Don't They Really Hear Us? A Design Space for Private Conversations in Social Virtual Reality

Josephus Jasper Limbago, Robin Welsch, Florian Müller, and Mario Di Francesco

Fig. 1: We explore factors affecting private conversations in social VR applications: the perceived safety, the usability of different interaction methods, and the related interplay. We draw a design space accordingly to foster self-disclosure in virtual environments.

Abstract—Seamless transition between public dialogue and private talks is essential in everyday conversations. Social Virtual Reality (VR) has revolutionized interpersonal communication by creating a sense of closeness over distance through virtual avatars. However, existing social VR platforms are not successful in providing safety and supporting private conversations, thereby hindering self-disclosure and limiting the potential for meaningful experiences. We approach this problem by exploring the factors affecting private conversations in social VR applications, including the usability of different interaction methods and the awareness with respect to the virtual world. We conduct both expert interviews and a controlled experiment with a social VR prototype we realized. We then leverage the outcomes of the two studies to establish a design space that considers diverse dimensions (including privacy levels, social awareness, and modalities), laying the groundwork for more intuitive and meaningful experiences of private conversation in social VR.

Index Terms—VR, Privacy, Conversation, Design, Self-disclosure

1 Introduction

Social Virtual Reality (VR) is revolutionizing interpersonal communication taking place remotely [30]. In fact, social VR applications allow users to engage in a shared virtual space through avatars, creating a sense of closeness over distance [22, 58, 65]. These applications foster collaboration and shared experiences; consequently, a wide variety of conversational situations – from business meetings and creative brainstorming sessions to casual gatherings – have made their way into VR and more so in the future [19, 79]. A key human capability to navigate conversational situations is our flexibility to seamlessly transition between public discourse and private conversation as needed in changing circumstances [25, 46, 73]. In the physical world, we initiate such transitions by adjusting our gaze, volume, and distance to the target audience [15]. Instead, today's social VR applications require explicit context switches such as bringing up menus and entering breakout rooms; these compromise presence and diminish the potential of VR for meaningful social experiences, ultimately harming self-disclosure [55, 59]. Furthermore, this poses a privacy risk if unwanted or unexpected listeners can eavesdrop on confidential information [67]. In any case, users may be unwilling to engage in private conversations in VR if they deem it unsafe [78].

Previous work has raised the need for private conversations in virtual environments [5, 57]. In particular, self-disclosure has been found essential in social VR to build and maintain authentic relationships, to relieve distress, and to get close to other people [59]. Several findings showed that users have a profound need for privacy in safe spaces too [71, 76]. On a different note, interaction design in social VR has largely focused on enabling group conversations [28, 41]. For instance, cancelling background noise was shown to mitigate adverse effects of conversational interference [71]. Moreover, research explored nonverbal cues such as gestures [66], gaze [63], and facial expressions [60] to increase presence and support communication. Enabling private conversations has recently received some attention in the context of virtual events and remote meetings in particular [17, 57]. Unfortunately, the need for private conversations in social VR [58] correlates to the scarce literature on interaction methods for enabling them (Section 2). As a consequence, exploring the design space of private conversation methods in this context is essential.

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This article explicitly addresses this research gap by exploring the factors affecting private conversations in social VR applications. Our work specifically considers different interaction methods and users' awareness with respect to the virtual world, guided by the following research questions: What factors do users consider important for private conversations in social VR? What is the design space for enabling private conversations in social VR? To address these research questions, we contribute the results of two independent studies to gather insights from different perspectives, involving participants with diverse expertise with social VR. On the one hand, we interview domain experts ($N = 7$) to gain a broad understanding on the issues and aspects that matter for private conversations in VR (Section 3). On the other hand, we carry out a controlled experiment in which participants ($N = 12$; 6 pairs) tested on two established baselines (namely, private talk and private room), then explored and described their own design ideas to effectively support private conversations in VR (Section 4). Based on these studies, we contribute a thematic analysis that identifies motives ranging from contextual factors and user needs to privacy indicators. From these, we derive a design space that considers the modality, the availability, the self- and other awareness, as well as the isolation from other social VR users (Section 5). Consequently, with this work, we lay the groundwork for designers of social VR applications to implement methods that promote self-disclosure through more intuitive and meaningful experiences of private conversations.

2 Related Work

There is a large body of work on: security and privacy in VR; interactions in multi-user virtual environments; and design studies for social VR. We discuss the most representative works in relation to our research topic accordingly.

2.1 Security and Privacy in VR

The security and privacy of the metaverse are compelling issues that have lately attracted the attention of the research community [14,23,68]. Among them, the data flow within the metaverse platform is particularly critical, as it may include sensitive information not only represented by biometrics. For this reason, researchers have specifically addressed the anonymization of sensor data [43] to counter within-metaverse tracking and surveillance. Widely used methods include transforming the user's avatar into a disguised form, creating one or multiple clones, and purposely confusing observers with deception [10]. However, Meng et al. [36] have shown that it is possible to infer the identity of users dynamically changing their avatars by observing their movement signatures purely based on recorded videos. This observation has led to more advanced obfuscation approaches, such as those based on differential privacy [9] – a mathematical abstraction that provides a quantitative definition of data protection. For instance, MetaGuard [44] is a plugin for Unity that allows users to enter an "incognito mode" in VR by leveraging differential privacy.

The intrinsic nature of VR has also led to novel security threats that do not resemble those in typical physical environments. One is the "human joystick" attack that steers user movement to a specific virtual space without them knowing [8]. Another is the men-in-the-room attack: a VR user is able to furtively observe others without being noticed due to vulnerabilities in the VR application [67]. Moreover, allegedly innocent VR environments can be intentionally crafted for malicious purposes. For instance, Nair et al. [42] demonstrate how a seemingly playful VR environment (i.e., an escape room) can be leveraged by an adversary to collect personal information about users, including age and gender.

Despite the technicalities, research in this area ultimately addresses developing solutions for effective safety design [78]. In relation to this, user privacy is deemed one of the major concerns preventing self-disclosure in social VR [59]. Our works specifically targets such in the context of private conversations in social VR.

2.2 Interactions in Multi-user Virtual Environments

Conversations are just one of the possible interactions between two or more users in virtual environments. Typical scenarios include different types of group dynamics in VR [51]. For instance, Rasch et al. [52] focus on joint locomotion, proposing diverse methods to express non-verbal intentions in a leader-follower task, such as teleport with preview visualizations. Instead, Rothe et al. [55] address facing formations by conceptualizing spatial sound for communication in social VR. Furthermore, Lee et al. [28] jointly leverage a spotlight mechanism and directional audio for multi-modal attention guidance to improve group conversations in VR meetings. Other research targeted group decision-making in use cases ranging from group navigation [69] to personnel selection [39]. The related findings revealed the importance of digital proxemics to establish social affordances in virtual environments [71]. In particular, it has been observed that personal spaces are flexible and suitable to support private conversations [70], even though some users may experience the feeling of missing out [54].

Some research closely related to private conversations has primarily focused on non-immersive virtual conferences and remote meetings. Importantly, Minglr [57] facilitates ad-hoc, private conversations by matching suitable conversational partners in a virtual conference. FluidMeet [17], instead, supports casual conversations by creating boundaries that enable seamless transitions between groups and private break rooms. To the best of our knowledge, however, there is no previous work that focuses on supporting the fluidity of switching between private and public conversations in VR, as it is common during social interactions in the physical world. Therefore, we specifically target social VR in a context where matchmaking is not a concern, and thus, methods developed specifically for remote meetings are not suitable.

2.3 Design Studies for Social VR

Research on designing for VR has addressed diverse application scenarios [22] – remote work [49], distance education [27], and digital tourism [26] are only a few examples in this context. A different perspective involves the design of VR applications for distinct target groups [50]. Ageing population has especially received increasing attention in the last few years [74]. Related studies have shown that it is valuable to focus on the views and types of experiences involving shared reminiscence [3]. On a different note, designing for VR accessibility [40] has also become prevalent, as in the realization of toolkits to improve the VR experience of people with low vision like SeeingVR [77].

Researchers have also considered areas adjacent to privacy in designing for VR. Among them, speculative design workshops have been leveraged to investigate the risks in malicious use of perceptual manipulations in VR [64]. Other studies have recognized privacy concerns in virtual spaces designed to support close ties over distance [76]; they have also elucidated design choices that favor social interactions in VR [35] and support inter-personal relationships [12]. The metaverse also encompasses the integration of different social VR apps: a user can enter a sub-metaverse from another one, similar to clicking a hyperlink in a page hosted on a website but pointing to another one. In this context, the design of security indicators suitable for sub-metaverses has been investigated in [72]. Our work takes some inspiration from the latter by taking a holistic view on factors affecting private conversations in social VR, not only limited to indicators.

3 Expert Interviews

The review of the related work highlighted the need for additional exploration. For this purpose, we carried out one study to explore the design dimensions for private conversations as a starting point to address user's concerns. Specifically, we decided to interview experts from both industry and academia to sketch out general design dimensions based on diverse research experience and user-centric considerations. Accordingly, we conducted semi-structured interviews with seven experts as detailed next.

3.1 Procedure

Experts provided informed consent and were given interview information such as the length of the study, that an audio recording would be made, and some demographic questions. The interview began by discussing the participant's research profile and its connection to private

Table 1: Overview of the seven experts who participated in our interviews. We asked the experts to describe their background as well as to characterize their expertise in psychology (Psy.), user experience (UX), user interfaces (UI), virtual reality (VR), social virtual reality (SVR), privacy (Priv.), and usable security (USec.) on a Likert scale ranging from 0 (for "No knowledge") to 7 ("Extensive knowledge").

Expert	Gender	Age	Sector	Self-described expertise	Psy.	UX	UI	VR	SVR	Priv.	USec.
E1	F	24	Academia	Social VR	■■■■■□□	■■■■■■□	■■■■■■□	■■■■■□□	■■■■■■□	■■■■■□□	■■■■□□□
E2	M	34	Academia + Industry	Social VR, Gaze-based interactions, Psychology, Digital mental health	■■■■■□□	■■■■■■■	■■■■■■■	■■■■■■■	■■■■■■■	■■■■■■□	■■■■□□□
E3	M	34	Academia	HCI, Usable security, Safety in VR, Ethics of immersive technology	■■■□□□□	■■■■■■□	■■■■■■■	■■■■■■■	■■■■■■■	■■■■■■■	■■■■■■■
E4	M	29	Academia	Audio and electrical engineering, Acoustics, XR audio	■■□□□□□	■■■□□□□	■■□□□□□	■■■■■■□	■■■■■□□	■■□□□□□	■□□□□□□
E5	F	31	Academia	User-centric security, Privacy	■■■■■□□	■■■■■□□	■■■■■□□	■■■□□□□	■■□□□□□	■■■■■■□	■■■■■■■
E6	NB	27	Academia	Social VR	■■■□□□□	■■■□□□□	■■■■□□□	■■■■■■□	■■■■■■□	■■□□□□□	■■□□□□□
E7	M	29	Academia + Industry	Game design, VR interaction design	■■□□□□□	■■■■■□□	■■■■■□□	■■■■■□□	■■■■□□□	■■■□□□□	■■□□□□□

conversations in VR to establish their expertise and relevance to the study.

After introducing the goal – exploring the design space for private conversations in VR – we asked participants about the key challenges in designing such experiences. They were encouraged to consider privacy needs in VR, how these differ from traditional settings, and whether new concerns arise in virtual environments or not. We also delved into technical and design challenges that could impact the experience of private conversations in VR.

We presented approaches such as Private Talk (a "phone call" metaphor) and Private Room (a "breakout room") as examples for the experts to ideate. Participants were asked for their thoughts on these methods, their effectiveness, and how isolation levels impact the experience. They were encouraged to propose alternatives to menu-based interactions for initiating private conversations and to consider the ideal user experience for these scenarios, including how to indicate privacy to users.

Another important aspect involved handling situations where outsiders might need to interject in a private conversation from both the perspective of those involved and those excluded. The interview concluded with an open invitation for additional thoughts on privacy and social interaction in VR.

3.2 Participants

Seven experts were recruited through our personal network and took part in the interviews (Table 1). To qualify as an expert, the participant had to fulfill the following requirements: an academic background, having published at a leading venue related to VR and (or) security or privacy (e.g., IEEE VR, ACM CHI, USENIX SOUPS), and (or) having spent considerable time designing or participating in social VR. We did not compensate the experts.

3.3 Results

We transcribed 138.89 (M = 19.82, SD = 2.91) minutes of audio and video recordings. We performed an inductive thematic analysis with Atlas.ti by following the theoretical approach in [7]. One researcher coded all transcribed interviews. Five themes can be inferred from the codes: *user needs*, *interaction design*, *system design*, *indicators*, and *context*.

3.3.1 User Needs

The experts discussed four general needs for private conversations in VR. All of them agreed that systems need to give users a sense of privacy: "*I guess the most important thing about a private conversation is that it's private right that you can feel confident in the fact that no one else is listening*" (E4). Six out of the seven experts (E1, E3, E4, E5, E6, E7) also mentioned that users need a mental model of separation from outsiders: "*you can kind of like see that [...] you kind of know that the walls are thick and kind of this safe space*" (E7). This aligns with the experts (E1, E2, E3, E4, E5, E6, E7) mentioning a need for trust: "*I'm having some friends in VR chat, I'm talking with everyone, we're talking about some like secret topics, which we don't want our parents to know, for example. And some of my friends' accounts got like got taken away by her mom, and it's actually her mom behind the topic, behind the avatar. That's going to be really scary, right? Yeah. Like, who is behind the avatar?*" (E1). E1, E2 and E6 also mentioned the need for self-expression: "*I guess the idea that once you engage into that space to communicate, hopefully, what you communicate stays there, or you can at least feel that it's not going to... Like you have the freedom to talk, you have the freedom to say things.*" (E6).

3.3.2 Interaction Design

Our experts identified several critical interaction design elements to facilitate private conversations in VR environments. Given the non-verbal interaction present in social VR, the experts (E1, E3, E6, E7) mentioned gestures as a central interaction modality. E1 raised the idea of non-verbal cues to signal a desire to start a private conversation: "*I point to them like, oh, I want to talk to you.*" (E1). E3 further elaborated on the role of gestures in enhancing communication, suggesting movements like raising a hand near the mouth to simulate whispering, which could imply secrecy. E6 further discussed the use of sign language as a common form of private conversation in VR, highlighting its importance for non-verbal communication. For verbal conversation, the ability to manage audio within VR was crucial (E3, E4, E6, E7). E3 discussed leveraging features like whisper detection, similar to voice assistants, where whispering could trigger a private conversation mode with directed audio. E4 and E7 noted the importance of feeling that the conversation is indeed private, where the surrounding auditory environment mirrors real-world social dynamics, ensuring that nearby users are not inadvertently included in the conversation.

Most experts (E1, E2, E3, E5, E6, E7) recognized avatars to play a key role in the experience of private conversations. E1 pointed out that VR offers unique opportunities in such a context: "*For example, if you're just having a video call or something, your avatar can kind of like remain still or just have some automatic movement. People just won't realize, oh, you're actually having a private conversation.*" (E1). This aligns with E3's suggestion to subtly select conversation partners, where gestures like looking at someone could replace overt actions like pointing or clicking. Several experts (E1, E2, E5, E7) also proposed using familiar metaphors to represent private conversations in VR. E1 and E2 proposed to imitate everyday life, such as with phone calls or sitting at a table. E5 introduced the idea of knocking on a door to signify entering a conversation, while E7 suggested playful metaphors, like tossing a ball to initiate a dialogue or using pigeons to deliver messages.

Beyond the body, experts also considered the role of spatial interactions for private conversations. Experts (E1, E2, E3, E4, E6, E7) underscored the role of spatial arrangement in private interactions. E2 mentioned how physical separation, like entering a different room or sitting on a certain piece of furniture, could signify privacy: "*You can personalize it like, [...] with this person I like that the table is here, but then with the other person I like that it's in the middle.*" (E7). E3 added that joint privacy bubbles, preventing avatars from coming too close, would be helpful. E7 expanded on this concept by suggesting that social VR applications could offer custom private spaces tailored to different relationships, creating personal environments where each conversation could take place.

Six experts also mentioned user interface (UI) design as critical (E2, E3, E4, E5, E6, E7). The UI should support private conversations with minimal intrusion. E2, E4, and E7 agreed that UIs need to be intuitive and quick to navigate. E5 suggested that privacy should be the default setting for conversations, removing the need for constant user input to maintain confidentiality. However, E6 and E7 criticized current VR UIs as cumbersome, advocating for more user-friendly and intuitive designs that streamline initiating a private conversation.

3.3.3 System Design

All experts touched on system design and how it affects the privacy of conversations in VR. In these terms, the experts identified several technical and control-related aspects that are critical for maintaining privacy in VR conversations. All experts emphasized the role of embodiment and tracking systems in private conversations. One expert mentioned differences in accessibility: "*Then you have always the imbalance of technologies, like who has what technology, who can do what's like, for example, we talk about eye tracking, not everybody has an eye tracking, eye tracking implemented in their headset. And then basically the eye, the gaze is telling a lot about the interest and where people are staring and stuff like that.*" (E2). E7 added that gestures, body language, and facial expressions are necessary components for any conversation, including private ones, to enrich the communication experience.

All experts provided background on how control mechanisms are essential to maintaining the privacy of conversations: "*So I feel like one thing to prevent outsiders kind of interrupt such conversation is kind of like, don't give them the access to kind of join in this conversation. Like, for example, in Discord, you have the private channels, which other people who don't have the access won't be able to even see the channel itself out there.*" (E1). E3 expanded on this aspect by emphasizing the need for permission settings that define access to private conversations and ensuring the ability to enforce boundaries. Control should also be reciprocal, with the ability for users to decide whether they want to engage in a private conversation or not. E5 added that the ease of keeping others out of private conversations is crucial for maintaining a sense of confidentiality. E6 noted that there should be a feature to disable notifications and avoid interruptions during focused conversations.

Three experts recognized the importance of spatial audio (E3, E4, E7). E3 mentioned that it naturally creates private areas, as users can walk away to ensure they are out of the hearing range. E4 emphasized the need for proper occlusion and distance-based attenuation so that background noise masks individual conversations. This includes ensuring that speech is directional, so when users turn away from someone, the sound propagating in that direction should decrease.

Experts (E1, E3, E5, E6, E7) emphasized the importance of user awareness and accessibility in managing privacy. E1 noted how mistakes in channel selection could expose private conversations. The experts also highlighted the challenge of spatial awareness in VR, where users might not notice someone joining or teleporting behind them, leading to privacy concerns: "*But if someone teleports and suddenly is next to me, then that's not something like, you know, I may not even notice, especially if they came behind me. There's also not this, you know, like you cannot hear their footsteps coming and things like that unless these things are replicated.*" (E3). E6 pointed out that bugs, like muted users still being heard, could create awkward situations. Next to this, formal authentication methods were mentioned as potential requirements by a few of our experts (E1, E3, E5), driven by authentication via passwords (E3) or biometric verification (E1).

3.3.4 Indicators

Experts mentioned visual, auditory and spatial indicators for private conversations. All experts highlighted the use of visual cues for privacy in VR. E2 suggested enforced alerts, while E4 and E5 proposed pop-up messages or visual fades to manage focus during conversations. E6 mentioned visually fading others out to enhance the sense of privacy: "*if your foot would visually fade them out, that would maybe help the concern of 'hey, this might not be actually muted'.*" (E6). E5 noted that visual text might be an adequate starting point but that VR interaction design should move beyond. Many experts spoke about audio cues (E1, E2, E3, E4, E6, E7). E1 and E2 mentioned leveraging subtle sounds like knocking to indicate when someone wants to join a conversation. E4 and E7 suggested employing acoustic signals, such as ringtones or audio pings, to alert users of incoming communication requests without overwhelming them. The entire sample of experts focused on spatial indicators. E1 and E2 discussed how private rooms or bubbles could provide a sense of security: "*I could see [...] this kind of bubble. For example, say, OK, there's an invisible wall around people saying, OK, this is their space now. They define that for now.*" (E2). E3 suggested a boundary where users disappear from others' views during private conversations, while E7 proposed shadow-like forms as a visual indicator for someone attempting to join.

3.3.5 Context

Many experts also mentioned that the design needs to be sensitive to context. Experts (E1, E2, E3, E5, E7) emphasized the importance of controlling the visibility of private conversations in VR. Users may not want others to know they are having a private chat – E1 emphasized that certain actions, such as pointing or entering a private room, make this apparent. E2 discussed using visual cues like bubbles to indicate privacy but acknowledged that this can raise questions from others. E3 suggested that while private interactions should be visible in some contexts, the details should remain hidden: "*Like if you think of something like a social network or something, sometimes you could create a group conversation on Facebook or Messenger, and nobody would know that you created one. But then if you're in something like a forum or a lobby or something like that, where there is like, you would see that there is a private conversation, but you cannot join it.*" (E3). E7 added that visual indicators help maintain a sense of activity in shared spaces without compromising privacy.

Other factors mentioned by our sample, such as familiarity with the conversation partner and VR itself, could also affect user behavior. E7 questioned why users would opt for VR over simpler methods like phone calls, especially given the effort involved in wearing headsets. The sensitivity of the topic and the expected length of the interaction also play a role – E2 distinguished between quick chats and longer, more secure private conversations.

4 User Study

We also carried out a separate study to complement the findings from the expert interviews. The purpose of this study was to focus on the actual user – not necessarily experienced in social VR – when exposed to the considered scenario. Accordingly, we conducted a lab study in which 12 participants used a social VR application we developed. Our objective was to expose users to a private conversation scenario so as to gather their experiences and suggestions.

4.1 Design and Task

For the experiment, we created a virtual environment of an apartment (Figure 2a), with a party taking place in the living room (Figure 2b). A separate empty space served as the private room (Figure 2c). In addition to the participants, we populated the virtual environment with non-player characters (NPCs), along with music and conversational speech. The task involved two phases.

In *Phase I*, participants employed methods from the state of the art to establish private conversations. The goal was to assess the different methods and describe their perception of the resulting privacy. After reviewing the related work and popular social VR applications, we considered two reference methods. The first is *Private Talk* (PTalk), based on VIVE Sync [16] and akin to starting a phone call: a user points at the person they want to talk to, then selects the phone icon above the other user's avatar (Figure 3a). The other user receives a popup

(a) (b) (c)

Fig. 2: (a) The virtual environment in the study is an apartment with a bedroom, a dining room, a kitchen, and a living room. (b) User's view of the living room showing the party situation participants were exposed to. (c) User's view of the private room, a separate virtual space.

invitation and can accept it; the surrounding audio was not altered. The second method is *Private Room* (PROOM), which establishes a virtual environment delimited by walls, only accessible to a selected group of users who have been granted permission by the room owner. This approach is similar to (i.e., aligned with) social VR applications such as Rec Room [53] and Horizon Worlds [37].

In *Phase II*, participants had to come up with their own methods to establish private conversations. The goal was to design and simulate alternate methods that were different from those in the first phase. The conceived methods were also tried out to get a sense of how they would feel if implemented.

4.2 Apparatus

We implemented the VR app with Unity version 2021.3.21f1, the XR Interaction toolkit, and Normcore [45] for multiplayer networking. We conducted the study in three sound-insulated rooms in our lab. We calibrated playing areas of around 2 by 2 meters in two of the rooms; the third room was used by the experimenter to oversee the study. We used two Meta Quest Pro systems [38]. We deployed the application to two workstations: one had an Intel Core i5-12600K processor, 32 GB of RAM, and a NVIDIA GeForce RTX 3080 GPU while the other had an Intel Core i7-7820X processor, 48 GB of RAM, and a NVIDIA GeForce GTX 1080Ti GPU. Content was then streamed to the headsets via Air Link over 5 GHz WiFi.

4.3 Procedure

The study took place as sessions involving groups of two participants (i.e., pairs) in addition to the experimenter. Each session lasted approximately one hour.

At the beginning, participants were briefed about the goals and objectives of the study. They were then presented with the privacy notice and the participant information sheet. The privacy notice explained how their personal data were used in the study, while the participant information sheet provided more details about the study procedures. Participants were assured of their anonymity and informed about the voluntary nature of their participation. After any questions or concerns they had were addressed, they were asked to sign a consent form, ensuring that their participation was based on informed consent and voluntary decisions. Afterwards, we instructed them to put on the Meta Quest Pro and how to use the device; we also gave them time to familiarize themselves with the hardware.

Once they were ready, we run the VR application for both participants. The experimenter joined them inside the virtual environment in a go-along fashion [66]. The application started with the users spawned into the bedroom. From there, each user picked an avatar from a selection and waited until all others had selected their own. A mirror was placed near the spawn area for users to see their avatar's body moving along with their real-world movements. This visuomotor synchrony helps enhance the users' sense of embodiment [21] and, at the same time, orients them with the device tracking capabilities. Participants were then taught how to use teleportation and were given some time to explore the virtual apartment populated with NPCs.

Next, we started *Phase I*. The participants took turns by assuming different roles, similar to the approach in [48]. Specifically, a given participant could be either the user engaged in the private conversation or a bystander – the conversation would have to be concealed from. This approach allowed them to experience the considered scenario from different perspectives. We considered the two reference baselines to establish private conversations. We first tested PTALK. Once both participants had tried both roles, we continued with PROOM. After the latter test was completed, we proceeded to *Phase II*. In detail, we asked our participants to propose their own method – by co-creating – to establish private conversations in social VR. We provided examples of common interactions found in VR applications as inspiration. Their proposed methods were then simulated to get a sense of how they would work when implemented. In all instances the users could freely choose a topic of conversation. After this, the VR session was over.

At the end of the VR session, we asked participants to take off the headsets and answer a questionnaire to assess their experience. The questionnaire incorporated questions from the Igroup Presence Questionnaire [18] (IPQ) and the short version of the User Experience Questionnaire [61] (UEQ-S), in addition to co-presence statements from [4]. Finally, we conducted a semi-structured interview where we asked both participants about their experiences, preferred methods in *Phase I* and their design thinking in *Phase II*. We recorded the interviews for later transcription and analysis. Participants received a gift card worth 15 EUR as compensation.

4.4 Participants

We recruited 12 participants (5 identified themselves as female, 7 as male) aged 24 to 28 years ($M = 25.6, SD = 1.6$) from our university's mailing list. All participants reported normal or corrected-to-normal vision. Three participants stated that they used VR *once a month or less* with a standalone VR headset (1), a smartphone (2), and a personal computer or console (all 3). The remaining 9 participants reported that they had *never used VR before*.

4.5 Validity

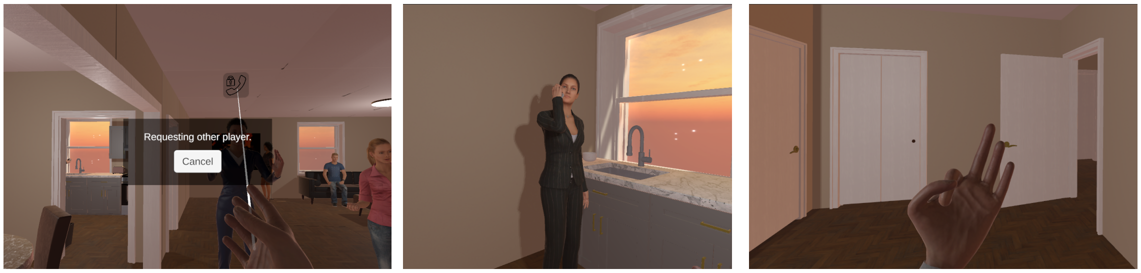
We employed the responses in the IPQ and co-presence questionnaire to verify the validity of our simulation (Table 2). The results revealed a very good feeling of presence in general, with satisfactory spatial presence despite low scores for involvement and experienced realism. As for co-presence, the results show that the feeling of being with another person was acceptable, even though NPCs were perceived as unaware of the users' behavior.

4.6 Results

We transcribed the interviews and performed an inductive thematic analysis with Atlas.ti following the guidelines in [7]. Our analysis revealed the six themes detailed next: *background noise*, *isolation*, *indicators*, *interaction methods*, *context*, and *privacy*.

4.6.1 Minimizing Background Noise

Participants (5/12) expressed interest in features aimed at reducing surrounding audio, allowing them to concentrate on talking with the



(a) (b) (c)

Fig. 3: The different interaction methods considered in and emerged from the user study. (a) Initiating a private conversation with PTalk involves pointing towards the phone icon on top of an avatar and clicking it. Solutions conceived by the participants included (b) mimicking phone calls in the physical world as well as (c) simple hand-based gestures.

other user. Issues were raised about loud background music or overlapping voices, hindering their ability to focus on the conversation. A few participants preferred to only hear the voice of the person they were talking to: "*I personally hope that I don't want to hear others so I can pay attention to your voice.*" (P8). However, P4 noted that this preference might not apply to everyone. Participants (P4, P11, P12) appreciated PRoom for not having this problem and highlighted its suitability for discussing very important matters without disturbance. One of the participants stated: "*I really like that you know, it [private room] was an isolated environment. It was like, you know, you did not have any external, like for example music that was there which were disturbing you continuously or you know, making it harder for me to listen to what the other person was saying.*" (P4)

A few participants suggested completely removing audio from outside conversations and other background noises when engaged in private conversations. Another suggestion was to make this customizable, from dampening the external sounds to muting them entirely, so as to make it more appealing to a larger audience.

4.6.2 Isolation for Enhanced Feeling of Privacy

While PTalk allowed people to have private conversations in the presence of others, several participants (5/12) felt that the isolation they experienced with PRoom gave a better sense of privacy. They felt it was safer to share information when they cannot see anyone except the person they are having conversation with, as deemed by P7: "*I can still see them [other characters] and even hear them. How can I take, like, persuade myself that OK, I can see them, I can hear them, but they cannot hear me. So it's kind of not very safe sense. But in the private room, there's not people in there except the one I talked. So I would say it's safer.*" (P7). P1 and P2 mentioned that separation "makes it clear" or "adds" that they were privately having a conversation and nobody else was listening. These remarks were brought up when they were asked about what they liked about PRoom. Some participants (4/12) expressed a lack of confidence in sharing private information using PTalk compared to PRoom.

Participants suggested removing the voices of people outside the conversation to create a greater sense of privacy in PTalk. P1 also suggested greying out the whole environment and retaining colors only for the other person in the conversation.

4.6.3 Indicators and Distinctions of Privacy Mode

Most participants (10/12) expressed the need for indicators of privacy status. This theme encompassed codes such as *clear distinction between public and private*, *confirmation of private mode* and, *indicator from game*. Participants emphasized the importance of these indicators for both the users engaged in the private conversation and those outside of it. For instance, P3 demanded some confirmation that nobody outside of the conversation could hear them: "*Especially in the first case where you can actually hear the other people, it will be like very good to have some kind of like confirmation that you're actually in a private and no one, you know, no one else is listening.*" (P3). There were no indicators for users in PTalk, other than a button for ending PTalk. Similarly, there are no indicators or differences for users in the vicinity of those engaged in PTalk, besides outsiders not hearing any sound from people in private conversations. The lack of cues caused hesitation or confusion among participants. For instance, P6 expressed initial reluctance to speak while in PTalk due to the absence of indicators: "*So the first method, at first I wasn't [confident] and like I was, I kept asking you 'so he really doesn't hear us? He really doesn't know?' So you know, because, since like intuitively you think that OK, I mean with the person. So like, what if he or she like listens.*" (P6). Moreover, it was unclear for people outside of the conversation whether two individuals were simply being quiet or in PTalk. This ambiguity could also lead others to assume that the participants were away from keyboard, as pointed out by P5. Furthermore, one person wondered what had happened when two people suddenly disappeared after being teleported to a private room. However, two participants (P1 and P10) recognized that making other people aware of an ongoing private conversation has privacy issues. While such indicators would clarify the situation, broadcasting the presence of a private conversation to everyone potentially compromises privacy, leading to a challenging tradeoff.

Participants noted that it would be beneficial for the application to explicitly inform users that nobody else can hear them once in PTalk. P7 suggested having a clear difference in the interface, such as a translucent barrier, which tells the user that the conversation is being protected. Similarly, indications that two users are having a private conversation were also recommended, as well as providing a hint when two people disappear to go to a private room.

4.6.4 Easy and Natural Methods in Virtual Environments

Another recurring theme encompassed two factors that participants consistently mentioned in relation to what they liked and disliked about the existing methods: suggestions for new approaches and recommendations for enhancing current methods. In describing what they liked about PTalk , "easy" and similar words such as "clear" and "straightforward" were commonly used. Most participants (8/12) find the steps of getting into PTalk easy to accomplish. One participant (P11) preferred PTalk over their proposed method – similar to PRoom, but with added steps from PTalk – as theirs ended up taking more effort: "*I might be lazy to take my method to the extent of it just because it takes additional steps, so I might be like doesn't matter, we can just talk over the phone [with private talk]*" (P11). Additionally, P10 was unsure whether they would prefer their method, as it involved typing, similar to sending texts on the phone in the real world. They speculated that it might be complicated to carry it out as they were unable to try it within the application. However, they remained open to evaluating it in the future. Participants (10/12) also expressed a preference for methods that felt natural. We define natural in this context as something that maintains immersion by being as realistic as possible, appearing similar to how users actually interact with people in real life. The use of floating icons above the avatar's head was particularly disliked by participants, as it breaks the sense of immersion: "*I mean this all kind of goes into a deeper kind of question of the reality of VR where it's like.*

Table 2: Quantitative results from the questionnaires. (left) Presence according to the Igroup Presence Questionnaire (IPQ), which uses a five-point Likert scale. (right) Co-presence statements from [4], which are instead expressed on a seven-point Likert scale.

Presence			Co-presence		
Attribute	**Mean**	**SD**	**Statement**	**Mean**	**SD**
General Presence	4.33	1.18	The agent did not care at all about my behavior	3.58	1.55
Spatial Presence	4.57	1.35	I thought I was in the presence of another being	3.17	1.21
Involvement	3.31	1.83	I felt like I was with the agent in the same room	3.50	1.19
Experienced Realism	2.23	1.46	I felt as if I was playing with the agent	2.42	1.11

So if I want to have a private conversation with someone at a party, I don't have a little icon on top of their head, so it's a little, you know, immersion jarring where you're thinking oh OK, I want to be a part of this world, but there's also this icon above a person's head." (P12). Similarly, teleportation to the private room was also disliked for feeling unnatural. Participants drew from their real life habits and experiences when proposing their own method. For instance, P5 and P7 suggested methods involving virtual phones (Figure 3b), as it mirrors their habit when engaging in private conversations, particularly in social settings like parties. However, it is important to consider that the experimenter had suggested drawing inspiration from the participants' experiences when they struggled to come up with the design of their method. Two participants (P8 and P9) also acknowledged that their suggested methods that work in the real world may not translate well to the virtual world. For instance, gestures that are clear in real life (such as that in Figure 3c) may be difficult and easily misinterpreted in the virtual world.

Many of the proposed methods involved moving to a soundproof room that is within the same virtual apartment. People go in the room, close the door, and then lock it to have a private conversation. This is basically a modified version of PROOM which feels more natural. There was also a suggestion to inform users on where to find these private rooms, so they would not have to look for them. Another common idea was to get rid of the call icons and instead directly point to the avatars. Some participants also suggested to enable sending direct text and voice messages. Finally, whispering was also proposed as a possible method.

4.6.5 Retaining Background Context

Participants (6/12) expressed a preference for not being completely disconnected from the current context when engaging in a private conversation. For instance, P11 raised their concern about missing out on something upon moving to the private room: "*I guess maybe in sense if there were more players, you might be in a situation where you miss out on something, I guess.*" (P11). Moreover, P12 explained that it would also feel awkward: "*Yeah, it can also be kind of awkward because I think you don't have the like social surroundings where it's more natural to actually have a conversation with someone at a party or whatever with the background noise. As opposed to going into this room or it's just completely silence and just OK, Hey, nice to meet you. And, like, kind of starting things over without the natural progression.*" (P12). Three participants (P1, P2, P9) also pointed out that they did not like the difference in environments between the public and the private room. They suggested that the private room should have the same vibe or, ideally, be an actual room in the same virtual environment. Moreover, participants expressed their desire to be socially present to others while using PTALK, and have the ability to quickly alternate between interacting with people inside of the private conversation and those outside of it. For instance, P4 asked for a feature where a user can poke a person engaged in a private discussion, such that it should be easy for that person to quickly respond and get back to the private conversation. However, it is difficult to balance between focusing on the conversational partner and managing interactions with the broader environment, as noted by P3. Besides, P5 and P6 mentioned that isolating from the general environment might send "wrong" messages to some people.

Participants suggested that the private rooms should mirror the public virtual environment or even consist of an actual room in the same setting. Additionally, there should also be a way to quickly interact with users who are not part of the private conversation.

4.6.6 Privacy Concerns

Lastly, most participants (8/12) expressed being reluctant or even unwilling to discuss private information in social VR due to several concerns. Some participants (4/12) acknowledged their limited knowledge and understanding of the security behind the technology used, which made them feel uncertain: "*Maybe not, because it's still like an application that is being controlled or like monitored by some somebody else in the cloud or if not monitored, at least developed. So yeah, unless I know the algorithm is secure, then yeah, no I guess.*" (P1). It is worth noting that 8 of the 12 participants were computer science students, which likely contributed to the scrutiny of the technical details behind the technology. Moreover, a few participants (P7, P9, P10) expressed the lack of trust in the people managing or operating the system as the main reason for their concern; they mentioned that the system might store and use data without their knowledge. P3 also pointed out that the other person should not be able to secretly record the private discussion. Two participants (P3 and P8) consider having a privacy notice or tips regarding data handling as a better option. However, P12 was not concerned as they acknowledged that they willingly share private information online, despite recognizing that it is not advisable.

A privacy notice or a statement from the application stating that private conversations are not recorded was suggested, to make users feel more confident. Furthermore, the other person should not be able to record without the knowledge of the participants involved. Another recommendation was to provide a white paper or detailed information about the application for users to read.

5 Design Space

We now present a design space for private conversations in social VR based on our findings. For this purpose, we distill the outcomes of the two studies we independently conducted – namely, the expert interviews (Section 3) and the lab study (Section 4) – into a single space. Different from [72], we do not separately regard context but purposely decide to specialize it into the derived dimensions, by focusing on both embodiment and environmental factors [32]. Our derivation is primarily based on the results of the thematic analysis in the two studies, but it is also supported by findings in the scholarly literature (see also Section 6 for additional discussion).

We start by assessing the suitability of the themes emerged in the two studies as elements of the design space. In particular, we first contrast the themes derived from the expert interviews with those from the user study. We then derive the dimensions of the design space. Accordingly, we identify the themes suitable as such and integrate the rest, including specific options that emerged therein, as individual categories. In doing so, we pay special attention to implementation feasibility, while still allowing for emerging technical solutions. The result of this process is the design space illustrated in Figure 4.

5.1 Modality

Characterizes how the transition to a private conversation is initiated, primarily in terms of interactions [32]. Accordingly, it includes categories corresponding to domains (*auditory*, *spatial*) or types of actions (*gesture*, *UI*). These are aligned with the nature of methods proposed

Modality	Auditory	Audio dimension; *examples: directional audio, whispering, facing formations*
	Spatial	Location dimension; *examples: proximity, designated room*
	Gesture	Controller or body movement; *examples: high five, covering mouth, mimicking phone call*
	UI	Point-and-click action; *examples: contextual menu, selection of icon or avatar*
Availability	Concealed	Undetectable by other users; *examples: disguised to bystanders as whistling or laughing*
	Noticeable	Could be inferred but not overheard; *examples: icon over avatar, simultaneous teleportation*
	Unrestricted	Available to all or certain users; *examples: public speech, users located in same room*
Awareness	Permissions	Explicit authorization; *examples: granting access before starting VR application*
	Consent	Agreement; *examples: explicit confirmation upon request to establish private conversation*
	Indicators	Abstract representation of "security" status; *examples: earcon, 2D shape at periphery of view*
Isolation	Complete	Virtual confinement; *examples: private room*
	Partial	Allows some exposure to environment; *examples: background audio reduction, blurring avatars of bystanders*
	None	Does not specify or alter environment in any ways

Fig. 4: A design space for private conversations in VR based on our studies. The dimensions are reported on the left side and the corresponding categories on the right side, including a short description and a few illustrative examples.

by both experts and users to establish private conversations. Note that domain-related transitions might be implicit (e.g., based on proxemics), whereas actions are always explicit (e.g., point and click) [71]. Clearly, the different modalities could also be combined for additional expressivity or to increase reliability: one example is whispering while "covering" the mouth. Interestingly, the auditory domain was more prominent in the user study, which highlights the importance of such a modality and supplementing expert data with an in-situ user study. This finding is supported by the literature [29, 55], but can also be justified based on the experience of users with commercial metaverse platforms [48]. In contrast, the experts suggested more advanced features that are found in research prototypes but are not yet implemented in products [28].

5.2 Availability

Denotes how private conversations are available or accessible to others (e.g., bystanders). It represents one side of the user needs and privacy themes that resulted from the expert interviews and the lab study, respectively [78]. *Unrestricted* conversations are available to all (e.g., they are public), or to users satisfying certain requirements (e.g., being in the same room). *Noticeable* conversations cannot be overheard but can be deemed such, for instance, as the related avatars are annotated with an icon. This includes inferring users engaged in a conversation through their appearance or behavior [36]. One example is given by two users simultaneously teleporting all of a sudden, as reported in the user study. Finally, *concealed* conversations are (designed to be) undetectable. For instance, the actual conversation could appear as laughing or whistling to bystanders [10].

5.3 Awareness

Relates to the different stages of recognizing the privacy of conversations from the perspective of the involved users. It represents another side of the user needs (expert interviews) and privacy (lab study) themes, partially extending to the trust in the VR application or metaverse platform. One category is granting *permissions* (with some granularity) to the VR application [24]. These define the requirements for enabling private conversations, similar to the process commonly used for mobile applications [11]. A different category is related to require *consent* upon establishing the private conversation, for instance, through an explicit confirmation [79]. Both should be accompanied by user-friendly descriptions on what granting the permissions and the consent entails, as explicitly pointed out by participants in the user study. These two categories are also aligned with mechanisms widely adopted in social media platforms [20], which are highly relevant to form the basis for affirming social contracts between users and the platform itself. Lastly, *indicators* provide an abstract representation of the "security" status related to a conversation. Note that they were clearly recognized as a theme in both the expert interviews and the user study; moreover, they are not restricted to visual elements but can also encompass diverse modalities [72].

5.4 Isolation

Refers to how users are "shielded" from the surrounding environment during a private conversation. This dimension corresponds to both the isolation and background noise themes from the user study; it also covers the control and accessibility aspects in the systems design theme from the expert interviews. *Complete* isolation is virtual confinement, such as in a private space. *Partial* isolation allows some exposure to the environment, for instance, by attenuating ambient sound or blurring / darkening avatars of users not engaged in the private conversation [34]. The *none* option does not attempt to specify or alter the environment perceived by users engaged in a private conversation in any ways. Note that isolation supports users' focus within their conversation [47]; it does not relate to how such a conversation is available to other users or bystanders, which is instead captured by the availability dimension.

6 Discussion

This work set out to examine user perceptions and propositions related to privacy in virtual conversations as part of social VR interactions. The two studies we conducted – including a controlled experiment using a prototype VR application – led to the definition of a design space for private conversations in VR. We now re-interpret the outcomes of our studies within that space so as to show its applicability in explaining our findings. Overall, our results reveal that users place a high value on both functional (e.g., minimizing background noise and making the method easy to use) and perceptual (e.g., indicators and retaining background context) elements of privacy in social VR.

6.1 The Co-location Problem

Participants expressed a greater sense of safety and security when engaging in private conversations while isolated from other users, such as in PRoom. Their mental model of others was that if they could hear and see others, those individuals could hear them as well. This is why they felt safer in PRoom than in PTalk, despite the fact that other users could not hear them in any case. This aligns with [1], where participants expressed privacy concerns and demonstrated reduced willingness to disclose sensitive personal information when they were in close proximity to (or received visual cues indicating the presence of) another individual.

However, it did not seem that moving to another location – as currently implemented in many social VR applications – provides an ideal solution. This is especially true for sudden teleportation: participants also expressed the need for a notification or a transitional indication about the actual action, revealing its purpose. Such issue of teleportation has been recognized in few studies and different visualization designs have been proposed to reduce confusion among observers in shared virtual spaces [13, 62].

6.2 A Soundscape for Conversations in VR

Sound is critical for private conversations in social VR [71]. Participants in our study have emphasized that *minimizing background noise* is a crucial element for effective conversation. In the physical world, individuals have the ability to focus their attention on a specific conversation even in noisy environments – the so-called cocktail party effect [2]. Such an ability has also been suggested to be critical in VR spaces [75]. Sound spatialization (i.e., the creation of a three-dimensional auditory experience) has been shown to greatly enhance auditory perception in noisy VR environments [56]. We actually implemented spatial sound in our application; however, participants still had some trouble understanding the other conversation partner, probably due to missing lip-syncing, as noted in [75]. Nevertheless, surrounding sound needs to be modulated ideally by supporting the users' ability for selective auditory attention; as suggested in [55] and [71], this could be done by considering proxemics or context variables through machine learning models.

6.3 User Experience versus Privacy

Participants' behavior with respect to sensory cues and the divergence of their mental model to the PTALK method have an immediate explanation: the need for a clear indication for those engaged in the private conversation that no others could hear them. Adding such labels and further cues helps embed the privacy feature into the users' mental model. Prior research has shown that giving up sensitive information such as biometrics is an inevitable tradeoff to benefit more from social VR [33]. Audio conversations are deemed more efficient than textual chat despite the lesser privacy. Still, our study reveals the central role of protecting private talking while maintaining at least some connection with the virtual environment. This justifies the possibility of concealing ongoing conversations by different means. For instance, people have been accustomed to associating silence from another avatar as the other user being quiet or away from keyword (if there is no movement); a similar scheme could be applied in this context.

6.4 Augmenting Natural Methods

The interviews of both users and experts highlighted the preference for methods that are natural and easy to use. Many participants to the user study proposed methods that were similar to PROOM with some modifications. One of them was creating soundproof rooms within the same virtual environment, making it more natural. Suggestions also included the real-world metaphor of using hands to open and close a door. The door could be locked to restrict access, and other users could knock to request entry. These familiar real-world interactions have positive effects as they reduce cognitive load and add to the immersion. However, prior study showed that striving for natural interaction by simply increasing interaction fidelity does not always improve usability and performance [6]. It also argued that making interactions slightly more natural may reduce usability if it does not achieve high levels of fidelity. Instead, one could leverage magic hyper-natural techniques, namely, natural methods made powerful by adding fictional abilities and intelligent guidance [31]. These could be preferable to their more natural counterparts in some cases, suggesting that superhuman abilities – such as knowing the locations of vacant private rooms (as suggested by one participant) – might be a better option. We hypothesize that these abilities make users worried about the possibility of others to overhear private conversations in undetectable ways. For this reason, the prevalence of metaphors deriving from the physical world acquire more significance because they contribute to the sense of safety [78].

6.5 Limitations

Our study is a first step towards designing private conversation methods for social VR, therefore, it has limitations. Several were related to the implementation of the VR app we developed for the user study. First, the application included only a single scenario. There are several other activities in social VR, not necessarily limited to a party situation. Second, NPCs were employed to simulate a crowd of users in the virtual environment. As pointed out by at least some participants, these characters were not believable enough, which could have contributed to a low sense of confidence in distinguishing potential conversational partners from others. Moreover, our social VR app prototype lacked several advanced features, including eye tracking and facial animations. This decision was mainly due to the nature of the study, in addition to the complexity of including them in the prototype. We mentioned the availability of these features in other applications, but the inability to try them out within our study might have reduced the variety of the methods proposed by the participants. Nevertheless, this technical limitation should not have affected the richness and diversity of our design space owing to the expert interviews. Finally, our design space was derived based on a thematic analysis from two independent studies. As a consequence, it reflects the number and diversity of the involved experts / participants. Nevertheless, the resulting themes are well aligned, with a clear mapping into the dimensions and elements in the design space. This empirical validation reinforces our confidence in the expressivity and richness of the derived design space, for which we do not attempt to claim completeness.

7 Conclusion

We considered private conversations as a key mechanism to enable self-disclosure in social VR applications. We specifically explored aspects related to the usability of different interaction methods and the awareness with respect to the virtual world. We conducted two studies: expert interviews; and a controlled experiment with a social VR prototype we realized. An analysis of the underlying themes allowed to synthesize a design space that lays out the foundation for more intuitive and meaningful experiences involving conversational content of private nature. Our studies revealed a complex relation between privacy, awareness, and VR environment design for private conversations in social VR applications. Current solutions like private talk and private room offer some degree of privacy, however, they fall short in addressing the nuanced user needs for easy, safe, and quick private conversations with others. Users prefer a sense of social connection even when being isolated, highlighting the drawbacks of current methods. An ideal private conversation solution in social VR needs to take a multi-faceted approach incorporating the level of isolation, awareness of others, the level of privacy, and the relevant modalities – auditory in particular – to promote meaningful social interactions that enable self-disclosure. Despite addressing only VR, we are positive that the devised design space can also be applied to augmented and mixed reality; however, these would entail more complex challenges and may require additional scrutiny.

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