rather than “male” and “female”. According to Stanney et al. (2020), if an individual’s IPD is properly fit to VR HMDs, sex differences in cybersickness are not expected. For both sexes, participants whose IPD matched the HMD experienced similar degrees of cybersickness, and recovered from any adverse effects from VR exposure within one hour post-exposure. However, females whose IPD did not fit the HMD (there were no males in the study whose IPD did not fit the HMD) experienced more severe cybersickness and could not recover within the same period. Therefore, developing VR HMDs with

hardware specifications tailored to fit female IPDs can significantly improve their experience by reducing or eliminating cybersickness symptoms.

While this solution is an important step towards more equitable VR technology, improvements in VR hardware to fit females will have little benefit if the software applications developed on VR hardware are not similarly inclusive. According to Grassini et al. (2021), females experience a stronger presence – the subjective psychological sense of "being there" – than males when using VR applications. This is especially important when considering the heightened emotional impact VR experiences have on females than males. As seen in Belamire's harassment experience playing the multiplayer QuiVR game, VR's unique immersive quality amplifies psychological harm associated with such experiences compared to other non-immersive mediums. VR applications should be developed to promote gender and social equality, alongside improvements in VR hardware, to make VR technology inclusive to a wider audience.

Part III. Conclusion and Future Work

This paper analyzes two challenges with VR technology and explores two gendered innovations to address them. Firstly, immersive VR applications contain discriminatory content and promote harassment behaviors, particularly towards women, racial minorities, and LGBTQ+ individuals. Analyzing assumptions about gender, sexuality, and race embedded in these applications can help improve the engineering processes used to develop them. By leveraging VR's uniquely immersive capabilities, VR technology can promote social and gender equality by increasing representation, challenging stereotypes, and developing empathy towards traditionally marginalized communities. Secondly, sex-based biases in VR hardware result in headsets being better suited to males than females. Companies developing VR hardware should revise their standard reference models by improving the sex balance in participatory research processes contributing to their product design. This enables companies to develop more sex-sensitive VR headsets that fit females' interpupillary distance. Ultimately, improvements to VR software and hardware must be developed in parallel to create equitable and

inclusive technology for a diverse user base.

Regarding next steps, research into VR's emotional and psychological impact, specifically social VR, is a largely underexplored area ("Fast rise in social virtual reality", 2021). Within this relatively small research pool, minority race and LGBTQ+ individuals' experiences in immersive social VR environments are understudied compared to women's experiences on these platforms. Through balanced participatory research, researchers should study the effects VR applications have on traditionally marginalized groups. These research findings can help reduce barriers and create opportunities for underserved communities. In addition, employing a diverse participant pool in VR hardware testing can help develop inclusive hardware. For instance, gender-diverse individuals, intersex individuals, children, and people with physical disabilities may require different specifications to achieve a good fit with VR devices. Despite its numerous benefits, VR is a not a silver-bullet solution to improving equity and inclusion, and additional research will be critical in ensuring VR can effectively achieve these goals.

Indeed, VR technologies have great potential to revolutionize how humans live, work, and interact. However, they are ultimately products of our own creation, which means they are not immune to the biases and stereotypes pervading our society. As VR creates a uniquely immersive virtual experience that can amplify both positive and negative human behaviors, VR design decisions should leverage the technology's capabilities to promote inclusivity and equity, especially for historically underrepresented communities. Analyzing assumptions about sex, gender, and race will help VR developers identify and correct stereotypes posing barriers for marginalized groups. A world with effective inclusivity trainings enhancing classrooms and workplaces, and constructive, collaborative virtual spaces allowing for empathy interventions, is not beyond reach. As VR technologies continue to gain widespread adoption, research and innovation cognizant of sex, gender, and race is essential to move the field in this direction. We must integrate these paradigms that fundamentally shape our world into VR development, so VR's positive potential can be fully realized in the future.

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