Consent, Deception, and Retaliation: Articulating What it Means to Feel Safe in Social Cross-Reality with Participatory Design of VR Dating

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ABSTRACT

Social VR has demonstrated new potential for relationships, but also novel forms of immersive and embodied harms. This will soon be followed by cross-reality experiences that support social interaction—and potential harm—across virtual and physical reality, as exemplified by emerging VR dating applications. This paper presents a participatory design study of VR dating with 16 stakeholders identifying as women and/or LGBTQIA+ to reflect on how safety can be designed for in cross-reality—not as a reaction to harm that is already occurring, but as a proactive initiative to address fears that may limit technology adoption and inclusion. Findings elucidate three types of cross-reality harms that participants identified as most related to a sense of safety: physical harm as retaliation for romantic rejection across realities, unintentional physical harm through assuming consent to similar behaviors across realities, as well as risks associated with misinformed decisions to meet in the physical world. Design directions to instill a sense of cross-reality safety involved augmented consent exchange capabilities and intervention of virtually and physically co-located bystanders.

CCS CONCEPTS

• **Human-centered computing → Empirical studies in collaborative and social computing**.

KEYWORDS

Consent; VR Dating; Cross-Reality; Safety; Harm; Social VR

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1 INTRODUCTION

Social virtual reality (VR) applications have provided enriched capacity for self-presentation, interaction, and collaboration [14, 23]. Yet they have also opened the door for novel forms of immersive and embodied harms [6, 15]. Social VR interactions—and their associated harms—will not remain relegated only to virtuality. Advances in cross-reality technologies, which can support social interactions across the virtuality-reality continuum [26], mean that users will be exposed to new opportunities for interpersonal relationships as well as new harms across virtual and physical environments.

We define cross-reality harms as those that occur in the physical world due to—or facilitated by—prior interaction in virtual reality. The potential for cross-reality harm is perhaps best exemplified by VR dating applications. Established dating app companies such as Tinder and Bumble have considered incorporating VR into the online dating experience [4, 12], and entirely new dating platforms tailored for VR are emerging in various stages of private beta and public release—examples include Planet Theta [45], Flirtual [22], and Nevermet [31]. The mobile dating apps that have preceded this new foray into VR have long been associated with online-to-offline harms, such as sexual assault [9, 13]; for example, multiple studies indicate that approximately 10% of all rapes are attributable to dating apps [33, 34, 44]. Given the physical sexual harms that already occur through online dating, along with harassment and other harms that already occur in social VR, we can expect VR dating—a convergence of these two contexts—to expose users to novel forms of cross-reality harms.

While cross-reality technologies are still in fledgling stages of public adoption, in this paper, we consider it an opportune time to reflect on how safety can be explicitly designed for in cross-reality interactions—not as a reaction to harm that is already occurring, but as a proactive initiative to address stakeholders' fears and concerns that may negatively impact (or dissuade) technology use. We begin such a reflection with participatory design of cross-reality dating with stakeholders who identify as women and/or LGBTQIA+: demographics often associated with social VR harm [14, 40], and disproportionately the victims of online dating violence [33] and sexual violence more broadly [16]. Specifically, 16 women and LGBTQIA+ stakeholders leveraged their prior experience with mobile dating apps and social VR to articulate a vision for cross-reality safety by forecasting the types of cross-reality risks and harms that should be prioritized in the design of VR dating. Taking cues from Blom and colleagues' design work on fear in urban environments [7],

the intent of the study was not to produce definitive, empirical accounts of which cross-reality harms actually occur, but to learn how cross-reality technology can instill a sense of safety through structures to mitigate harms that eventual users are most concerned about. Research questions motivating this paper include:

RQ1. *What are the potential interpersonal risks and harms in cross-reality dating that would most impact women and LGBTQIA+ stakeholders' sense of safety and willingness to use such technology?*

RQ2. *What should be the long-term design goals or directions for maintaining a sense of safety in cross-reality interactions?*

Our findings articulate three cross-reality harms that our stakeholders were most concerned about, alongside design goals for instilling a sense of cross-reality safety through mitigating such harms. Collectively, the findings articulate directions for future research and design focused on safety-conscious cross-reality interaction.

2 RELATED WORK

Social VR platforms have rapidly grown in popularity due to the richness of interactions that users can experience over long distances. Even in these spaces, online harassment persists, and typical harassment can be transformed into a deeply humiliating and personal experience for users due to its embodied nature [15]. Research portrays such harms as particularly affecting individuals from underrepresented groups such as women [38], children [25], and LGBTQIA+ individuals [48]. These empirical findings have motivated research into design of social VR platforms pursuant to safety [48] through, for example, personal space bubble design [42] and consent boundaries [39]. We build on this research through a focus on the traversal of social interactions across virtual and physical realities, which some research refers to as cross-reality [5].

Mapped to the reality-virtuality continuum [26], cross-reality systems enable social interaction across degrees of fully-virtual and fully-physical environments [5]. This can involve partners transitioning their interaction across realities, or individuals in different points of the reality-virtuality continuum simultaneously communicating (e.g., a work meeting in which employees are interspersed across virtual and physical reality). While research over the last decade has explored the utility of cross-reality in various contexts [1, 11, 17, 21], we have yet to see a consideration of cross-reality safety and harm (rather, the literature tends to focus on harms specifically in virtual reality [15] or specifically in augmented reality [32]).

We base our exploration in the context of VR dating in part due to emerging examples of such applications in the commercial space, which either offer VR spaces specifically for dating and romance [45] or connect daters who can then interact in social VR [22, 31]. Another reason is the ample evidence of harms related to traditional mobile dating apps that traverse online and physical contexts such as sexual assault [33, 34, 44]. This positions VR dating as a likely flashpoint for harms that typically occur separately within social VR and within online dating. Drawing on prior work into fear, concern, and the notion of *harnessing* safety [7, 36, 37], our study frames design for safety not as the reaction to known harms, but the proactive address of "fear-related concerns" [7] that could drive, or discourage, adoption of cross-reality technology by already-marginalized groups.

3 METHODOLOGY

We explored our research questions through participatory design [29] workshops with prospective VR dating users in the Midwest United States who identify as women and/or LGBTQIA+ (n=16). The study was approved by our university's institutional review board (IRB). Several of our methodological and recruitment decisions were informed by a prior study dedicated to producing methodological guidance for participatory design of emerging technologies for sexual violence mitigation [10]. We also consulted with a certified sexual assault nurse examiner and psychology researchers specializing in sexual violence. First, it was determined that the participatory design sessions would be conducted in groups so that participants could offer emotional and social support to one another; stakeholders were thus encouraged to invite a friend if they aligned with our inclusion criteria because of the inherent comfort they shared. Sessions were also conducted in person in a research lab to guarantee privacy and provide an intimate space for participants to build rapport and develop comfort in sharing personal stories. To support informed decisions to engage with the sensitive nature of this research, recruitment methods clarified the in-person and group nature of participation and clarified that the study would involve discussion and design of VR dating and harm in online dating and social VR.

3.1 Participants and Recruitment

We sought participants who identified as women and/or LGBTQIA+ because these demographics are most often the victims of sexual violence (both in general [16] and in computer-mediated contexts [33]) and are often associated with social VR harm [38, 40]. We further sought prior experience with either dating apps or social VR platforms and an interest in using VR for dating (required use of VR dating apps, in particular, was determined to be impractical due to the limited and inconsistent availability of such platforms to the public at the time of recruitment). Recruitment methods included messages on social media, a university student mailing list, a sorority mailing list, and snowball sampling.

Of the 16 participants, 14 identified as women and 2 as nonbinary. Seven were heterosexual, 4 were bisexual, 2 were homosexual, one was pansexual, and two chose not to disclose their sexual orientation. Ages ranged from 19-26, which aligns with the most common age group for online dating [3]. Thirteen had prior online dating experience, 9 had social VR experience, and 7 had experience with both. One participant lacked experience in both dating apps and social VR, and participated at the behest of another participant for comfort and camaraderie reasons.

3.2 Data Collection and Analysis

Participants were split across four groups; sizes ranged from 3-5 people. Each group engaged in activities totaling 9 hours in duration; these were split into three 3-hour sessions to avoid participant fatigue. Each session had a distinct theme; this paper reports on analysis of the first session which pertained to visions of safety and anticipated risks in VR dating.

The session began with introductions and informal conversations among participants to establish familiarity, followed by an introduction to the current state of VR dating and online dating more generally, as well as a demo of social VR technology, to accommodate the varying familiarity of participants with online dating and VR. Participants were then presented with a visual map of a reality-virtuality continuum that was tailored to the VR dating context by elucidating the steps for discovering a potential dating partner in VR, interacting with the potential dating partner in VR, meeting in the physical world, and engaging in physical sexual activity. Participants elucidated safety concerns and anticipated harms by attaching post-it notes representing the harm to an area of the continuum where they considered the harm most likely to occur. This was followed by a prolonged discussion amongst the group through which they volunteered personal stories and other reasons why the anticipated harm was a concern to them. Participants then engaged in a scenario-generation exercise through which they prepared a story about a fictitious VR dater experiencing the respective harm as a basis for exploring why the harm may occur and proposing design directions that developers could take to mitigate such harm and instill a sense of safety.

Transcripts of the design sessions along with visual artifacts produced by participants were subjected to reflexive thematic analysis [8]. This involved three researchers familiarizing themselves with the data through individual review and casual note-taking, followed by collaborative coding and initial thematic map generation, which was further subjected to reflective critique and revision in recurrent group meetings. A bulk of participants' concerns centered on the transition between virtuality and reality, hence the focus of this paper on cross-reality harm. The writing of this manuscript thus served as the final stage of reflexive thematic analysis pertaining to our investigation of the aforementioned research questions.

4 FINDINGS

Participants collectively articulated a vision for how cross-reality technology could instill a sense of safety through design by acknowledging and preempting specific types of harms that may occur when users transition from virtuality to reality. These anticipated harms were mutually informed by participants' prior online dating and social VR experiences and the unique ways they expected VR dating to alter the online dating process.

In contrast to mobile dating apps, where users engage in app-use primarily to *discover* potential dating partners, participants in our study envisioned VR dating environments being used to discover *and* build relationships with dating partners online, sometimes for several months before traversing the relationship to the physical world. This prolonged interaction in VR was the root of several cross-reality harms that participants expressed most concern for, which we organize into three themes: 1) physical harm as retaliation for romantic rejection after crossing realities; 2) unintentional physical harm by assuming or trivializing the importance of consent across realities; and 3) intentionally misinforming other users' decisions to meet in the physical world and expose them to physical harm. We review these in subsections 4.1 to 4.3.

While it remains unknown how prevalent these types of cross-reality harms will be, participants expressed how the *potential* for these harms dictated their perception of safety and ultimately, their willingness to use VR dating applications. Specifically, our analysis elucidated three cross-reality design goals to instill a sense of safety when VR daters traverse interactions to the physical world, which we coded as *design goals for cross-reality safety*. These include: 1) explicit conveyance of consent or personal boundaries across realities; 2) cross-reality bystander intervention that leverages staff at physical-world locations; and 3) cross-reality "buddy" systems in which friends or other users of the VR dating application can observe and participate in the physical world meeting virtually to monitor safety. We review these in section 4.4.

4.1 Physical Harm as Retaliation for Romantic Rejection After Crossing Realities

Participants expressed concern about intentional harm as retaliation for romantic rejection after transitioning a relationship from virtuality to reality. This concern was rooted in the recognition that VR environments could be used to develop a strong sense of intimacy over time prior to traversing into the physical world, therefore increasing a sense of loss and rejection if the initial physical world meeting does not go well. This was contrasted with traditional mobile dating apps today where the role of online interaction was seen as to discover and quickly evaluate whether a partner is suitable for a physical world meeting where compatibility could be truly assessed [51]. Some participants pointed to the embodied nature of VR as a reason intimacy could be better developed than in mobile dating apps. As P6 put it:

"But in VR, there's a more personal aspect of it, where you have gestures and body language that on top of the speaking, and like being in a physical space with someone that does give more much more information about a person."

The ability to convey information with body language and *"physical"* behaviors in addition to speech led some participants to anticipate daters fostering significant emotional attachment in VR prior to physical-world meetups. Some envisioned daters spending upwards of multiple months in VR to develop a connection before traversing their interaction across realities, which they largely considered to be beneficial for their dating lives. P10 alluded to the protracted period of time for intimacy building in VR prior to the first physical world encounter:

"When like, two people decide, 'okay, look, let's finally meet in-person [in the physical world], we've been like dating in VR for like six months...'"

While this enriched capacity for online intimacy was viewed positively, participants also problematized it by pointing out the potential that one's physical-world self may not match the impression formed in VR. Attributes and behaviors such as physical appearance and physical-world behaviors and mannerisms may be unknown or misunderstood in VR, through no fault or intent to deceive. This could result in an abrupt rejection of a partner during a physical-world encounter after weeks or months of forming a connection online (e.g., one realizes they are not sexually attracted to their partner's physical body).

For traditional dating apps, the first physical-world date may occur soon after discovery online, where essential qualities could be assessed quickly before any romantic attachment. For VR dating

apps, participants feared that rejection during the initial physical-world meeting might be considered unfair or unjustified by their partner. This could cause the person to lash out emotionally and potentially engage in harassment or physical harm in retaliation.

"...say you go out on a date in real life, and you're not interested anymore? And then what if the other person's response was really like violent, very, like, physically threatening in response to that..."

This concern of retaliatory harm resonated with participants, some of whom mentioned or alluded to personal experiences of managing rejection—and related combative or harassing behavior—in mobile dating apps.

4.2 Unintentional Physical Harm Through Assumed and Trivialized Consent Across Realities

Participants often exhibited concern about unintentionally-inflicted physical harm as a result of assuming and trivializing consent to interpersonal behavior during the transition from virtuality to reality. Some of this concern related to a perception that VR dating environments are a *"less serious"* modality for interaction than the physical world in the sense that the repercussions of one's behavior on other people in VR are inherently minimal or nonexistent. As P5 described it:

"...like a VR date, because like, since this is VR, not actually in-person, I feel like people may tend to like, you know, slack off."

This notion of slacking off was echoed in the dialogue of other participants who viewed interaction in VR as essentially not *"real"* and thus not beholden to the same social conventions and precautions for safety that are typical in physical-world interactions.

Consequently, participants suspected consent would be trivialized in most interactions in VR. In other words, users may deem it unnecessary to ask for and receive a partner's agreement to interpersonal behavior if the effects of one's behavior in VR are considered inconsequential. The types of such consent-inapplicable behaviors envisioned by participants in VR dating ranged from the benign to the extremely sexually graphic. Yet the harms that participants expressed concern about were not strictly the nonconsensual acts that may occur *in* VR, but the normalization of trivialized consent in subsequent physical-world interactions where physical sexual assault could occur. As P16 discussed:

"Because they're like, well, it's not, it's not real, right? Like, why not [engage in the behavior without consent]? And it's like, well, no, that just goes against, like, the moral aspect of it all. And like, people can get confused with that in real life, too."

It is this confusion P16 referenced that could result in unintentionally inflicted cross-reality harm: the touching of one's physical body without permission because of the perceptually routine, inconsequential nature of similar behavior in VR.

Even in situations where consent is respected and established in VR, participants anticipated cross-reality harms due to misassumptions of consent to similar behaviors across virtuality and reality. P7 exemplified this with hand-holding:

"...if you touch in VR, or if you like, held hands in VR, and you just assume now that we're meeting in public [in the physical world], we can also hold hands."

While the consequences of accidental non-consensual handholding may primarily be awkwardness and discomfort, impacts can be severe through mis-assumed consent to more intimate behaviors such as kissing and sexual touching that might have been acceptable in VR but not when first meeting in the physical world. Participants imagined that without the explicit establishment of boundaries when transitioning to physical environments, unintentionally inflicted physical harm through assumed consent could be a routine occurrence.

4.3 Sexual Predation and Statutory Rape through Misinformed Consent to Physical Encounters

Participants voiced concerns that the enriched self-presentation capabilities within VR may provide new ways to misinform decisions to meet a user in the physical world, thus rendering them susceptible to physical harms that could have been avoided. Self-presentation affordances of VR environments, particularly customizable avatars and voice filters, were often noted as obstructions to forming an impression of who is really *"on the other end"* of the VR headset. While participants were largely encouraging of freedom of self-expression, they anticipated difficulty in predicting or assessing a person's physical world appearance and other key details for dating, such as age, prior to transitioning from virtuality to reality.

Some participants drew a comparison to their experiences with mobile dating apps and the importance of profile pictures to assessing veracity of online identity claims—an element that may be lost in VR self-presentation. As P8 explained:

"I've come across using apps like Tinder, someone says that they're 24, but then it's a picture of a man who's definitely well into his 60s. And if you were to take away that, that picture element, there would not be as many ways to safeguard against that. So I could set up an avatar and be like, oh, yeah, my avatar is whatever [...] how are you enforcing an accurate representation of yourself?"

Participants felt unsafe due to the potential obfuscation of one's physical-world self for two reasons. One involved catfishing to coerce vulnerable users to meet face-to-face where deliberate harm could occur. The other involved children misrepresenting themselves in VR to convince adults to meet them face-to-face for dates, where such adults would be at risk of committing statutory rape or being misunderstood by others as a sexual predator. Regarding the first, participants discussed avatar customization being used maliciously by older individuals to *"prey"* on younger users through forming intimate relationships on false pretenses and eventually encouraging those users to meet in the physical world in unsafe environments. In P15's words:

"Like some, like 50 year old is like, 'oh, I'm 21' and you can make your voice, I'm sure you could like change your voice filters [...] yeah, stuff like that. You can catfish, prey on, like, younger folks."

Other participants talked about misrepresentation of physical-world identity occurring for non-malicious reasons. Children and teens were typically mentioned in scenarios through which underage users would try to present in VR as adults, not to trick other users into dating them, but due to earnest attempts to enter the

dating pool and act like adults themselves—unaware of, or unconcerned with, the cross-reality harms this may trigger such as statutory rape (unlawful sexual activity with a minor). Per P7:

"I would hope that parents would put in things in their VR systems at home, that would limit children. Especially when it comes to like romantic settings. But people and children are very curious. And it would be very easy for them to dress themselves up to look like an of-age avatar, and then go out and experiment and try to learn things about, you know, adult content."

P7's note of children "*being curious*" emphasized an understanding that VR dating applications may be an enticing space for younger users to interact within adult spaces and form relationships with older individuals, even if those relationships are based on incorrect presumptions of physical-world identity. This demonstrates the contrast in cross-reality harms when identity deception is used maliciously to coerce victims into physical-world meeting, and here by children where participants began to think of themselves as unwitting *perpetrators* of cross-reality harm, rather than victims.

4.4 Design Goals for Cross-Reality Safety

The unifying theme around participants' suggested design directions to preempt the aforementioned harms and instill a sense of cross-reality safety was to enable various safety structures while one is meeting a VR dater in the physical world for the first time. Our analysis elucidated three design goals for cross-reality safety: 1) visualization of consent to interpersonal behavior across realities, 2) transforming physical-world businesses into bystander intervention networks, and 3) cross-reality buddy systems.

4.4.1 Augmenting Consent Exchange. Concerns of nonconsensual acts during physical encounters with VR daters were prevalent due to worries that users would assume consent to certain behaviors in physical reality that were acceptable (or tolerated) in VR, or would trivialize the importance of consent altogether (see section 4.2). In response to these fears, participants recommended that future design of cross-reality interactions focus on using the unique affordances of the technology to scaffold explicit exchange of consent to interpersonal behaviors to normalize the asking and receiving of consent across realities.

Discussion of augmented consent exchange, conceptually, usually involved descriptions of *"physical"* or visual representations of agreement to behavior that dating partners could unmistakably *"see"* therefore alleviating any chance of mis-assuming permission to an interpersonal act, or conclusions that consent is somehow inapplicable. It was not unusual for participants to allude to prior experiences here, particularly in how unreliable signals such as *"body language"* and *"enthusiasm"* can be misunderstood not only in VR but in other online and physical world contexts as well (empirical research on sexual consent practices provides support for these anecdotes [28]). Per P1:

"The only thing I would say is like, it's hard to tell enthusiasm through technology [...] And like, again, like you can't really tell if they're, like, fully into it or not [...] Some people can be saying yes, but that has a lot to do with, like body language and everything."

Articulations of what augmented consent exchange may do or look like thus put a focus on making these normally implicit signals more blatant or *"visual."* For instance, P1 explained: *"A big thing is body language [...] so finding some sort of supplemental feature that maybe shows body language in a way, I don't know what exactly that would look like."* Whereas P1 struggled with envisioning how consent-related body language could be expressed, P8 used the design metaphor of colors: *"There's a lot of ways that you could use some sort of color changing element to communicate [...] it could be used for other sorts of things that could be used for like consent."*

4.4.2 Augmenting Bystander Intervention. Some fears around traversing virtual interactions to the physical world related to retaliatory harm if they lose attraction for their partner's physical-world self, and unexpectedly unsafe situations related to identity deception in VR (sections 4.1 and 4.3). Some design suggestions stemming from these scenarios involved cross-reality bystander intervention networks where users, while still in VR, could identify physical world establishments whose staff are pre-trained to monitor and correspond with VR daters who are traversing their interactions to the physical world for the first time. This was viewed as almost an intermediary experience between virtuality and one-on-one physical reality interactions that still included many of the environmental safeguards that may be customary in VR. Per P10:

"So like a VR app could partner with these [...] small businesses [...] they could create like a safe, like, environment [...] but you could have a certain list of places near you, where you could meet safely, and you would have people over watching you just in case something goes awry. Or like because you know, that this place is, is a safe space, because it was it was listed on the VR app. You could go to [a trained bystander] and say, 'hey, like, I don't feel comfortable in the situation right now. Could one of you or your staff members, come help me if that's okay?' And then that would be like a great way to like, try and like, make it a bit more safer."

As P10 and other participants explored, a key aspect for realizing these spaces would be the presence and means of covert communication with dedicated staff whose goal would be to observe the VR daters and interrupt unsafe interactions (while augmented reality (AR) would be the assumed means of such communication, participants tended to leave these details open-ended).

4.4.3 Cross-Reality Buddy Systems. A popular variation of the bystander intervention networks from the above subsection involved *"buddy"* systems where daters could be paired with other VR dating application users—known as *"buddies"*—who would be tasked with monitoring one's safety when meeting another user in the physical world for the first time and responding virtually to emerging threats. This contrasts with bystander intervention networks in two ways. One is that while staff-turned-bystanders could immediately intervene in unsafe situations due to their physical co-presence, cross-reality "buddies" would assess the situation from afar (referred to as multi-user cross-reality in [5]). The other difference is that "buddies" would give dedicated attention to the user whereas physically co-located staff would presumably have their attention divided by all customers at their establishment. In addition to offering individualized support, participants pictured buddy systems as more comfortable because they are supported by other participating users who might have similar worries and challenges within the environment. P11 envisioned users being able to immediately capture a buddy's attention to get help:

"So I looked at like, the buddy system, creating a buddy bar where you like, you go in, you wait to be paired with a buddy. And you have your buddies chat box in the corner. And I thought about maybe your buddy needs something, the buddy's voice will mute everything that's going around you so that you can hear them."

5 DISCUSSION AND CONCLUSION

In this paper, we presented a participatory design study with women and LGBTQIA+ stakeholders about their visions for safety during cross-reality interactions in the context of VR dating. The study identified three types of cross-reality harms that participants were most concerned with, which motivated long-term visions for safety by design—design goals for instilling a sense of safety during the use of cross-reality technologies. In the following subsections, we reflect on two overarching directions for foregrounding safety in cross-reality design, and explore opportunities for future research.

5.1 Cross-Reality Safety Through Augmenting Consent Exchange

Participants commonly recommended that cross-reality technologies be utilized to assist VR daters in visualizing or expressing explicit consent—or lack thereof—to interpersonal behaviors across realities. This recommendation was in response to concerns that VR daters would establish patterns of trivializing the importance of consent, or assume consent for similar behaviors across virtual and physical environments, potentially leading to inadvertent physical and sexual harm. This concern is empirically supported by research in online dating and social VR. For instance, users of the dating app Tinder have been found to assume consent to sex based on cues perceived on the dating app such as a bikini photo [50], whereas social VR users have reported challenges with establishing and maintaining consent "boundaries" when interacting with others in virtual environments [39].

While conceptual designs for computer-mediated consent technology have been explored in related domains such as sex-themed video games [30], sex robot interactions [41], and social media platforms [19], as well as more directly with augmented reality-based sexual consent concepts [49], the field has yet to produce and assess functional prototypes of AR/VR consent mechanics, that can facilitate expression, and re-confirmation, of consent to interpersonal behavior across realities. Future work could involve stakeholders in the co-design and evaluation of functional prototypes.

5.2 Cross-Reality Safety Through Augmenting Bystander Intervention

Participants spent a lot of time discussing ways to use cross-reality technology to involve other people in maintaining a sense of safety when traversing interaction from a VR dating environment to the physical world. Examples include communicating with employees at the physical meeting location (e.g., bartenders) for immediate intervention, or with other people online who could monitor their safety status and call for help on their behalf. These ideas draw parallels with HCI research into mobile and wearable technologies for safety in physical environments and highlight new opportunities for future work. For example, prior efforts have involved mobile apps to help women avoid harm through monitoring their location with GPS [46] and providing safe routes to evade street harassment [2]. Wearable devices for seeking help if one is being sexually harassed [35] as well as odor-emitting capsules and other deterrents to repel a rapist [27] have also been reported on. There is a need for further advances in safety-oriented technologies in the physical world, as a critical assessment of mobile phone-based panic buttons emphasizes [20]. Future work could use a blend of VR and AR as contemporary design materials to support the intervention of bystanders who are physically co-located or virtually present.

5.3 Future Investigation of Cross-Reality Safety

This research into foregrounding perceptions of safety in cross-reality interactions is ongoing, and would benefit from larger sample sizes and the inclusion of other user demographics in articulating their visions for safety. Examples include cisgender men and improved diversity in the ethnicities represented. As cross-reality technologies begin to garner public adoption, future research can also study which harms actually occur in cross-reality interaction (which may differ from those forecasted by our participants), the long-term impacts of cross-reality interactions, and how such empirical knowledge could inform additional designs for safety and harm mitigation. How accurately these forecasted harms match actual occurrences in the future use of VR dating applications and other cross-reality technologies is tangential to the study's focus on instilling a sense of safety through design. Nonetheless, there is some basis to suspect they will likely occur due to empirical studies on mobile dating apps and social VR separately. For instance, the crux of participants' design guidance was an assumption that individuals would spend ample time in VR to develop intimacy and relationships, which would inadvertently predispose them to later harm in the physical world. Prior work has found long-distance romantic couples to spend extensive time in VR [47], and popular media such as an HBO documentary has also found individuals to develop romantic connections in VR [18]. Furthermore, issues of unexpected child-adult interactions have been found in social VR [24], and there is a long line of research into identity deception in online dating (e.g., [43]). As VR dating applications progress beyond beta stages and amass userbases, future empirical work can utilize VR dating users to validate the proposed safety measures and identify if additional harms should be considered in the safety-oriented design of cross-reality communication.

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