

# "Talking without A Voice" : Understanding Non-Verbal Communication in Social Virtual Reality

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Exploring communication dynamics in digital social spaces such as massively multiplayer online games and 2D/3D virtual worlds has been a long standing concern in HCI and CSCW. As online social spaces evolve towards more natural embodied interaction, it is important to explore how non-verbal communication can be supported in more nuanced ways in these spaces and introduce new social interaction consequences. In this paper we especially focus on understanding novel non-verbal communication in social virtual reality (VR). We report findings of two empirical studies. Study 1 collected observational data to explore the types of non-verbal interactions being used naturally in social VR. Study 2 was an interview study (N=30) that investigated people's perceptions of non-verbal communication in social VR as well as the resulting interaction outcomes. This study helps address the limitations in prior literature on non-verbal communication dynamics in online social spaces. Our findings on what makes non-verbal communication in social VR unique and socially desirable extend our current understandings of the role of non-verbal communication in social interaction. We also highlight potential design implications that aim at better supporting non-verbal communication in social VR.

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

Additional Key Words and Phrases: social virtual reality, non-verbal communication, computer-mediated communication, social VR, online social spaces, social dynamics

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## 1 INTRODUCTION

Social VR refers to 3D virtual spaces where multiple users can interact with one another through VR head-mounted displays (HMDs) [50, 51] (See Figure 1). While other online digital spaces that have been extensively studied (e.g., MMORPGs and 3D virtual worlds) mainly support avatar-mediated communication on screen, social VR fully immerses users in real-time and more embodied interaction that are similar to face-to-face communication, rather than merely looking at a computer screen. It also affords a broader spectrum of communication modes including both verbal and non-verbal interaction such as voice, gestures, proxemics, gaze, and facial expression.

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In the past five years, booming commercial social VR applications such as Facebook Spaces, VR Chat, AltspaceVR, and Rec Room have led to an emerging research agenda on social VR in HCI and CSCW, drawing research attention to new research questions such as social VR design [35, 50, 60], communication and interaction modes in social VR [51, 52, 59], and social interaction consequences [12, 13, 72]. However, few have explored new practices and phenomena of non-verbal communication in social VR as well as their influences on social VR users' interaction consequences.

In fact, exploring communication dynamics in digital social spaces such as massively multiplayer online games (MMORPGs) and 2D/3D virtual worlds has been a long standing concern in HCI and CSCW [16, 19, 32, 45, 66, 68]. These streams of research closely relate to social computing, experience design, embodied interaction, and computer-mediated communication. In particular, much attention has been given to how non-verbal communication can still be mediated, supported, and facilitated in these online social spaces where users' physical bodies are absent. In general, non-verbal communication can be defined as all potentially informative behaviors that are not purely linguistic in content [42], such as gaze, gestures, body language, and spatial distance. In the past two decades, extensive work has investigated avatar-mediated communication non-verbal communication [8, 21, 24, 29, 31, 67, 71] and the use of emoticons and symbols [10, 33, 45] as two key mechanisms to simulate non-verbal communication in traditional virtual worlds.

Two limitations emerge in prior literature. First, the majority of research focuses on virtual worlds (e.g., *Second Life*) in a lab setting, which may or may not reflect people's natural behaviors when they are not aware of being observed. Second, traditional virtual worlds only support avatar-mediated communication on screen. They also only allow for limited types of non-verbal behaviors such as gestures and gaze. As online social spaces evolve towards more natural embodied interaction, how can we mediate and support non-verbal communication in more novel and nuanced ways in these spaces? And how can these technology-supported non-verbal behaviors extend our existing understandings of non-verbal communication?

To address these limitations, in this paper we especially focus on understanding novel non-verbal communication in social VR. We report findings of two empirical studies. Study 1 collected observational data to explore **RQ1: What kind of non-verbal interactions are being used naturally in social VR?** This study provided the information needed to create more robust research questions that we used in the following study. Study 2 was an interview study (N=30) that investigated: **RQ2: How do people perceive and understand non-verbal communication in social VR?** and **RQ3: How, if at all, does non-verbal communication affect interaction outcomes in social VR?** Our findings highlight: 1) offline non-verbal behaviors were being used naturally to communicate in social VR (RQ1); 2) social VR users generally viewed non-verbal behaviors as positive because they were more natural, immersive, and natural means of communication (RQ2); and 3) non-verbal communication in social VR allowed for privacy, social comfort, and effective protection for marginalized users (RQ3).

Therefore, we make a number of contributions to CSCW. First, our focus on how non-verbal communication is used, perceived, and experienced helps address the two limitations in prior literature on non-verbal communication dynamics in online social spaces by situating in a new and novel research context (i.e., social VR) and focusing on online users' own accounts. How people behave and interact in social VR is an emerging, but understudied, topic in CSCW. Our case study, therefore, provides new empirical evidence of the role of non-verbal communication and its influence on interactive experiences in this new research content and emerging novel sociotechnical system. Second, our findings on what makes non-verbal communication in social VR unique and socially desirable, especially compared to offline and traditional virtual worlds settings, extend our current understandings of the role of non-verbal communication in social interaction. We also highlight potential design implications that aim at addressing benefits and drawbacks of non-verbal communication, which may inform the design of future social VR systems.



Fig. 1. Two Social VR platforms:

AltspaceVR (left; <http://www.altvr.com>); VRChat (right; <http://www.vrchat.com>)

## 2 RELATED WORK

A large body of prior work in HCI and CSCW has explored non-verbal behaviors (e.g., emoticons, eye contacts, hand gestures, and gaze awareness) in various forms of computer-mediated communication, including videoconferencing, voice chat, and virtual team (e.g., [25, 26, 34, 46, 54, 58, 66]). Collectively, these studies have highlighted the significance of non-verbal communication in our online social lives: in addition to verbal and textual communication, non-verbal communication is a necessary alternative to convey emotions, feelings, and rich information in a natural way. In this section, we focus our literature review on two strands of research on non-verbal communication: types and influences of non-verbal communication in offline face to face interaction; and how traditional 2D or 3D virtual worlds afford and support non-verbal communication. We especially focus on non-verbal communication in traditional virtual worlds rather than other online settings because social VR, as an immersive 3D avatar-based virtual environment, is more comparable and relevant to virtual worlds and gaming environments.

### 2.1 Types and Influences of Non-verbal Communication Offline

In this paper, one of our goals is to explore what kinds of non-verbal interactions can be used naturally in immersive social VR environments. By "naturally," we refer to the interaction dynamics and experiences similar to an offline face-to-face setting. Therefore, it is important to understand what types of non-verbal communication often emerge in offline social lives as well as their influences.

In general, non-verbal communication can be defined as all potentially informative behaviors that are not purely linguistic in content [42]. It usually includes a sender, a receiver, directed behavior, and continuous non linguistic information. Much of our information is communicated non-verbally. This is especially true for socially relevant communication [28]. For example, Clark et al. [17] demonstrated how non-verbal cues could lead to coordination, and extend the understanding of communication in the context in which it was shared. This can be in the form of visible body language or a visual cue. Prior literature has summarized four traditional modalities of non-verbal communication, including facial behavior, gaze, gestural behavior, and spatial behavior.

*Facial Behavior.* The interpretation of faces is a typical example of continuous non linguistic information. Faces are a form of identification and can communicate information regarding gender, age, race, emotion, intention, physical health, attractiveness, and emotional state. In many ways,

universal facial expressions such as happiness, surprise, contempt, sadness, disgust, fear, and anger [18, 20] can communicate a person's state and intention. They allow for deliberate feedback, such as a greeting smile, and unintentional feedback, such as blushing or a reaction to a smell. People's perception of faces can also inform whether a person should be trusted [65].

*Gaze.* Eyes not only communicate sensory information, but also turn said information into social perception. This allows people to communicate one's intentions and understand others' intentions. By detecting where someone is looking, people are able to determine the target of someone's attention and then infer their behavioral attention [42]. Eye gaze can also increase the intensity of all facial emotions [40]. For example, Kleck and Nuesle [41] found that when confederates gazed more, rather than less, at the interviewer, they were perceived as friendly and self confident.

*Gestural Behavior.* Gestural behavior involves movement of the hands and other body parts. Gestures allow for communication where speech is ineffective or not needed. For example, flamboyant gestures can be used to gain another person's attention [27] and for acknowledging of others' discourse [64]. Certain actions are also represented better through gestures than verbally – e.g., in the form of mimicry or a visual animation to a speaker [43]. However, gesture as a form of bodily action has certain advantages (e.g., more vivid) and disadvantages (e.g., causing misunderstandings) over verbal communication because gestures are learned and can vary across different cultures.

*Spatial Behavior.* Proxemics, or spatial behavior, are the measurable distances between people as they interact with one another [30]. It allows individuals to utilize space to communicate comfort, anger, friendliness and standoffishness through four distance zones: intimate, personal, social, and public. Each distance zone has a specific range of proximity which can afford certain types of communication. For example, the intimate zone is common for communicating through physical contact activities such as expressing affection, comfort, physical stress, protection. Yet, social distance is culturally dependent and often used in social gatherings (e.g., meetings and events), which allows for communication of strangers and friends without violating intimate or personal distance [30].

In summary, it has been widely acknowledged that non-verbal cues such as facial expressions, gaze, gestures, body language, and spatial distance play an essential role in people's everyday social interactions [15, 22, 57]. However, as computer-mediated communication, where the physical body is absent, has pervaded how people meet, interact, and communicate in modern social life, to what degree can non-verbal communication be accommodated and supported in online social spaces? To what degree can it still effectively convey meaning and affect social interaction consequences? Traditional 2D or 3D virtual worlds have been extensively studied to explore these questions.

## 2.2 Non-verbal Communication in Traditional Virtual Worlds

In this research, we define traditional 2D or 3D virtual worlds as "a synchronous, persistent network of people, represented as avatars, facilitated by networked computers" [9]. Typical examples include *Second Life* and most multiplayer online games such as *World of Warcraft*. Prior research has shown that non-verbal communication can be afforded and supported in these online spaces through two main mechanisms: 1) avatar-mediated communication to simulate non-verbal communication [8, 21, 24, 29, 31, 67, 71] (i.e., gaze, gesture, animation, and spatial behaviors); and 2) the use of emoticons and symbols to communicate. [10, 33, 45]. Table 1 summarizes main non-verbal communication modalities supported in various virtual worlds.

*Avatar-Mediated Communication.* As Manninen and Kujanpää [48] posit, the main difference between virtual worlds and the physical world is the need for an avatar as a proxy for the player and all his/her possible communication conducted in the virtual environment: An avatar is one's interface to other human users. Using this interface is a process of constantly reading and interpreting: The expressions and movements performed by the online users are translated through the avatar into

Table 1. Main non-verbal Communication Modalities Supported in Virtual Worlds

|   | Facial Behavior | Gaze | Proximity | Kinetics | Text/Chat | Emoticon |
|---|-----------------|------|-----------|----------|-----------|----------|
| Second Life [24, 67, 71]                            |                 | •    | •         | •        | •         | •        |
| VLNET [29]  | •               | •    | •         | •        |           |          |
| Active Worlds [56]                                  |                 |      | •         | •        | •         |          |
| Experimental Game World [33]                        | •               |      | •         | •        | •         | •        |
| Open Wonderland [31]                                |                 |      | •         | •        | •         |          |
| Experimental Collaborative Virtual Environment [21] | •               | •    |           | •        |           |          |

the virtual environment. Users also adjust their behavior and decide their responses based on the cues they read from other avatars [48]. Therefore, avatars play a central role in the communicative dynamics of virtual worlds: Communication is avatar-mediated via computer-mediated channels. The avatar, as the unique representation of an individual user in the virtual world, is the carrier and realizer of all communication, including non-verbal communication, with the world and with others.

In most traditional virtual worlds, non-verbal communication is simulated by avatar-mediated communication. These virtual worlds often provide a variety of scripted avatar behaviors, such as gestures (e.g., waving), animations (e.g., jumping and dancing), and gaze. Users then express and interpret non-verbal cues by controlling their own avatars or reading others' avatars. For example, regarding gaze, Yee and Bailenson found that social interactions in virtual worlds such as *Second Life* were governed by the same social norms in offline behavior, as shown in non-verbal behaviors such as eye gaze and gaze aversion [71]. Not directly gazing at the audience was also considered rude or "snobs" in virtual worlds [67]. Notably, gestures such as waving was also commonly used in avatar-mediated communication to show greeting or display of joy [8]. Similarly, making avatars dance together, or pat each other's shoulder, often suggest intimacy and support [23].

In addition, how closely avatars stand together in virtual worlds simulates spatial behavior in offline world. Previous studies have found that people behave similarly in virtual worlds as they would in the real world regarding proximity – e.g., intimate and personal distance indicate closeness and familiarity while social and public distance suggests the protection of privacy [31]. As Friedman et al. has shown, invading other avatars' personal space often led users to retreat from the invader [24].

*Symbols and Emoticons.* As a supplement to avatar-mediated communication, users in virtual worlds also implement emoticons and symbols to communicate non-verbally. The use of symbols and emoticons varies from platform to platform but usually focuses on adding emotions, cues, and context in text chat (e.g., using symbols of smiling faces frown faces) [10, 33]. For example, Bennerstedt and Ivarsson found that players used emotes and symbols in gameplay for team coordination, especially when text chat may impede their objective [10]. Leavitt et al. also highlighted the important role of "pings," alerts that are easy to activate and provide auditory and visual cues, in competitive online multiplayer game [45]. Such actions of triggering a "ping," clicking a symbol, or quickly typing an emote can save players' time in a fast paced competitive game.

However, compared to offline non-verbal behaviors, using symbols and emoticons for non-verbal communication in virtual worlds still requires much more time as they are embedded in text chat. Despite this limitation, many virtual world users and game players consider symbols and emoticons beneficial for their online communication. As Innocent et al. suggested, users generally understood and enjoyed communicating via symbol chat (modifiers, location, and emotions), and even adapted the symbols to communicate more effectively [33].

In summary, previous literature has revealed a number of key limitations of studying nonverbal communication in virtual worlds. First, the majority of research in this area has either been conducted in *Second Life* or in a lab setting. New research contexts should be explored. Second, traditional virtual worlds only support avatar-mediated communication on screen. This restricts how natural and embodied non-verbal communication through avatars may be felt to users and how significantly such communication can affect social interaction consequences. These virtual worlds also only allow for limited types of non-verbal behaviors, as shown in Table 1. With the constantly evolving social technologies and social needs, to what degree can emerging sociotechnical systems mediate and support non-verbal communication in more novel and nuanced ways? This leads to our focus on social VR. Though non-verbal communication in social VR is still not as comprehensive as in the offline world, it demonstrates a broader spectrum of modes than any traditional 2D or 3D virtual worlds, including both verbal and non-verbal interaction such as voice, gestures, proxemics, gaze, and facial expression. How the affordances of such a broader scope of non-verbal behaviors may lead to more positive (or negative) social interaction experiences is an interesting research inquiry.

Therefore, we proposed the three research questions that we mentioned at the beginning of this paper:

**RQ1:** What kind of non-verbal interactions are being used naturally in social VR?

**RQ2:** How do people perceive and understand non-verbal communication in social VR?

**RQ3:** How, if at all, does non-verbal communication affect interaction outcomes in social VR?

### 3 STUDY 1

Our main research question was first to understand what types of non-verbal interactions occur in the context of social VR. As social VR research is still in its infancy, we had to conduct some descriptive research to document the behaviors that were being used naturally by social VR users.

#### 3.1 Methods

We conducted unobtrusive observations to collect data. In unobtrusive observations, the researchers are unobtrusive or nonreactive observers [1, 2]. They may not interact or communicate with online users but rather only watch and record their activities and interactions.

*Data Collection.* Three research assistants attended events on the popular social VR platform Altspace for four weeks. An event can be created by anyone on the platform and public events are searchable through a calendar-like feature on Altspace's website. During this time, the observers attended a 61 public events, amounting to 82 hours of observation. For these observations, the researchers would use their avatar to physically attend the events, but were instructed to have limited verbal interactions with other users and primarily observe what others were doing. Each individual observation of an event averaged from 20 minutes to two hours depending on the duration of the event— the researchers were present for the entire duration of the event. Due to the inability to take notes while in a virtual reality environment, the observers documented their experience after the event ended in a shared spreadsheet. This spreadsheet recorded the date and time of the observation, along with the name of the event, number of people attending the event, and a detailed narration of the activities observed along with personal insights. These narratives ranged from two to eight paragraphs. Observers also took screenshots of interactions that they thought were good examples of non-verbal interactions. Every week, the researchers met with the authors to discuss highlights and insights of the observations.

*Data Analysis.* The collected data was analyzed through a process of open-coding follow the methodology of Strauss and Corbin [62]. First, after the observations were completed, all observers

Table 2. Examples of types of observed non-verbal behaviors

| Context                   | Type of behavior                                     |
|---------------------------|--|
| Indicating attention      | Nodding, Head movement/gaze direction, hand gestures |
| Approval                  | Emojis, applause                                     |
| Directing attention       | Pointing, patting chest                              |
| Social grooming           | Waving, dancing, kissing                             |
| Interpersonal provocation | Poking, pushing, moving too close                    |
| Social disruption         | Flying, extensive movement                           |
| Entertainment             | Dancing, emojis, playing with objects                |

and the researchers collaboratively discussed and generated a list of codes that indicated non-verbal behaviors such as dancing and pointing as well as the context of the event (e.g., party, musical performance) based on the observations. This led to 27 codes in total (see Table 2). Second, the observers and the researchers worked in a collaborative iterative process to assign a number of codes to each observation. Third, the observers and the researchers grouped the coded observations into categories based on perceived purpose of the behaviors as derived by context of the event and the detailed narrative of the activity/action as described by the observer.

### 3.2 Findings

The first type of non-verbal interaction that we observed naturally occurring in social VR was the use of movement to *indicate that someone was paying attention*. These included nodding behaviors and moving the body or head toward the person or object that was subject of attention. Because not all users were wearing headsets (if one is wearing a headset then the head naturally is pointed toward the object of attention) eye gaze was also an indicator of attention. Nodding was especially prominent in events where there were numerous people watching someone, such as speeches or staged theatrical events.

Another type of non-verbal behavior that was frequently observed was the use of applause to indicate *approval*. While nodding could also indicate approval, an applause was a more visually obvious form of approval. Interestingly, we also found that users incorporated emojis, which appeared above their avatars' heads, to signal that they were on board with the direction of the conversation.

Pointing and patting one's own chest was used as a form of *directing attention* either at a remote object/person or oneself. Much like how these actions are used in offline scenarios, they would mainly be used in conjunction with verbal indicators. For example, there was a person giving a powerpoint presentation on how to make objects in social VR, and they used the pointing gesture toward the powerpoint during their presentation to direct attention to what was on the screen.

Behaviors such as waving, dancing, and kissing were mostly used in *social grooming* contexts. Perhaps due to the fact that the observations were only of public events, these were not intimate actions but took on more of a friendly nature, most often used in the context of greeting people. Dancing, in particular, was also used to indicate excitement and joy, and had a mirroring and/or contagious effect of animalistic behavior where people would engage in dancing as a form of short greeting.

Dancing as a form of social grooming was distinct from dancing as a form of *entertainment*— the latter would involve people dancing to music in an environment that was overtly a party. Other behaviors that were of entertaining nature included playing with objects, such as passing a ball back and forth at a beach barbecue, or playing the guitar. In the case of interacting with objects

that required sound, however, the sound had to be played independent of the action, so the action sometimes did not sync perfectly with the audio.

There were two contexts that involved deviant behavior. The first is *interpersonal provocation*, which refers to a person bugging another specific person. Examples included pushing, poking, and bumping one's body up against another. Of course there were situations where this was unintentional (e.g., accidentally bumping into someone) but provocations occurred when the behavior was repeated.

*Social disruptions* are a more general form of deviant behavior not directly at a particular individual but within a group or crowd. For example, if there is an event where people have their attention directed toward a particular object, such as watching the launch of spaceship on a screen, a person wanting to disrupt that scene would fly around or flail their arms to distract people or block the view.

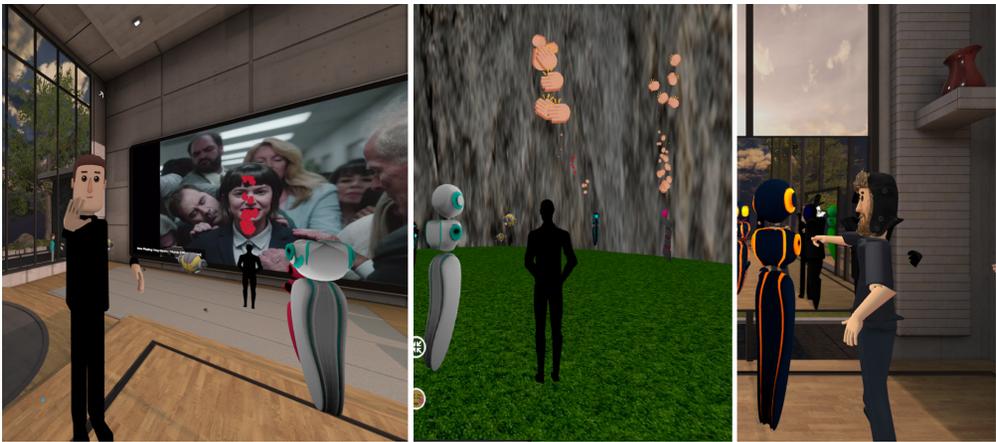


Fig. 2. Examples of non-verbal behaviors in social VR. From left, an extended hand, applause in the form of emotes, and pointing

## 4 STUDY 2

Though Study 1 offered valuable insights on social VR users' non-verbal behaviors, it could not explain how and why users conducted these behaviors. Therefore, after reviewing findings of Study 1, we considered that it was necessary and important to further understand social VR users' motivations, perceptions, and experiences behind their non-verbal behaviors rather than just observing these behaviors. This motivated us to conduct a follow-up interview study to explore 1) how people perceive and understand these various types of non-verbal communication that have been used in social VR (RQ2); and 2) how using such non-verbal communication affects their interaction outcomes in social VR (RQ3). Additionally, findings from Study 1 informed the design of interview questions relating to user behaviors in social VR in Study 2.

### 4.1 Methods

*Recruitment and Interviews.* Study 2 is part of a broader research project on social experiences in social VR. To recruit participants, we posted a recruitment message on nine popular online forums for social VR users (e.g., Reddit-RecRoom, Reddit-AltSpace VR, and Reddit-VRChat). We also directly recruited participants by entering popular social VR spaces (e.g., AltSpace and VRChat)

Table 3. Demographic information of interviewees

| ID  | Gender      | Age | Ethnicity | Experience (months) | Social VR platforms used  |
|-----|-------------|-----|-----------|---------------------|---|
| P1  | Cis Male    | 19  | White     | 12                  | Rec Room, VR chat   |
| P2  | Cis Male    | 23  | White     | 18                  | Rec Room, VR chat   |
| P3  | Trans Woman | 30  | White     | 6                   | Altspace, VR chat   |
| P4  | Trans Woman | 32  | White     | 6                   | VR chat, Rec room   |
| P5  | Cis Male    | 29  | White     | 30                  | VRChat, Altspace, RecRoom   |
| P6  | Cis Male    | 29  | White     | 4                   | VRChat, Altspace, RecRoom   |
| P7  | Cis Male    | 18  | Asian     | 10                  | Altspace, VR Chat   |
| P8  | Cis Female  | 27  | White     | 12                  | VR chat, Rec room   |
| P9  | Cis Male    | 24  | n/a       | 24                  | VR chat, Big screen, Altspace, Rec room   |
| P10 | Cis Male    | 20  | Asian     | n/a                 | Altspace, VR chat, Rec room, High Fidelity, Facebook Spaces                                     |
| P11 | Cis Male    | 21  | White     | 5                   | Altspace, VR chat, Rec room   |
| P12 | Cis Male    | 49  | Asian     | 24                  | VRCchat, RecRoom  |
| P13 | Cis Male    | 46  | Black     | 36                  | VR chat, Vtime, Big screen  |
| P14 | Cis Male    | 32  | Hispanic  | 24                  | Altspace, EngageVR, Rec Room, Mozilla Hubs  |
| P15 | Cis Male    | 26  | White     | 36                  | Rec room and VR chat  |
| P16 | Cis Male    | 65  | Hispanic  | 24                  | Sansar, Altspace, Ectasia, Rec Room, Decentralized, High Fidelity, Sonoroom, Sonorome, Vtime XR |
| P17 | Trans Woman | 26  | White     | 18                  | VR Chat   |
| P18 | Cis Male    | 55  | White     | 30                  | Sansar, High Fidelity, VR chat, Altspace  |
| P19 | Cis Male    | 43  | Asian     | 36                  | VR chat, RecRoom, Pokerstar   |
| P20 | Cis Male    | 20  | White     | 24                  | VR Chat, Rec Room, Pavlov VR, Big Screen  |
| P21 | Cis Female  | 45  | White     | n/a                 | VR chat, Altspace, Omnium Space, High Fidelity, RoomE   |
| P22 | Cis Male    | 32  | White     | 18                  | VR chat, Rec Room, Big Screen   |
| P23 | Trans Woman | 21  | White     | 24                  | VR chat, High Fidelity, Altspace, Rec Room, Big Screen  |
| P24 | Cis Female  | 27  | White     | 6                   | Altspace, VR chat   |
| P25 | Cis Female  | 20  | Asian     | 9                   | VR Chat   |
| P26 | Cis Male    | 30  | White     | 6                   | VR Chat, Rec room, Altspace   |
| P27 | Cis Male    | 45  | White     | n/a                 | Altspace, Oculus Rooms  |
| P28 | Cis Male    | 48  | White     | 24                  | VR chat, RecRoom, Altspace, Anyland, Sansar, Neos, High Fidelity                                |
| P29 | Cis Female  | 21  | Black     | 24                  | VR Chat   |
| P30 | Cis Male    | 43  | White     | 36                  | Altspace, VR Chat, Big Screen, PokerStars VR  |

and asking random users' willingness to participate in this study. All participants who responded to our requests and agreed to participate were interviewed. As a result, 30 semi-structured in-depth interviews were conducted. Interviews were conducted via text or audio chat through Discord, Skype, or Google Hangouts based on participants' preferences from October 2019 to November 2019. The average length of interviews was 60 min and participants were given a \$20 gift card after they completed the interviews. Interviews started with questions about basic demographic information and devices and social VR applications that participants use most. The main interview questions were related to their social interactions and relationship building in social VR, important activities and social experiences they conduct in social VR, and their perceptions and understandings of social VR affordance.

*Participants.* Among the 30 participants, 21 are cis male, five are cis female, and four are trans women. Of the 29 participants who shared their ethnicity, 20 are White, two are Black, five are Asian, and two are Hispanic. Two participants (P26 and P27) self identified as disabled users. Participants aged from 18 to 65 (average age: 32.2) and with diverse experiences of social VR ranging from 5 months to 36 months (average: 18.7 months). Participants had also experienced a variety of popular social VR platforms including *Rec Room*, *VR Chat*, *AltspaceVR*, *High Fidelity*, *Facebook Spaces*, *Vtime*,

*Engage VR, Mozilla Hubs, Sonoroom, Pokerstar, Oculus Rooms, Sansar, Anyland*, and so forth. Table 3 summarizes the demographic information of the participants.

*Data Analysis.* We used an empirical, in-depth qualitative analysis [63] of the collected data to explore people's diverse experiences of non-verbal communication in social VR. We sought first-person, subjective, narrative accounts of their experiences in the interviews, and we coded them thematically.

Based on McDonald et al.'s [49] guidelines for qualitative analysis in CSCW and HCI practice, our analytical procedures focused on eventually yielding concepts and themes (recurrent topics or meanings that represent a phenomena) rather than agreement – because even if coders agreed on codes, they may interpret the meaning of those codes differently [49]. Therefore, we did not seek inter-rater reliability in our analysis but endeavored to identify recurring themes of interest, detect relationships among them, and organize them into clusters of more complex and broader themes.

Specifically, two of the authors closely read through the transcribed interview data to acquire a sense of the whole picture as regards how social VR users used, perceived, and experienced non-verbal communication for further analysis. These two authors then highlighted interview questions that were relevant to RQ2 and RQ3 and identified a set of initial thematic topics and sub-themes (e.g., perceptions, practices, strategies, consequences, and challenges) emerging in participants' answers to these interview questions. A shared spreadsheet was used to document, combine, and refine these themes and sub-themes per research question by color coding. After that, all three authors collaborated in three rounds of an iterative coding process using the shared spreadsheet to discuss, combine, and refine themes and features to generate a rich description synthesizing social VR users' perceptions and experiences of non-verbal communication.

## 4.2 Findings

Using quotes from users' own accounts, in this section we present our findings as two parts. First, to answer RQ2 (*How do people perceive and understand non-verbal communication in social VR?*), we identified three common themes that demonstrated how users perceive and understand non-verbal communication in social VR: as more immersive and embodied interactions for body language; as a similar form of communication to offline face-to-face interaction in terms of spatial behavior, hand behavior, and facial expressions; and as a natural way to initiate communication with online strangers.

Second, to answer RQ3 (*How, if at all, does non-verbal communication affect interaction outcomes in social VR?*), we described the social consequences of interacting through non-verbal communication in social VR for various user groups, including marginalized users such as cis women, trans women, and disabled users. We specially highlighted how non-verbal communication in social VR afforded privacy and social comfort as well as acted as a protection for marginalized users.

**4.2.1 Overall Positive Perceptions of Non-verbal Communication in Social VR.** In our analysis, we discovered that most participants considered non-verbal communication positive in their social VR experience. In social VR, non-verbal communication is mediated by full-body tracked avatars. This is novel and unique from any other forms of non-verbal behaviors in computer-mediated communication that have been studied, which may explain participants' overall positive impression. Specifically, we identified three key themes emerging in their perceptions and understandings of full-body tracked avatar mediated non-verbal communication in social VR.

### **More Immersive & Embodied Interactions for Body Language**

Similar to traditional online virtual worlds, social VR users prefer to communicate and express themselves via the body of their avatars. However, the uniqueness of social VR is that it affords full

body tracking - e.g., one's physical body actions would correspond to his/her avatar body actions, which is an emerging novel technological feature. Our participants highly praised this feature as it allowed for a more immersive and embodied form of non-verbal communication than those in traditional virtual worlds – one's body and body movements directly link to how non-verbal communication could be produced and understood. P23 (Trans Woman, White, 21) explained this novel experience in VRChat,

*Just the body itself, like what it presents is the biggest thing, like the immersion in the world, and then the fact that there's like a full body that's moving around like an actual person. This completely changes how people communicate with each other.*

According to P23, it was full body tracking that made communication in social VR more immersive. First, being able to "mirror" one's body movements in and out of social VR automatically made non-verbal communication a familiar form of interaction to many, as it incorporated features inherent to participants' physical existence. Second, the ability to directly manipulate the virtual body to express allowed for a more engaging communicative experience by having a body "moving like an actual person".

In particular, participants highlighted how expressing themselves via a full body tracking avatar made body language such as gestures a vital way to communicate in social VR. P21 (Cis Female, White, 45) described her experience in VRChat,

*It's all in the gestures. The fact that you can do more gestures in social VR is fascinating. Gestures are actually becoming a means of communication – body language. It is quite strong, may be even stronger than communicating via voice or words. This is extremely important for first time users as it is more natural for them.*

In P21's opinion, body language such as gestures, rather than voice or text, seemed to commonly be seen as a mode of "default" and effective communication in social VR. This was extremely important for first time social VR users as they could just use body movements to express themselves, which could be more natural and easier than learning to use keyboard or controllers.

In this sense, using body language through full body tracking avatars dramatically helped users depict their emotions, intentions, and convey subtle information in a more intimate way. To some degrees, this made non-verbal communication more powerful than any verbal communication in social VR. It also made engaging in social VR a more expressive experience than that of any other traditional virtual worlds, as P7 (Cis Male, Asian, 18) reflected about his experience in VRChat,

*The way that you can translate body movement in social VR is especially powerful. Since body language is so important to how you interpret other humans, something like this has existed for a long time in games or Second Life. But what you can do in social VR is felt completely different and revolutionary. It's just so much more immersive. You can really reach out and touch someone's shoulder. If someone is having a bad day, I can really pat their back. This is so much more personal and intimate.*

As P7 noted, how body language was produced, conveyed, and interpreted in social VR could be very different from that in traditional online virtual worlds. On the one hand, social VR afforded more varied, realistic, and expressive gestures by using full body tracking. On the other hand, gestures in social VR seemed to imply deeper feelings of connectedness: despite no haptic interaction was exchanged, examples of non-verbal gestures such as touching someone's shoulder or patting someone's back in social VR were felt "much more immersive," "personal, and "intimate" to participants. This may suggest a more effective and socially satisfactory way to exchange emotional support in social VR via non-verbal communication.

Others also echoed this view. For example, P9 (Cis Male, 24) added,

*The best part of social VR is that it is not only first person but also you are in the world as yourself. You are the character itself. You can high five people and do little body language things that you can't normally do with people in other media. This makes you feel more connected to others.*

For P9, the reason why social VR could afford a more rewarding social experience than other media platforms was how people could have more control over their avatar to conduct non-verbal communication (e.g., "high five" and "little body language things").

### **Similarities to Offline Face-to-Face interaction**

In addition to supporting more immersive and embodied interactions for body language, participants also considered non-verbal communication in social VR similar to offline face-to-face interaction in terms of spatial behavior, hand behavior, and facial expressions. This familiarity and naturalness greatly contributed to their generally positive perceptions.

One important similarity that many participants highlighted was how spatial behavior and proximity information were conducted and conveyed in social VR. For example, P5 (Cis Male, White, 29) described his experience across all popular social VR platforms:

*What I like most about social VR is having the ability to have the positional audio and recognizing the distance between the audio. This should be what a real interaction feels like: you will hear people differently such as footsteps based on the distance, and you will act differently accordingly. You rarely see this in other virtual worlds or games.*

In this quote, P5 especially appreciated how audio cues of distance for interaction in social VR echoed familiar dynamics of real world interactions. For him, spatial information such as position was crucial to engage in a realistic and immersive online interaction. Comparing to traditional virtual world and online games, social VR successfully incorporated these non-verbal cues in its interaction dynamics, which "should be what a real interaction feels like" according to P5.

Others also pointed out that the ability to show delicate hand behavior such as finger movements made non-verbal communication very similar to how people interact offline. For example, P20 (Cis Male, White, 20) and P22 (Cis Male, White, 32) described how they used finger movements in VR chat and RecRoom to better express themselves:

*I call the valve index controllers the "knucks." They allow you to have finger movements such as thumb up and pointing. I think these subtle movements and signs really help in a social setting, no matter online or offline, such as when I wanted to show support to someone or get someone's attention but without talking. (P20)*

*Using the valve index controllers, now you can digitally manipulate your fingers. They have their issues but they look great and I'm very positive about them. You can see what others people are doing with their fingers. This makes you feel more interactive. (P22)*

As P20 and P22 point out, finger movements play an important role in human communication. They are so subtle that they do not shadow other major non-verbal cues such as body language. They are also so delicate that they provide supplementary non-verbal information to help people express and share feelings in alternative ways (e.g., a simple thumb up or thumb down to show support or dislike). For our participants, the fact that this complicated and detailed movement (e.g., one finger) can be captured and tracked in social VR not only help them replicate feelings and

behaviors as those in offline face-to-face interaction but also greatly improve the quality of their social experiences in social VR.

Similarly, the ability to make facial expressions was highly praised by many participants. P2 (Cis Male, 23, White) and P3 (Trans Woman, White, 30) described how they enjoyed having facial expressions on their avatars across VRChat and RecRoom,

*You can basically put in emotes over your avatar's face to show if you are happy or sad. It's called Expresso. Yes you can communicate with body language but putting facial expressions on your character makes much difference. (P2)*

*It's important to have facial expressions in social VR. So you can smile while you're saying something happy or give an angry face when you're angry with people. It feels like you are a real person more than a virtual character. (P3)*

These quotes highlighted that participants had a strong demand for using their faces, an inherent part of our everyday communication, in their online social lives. Compared to many traditional virtual worlds and online games where faces are often merely a static 2D image, the affordance of facial expressions made non-verbal communication in social VR more vivid to another level: directly revealing emotions (e.g., happy, sad, or angry) on someone's face as in offline face-to-face interaction. This is not only more powerful than only relying on body language to communicate but also makes participants feel like *"a real person more than a virtual character."*

### **A Natural Way to Initiate Communication with Online Strangers**

Participants also viewed non-verbal communication in social VR as positive and effective because it became a less invasive way to start interactions with online strangers.

Many participants mentioned that they came to social VR because they wanted to meet people and socialize. However, meeting new people for the first time and starting a conversation with online strangers can be awkward. In this process, non-verbal communication became a key strategy to identify strangers who they wanted to approach or make friends of, as P9 (Cis Male, 24) made note about his experience in VRChat and AltspaceVR,

*Usually, I would at first observe other people's interactions and behavior like body language. Then I would decide if I would approach them to make a connection.*

In P9's example, observing and interpreting one's non-verbal behavior was an important and necessary communication strategy – to decide if he felt comfortable or safe to communicate with a given user. After such a decision was made, the affordance of rich non-verbal communication in social VR also helped them overcome this feeling of uneasiness when interacting with strangers. In many ways, non-verbal communication (e.g., waving, holding hands, or shaking hands) became a natural icebreaker activity. P4 (Trans Woman, White, 32) described how she could make friends in RecRoom,

*In order to become friends with somebody, you just hold out your hand and you shake hands for five seconds and then you become friends and then hop in a game. It's awesome.*

Apparently, interactions in social VR blend together the benefits of both digital communication and physical touch, which then provide an easier transition to initiate social connection. In P4's case, she did not need to introduce herself or make any carefully crafted remarks in order to express interests or intentions in making new friends. Rather, it seemed to be a consensus that a hand shaking in social VR was sufficient to break the ice and signal friendliness. This further highlights the nuance and importance of non-verbal communication in social VR – it allows users

to communicate in a way in which they feel appropriate, natural, and comfortable especially when meeting strangers.

Others also highlighted how using non-verbal communication to make new friends could be much easier in social VR than in offline world. For example, P19 (Cis Male, Asian, 43) explained his experience of RecRoom,

*Everybody can just meet everybody that you're with and walk into a number of rooms in rec room. You got to do a fist bump and then you're part of a party and then you can go someplace together. This may sound awkward in real life but it is so natural in social VR. You just make friends this way and everyone is up to it.*

In this quote, P19 explained how non-verbal communication such as a fist bump allowed for easy social inclusion into a seeming foreign space in social VR. In contrast, walking towards a stranger and simply fist bumping him/her without any talking in the offline world may rarely generate positive experience in offline social interactions. In this sense, non-verbal communication in social VR seems to afford interaction dynamics between strangers that differ from those either in other online social spaces or in the offline world: more expressive and diverse than other online social interaction, and more flexible and less awkward than offline interactions.

It should be noted that participants also expressed some concerns about the current adoption of non-verbal communication in social VR platforms. For example, P15 (Cis male, 26, White) noted that non-verbal communication could be physically demanding especially when wearing a head mounted display. This exhaustion may make non-verbal communication not sustainable or inaccessible to some users. P2 (Cis Male, White, 23) also suggested that more accurate "tracking" features such as facial recognition would promote natural bodily communication and more realistic forms of non-verbal communication. Despite these critiques, our participants collectively depict their overall positive perceptions of non-verbal communication in social VR: the expression and interpretation of body language in a first person viewpoint has much to do with the full tracking virtual body and the replicated feelings of offline face-to-face interaction, which leads to more immersive and embodied interactions and a more natural way to initiate communication with strangers.

**4.2.2 Social Interaction Consequences of Non-verbal Communication.** As we have shown, our participants recognized that non-verbal communication afforded nuanced social dynamics in social VR that were overall positive with some drawbacks. In this section, we report that they have also highlighted two significant social interaction consequences that these dynamics led to: affording privacy and social comfort, and protecting marginalized users. It should be noted that we purposefully did not offer a definition of *social interaction* in our interview questions to provide participants with greater flexibility to openly answer the questions and reflect on their subjective personal social experiences in social VR. We also acknowledge that non-verbal communication in social VR might lead to many other social interaction consequences. However, our participants mainly highlighted these two.

### **Affording Privacy and Social Comfort**

Generally, participants reported that using non-verbal communication greatly protected their privacy. Like any digital social space, how to manage and protect privacy is of concern for social VR users. Social VR systems afford the intentional or unintentional sharing of tremendous personal information including facial features (e.g., through avatar creation), behavioral patterns, voices, and reaction to videos/photos/scenes. The amount of information that users are able to share in social VR system is much more than what they can through other sociotechnical systems such as social networking sites or online games. This leads to higher risks for their privacy when interacting in

social VR. However, many participants noted that using non-verbal communication led to higher protection of their voice data and other personally identifying information. For example, P13 (Cis Male, Black, 46) noted the feeling of privacy and freedom associated with anonymity in VR Chat,

*The fact that I can communicate with people without voice at all gives me sense of ease. Because I would have some kind of anonymity in an environment that everything may possible reveal who you are – your appearance, your accent, and you tone.*

For P13, anything he did or how he did it in social VR could risk exposing his identity, such as how he created his avatar or the ways he talked. The similarities of social VR to the offline face-to-face interaction actually made concealing private personal information more challenging. In this sense, engaging in social VR seemed to become a dilemma for many: enjoying the high immersion but risking undermining privacy. However, P13 highlighted that depending on non-verbal communication could effectively protect someone's privacy and information in social VR by introducing a certain level of anonymity, which could reconcile this dilemma.

In addition, participants noted that non-verbal communication helped them overcome social anxiety and be more open. Some even commentated that this may not happen without social VR, as P5 (Cis Male, White, 29) explained about his experience in RecRoom,

*I find people who might otherwise be a little bit more introverted in real life are more comfortable in VR Chat, Altspace VR, and RecRoom. And I feel that people are more likely to just go and meet with people because they have many ways to make them comfortable about talking with people, such as using body language. I guess even at a level of closeness that they wouldn't maybe be near that person physically if they were in real life.*

P5's observation is interesting because the affordance of powerful non-verbal communication in social VR appeared to result in more productive social interactions, especially for people who may be introverts in the offline world. As he suggested, such users may feel more comfortable and open to communicate with strangers in social VR than in the offline world. As a result, engaging in social VR may become a desirable alternative for them to meet and connect with people and to expand their social lives.

Others also pointed out how practicing body language, gestures, and proximity in a safe way in social VR helped users overcome social anxiety. For example, P21 (Cis Female, White, 45) reflected her experiences of VR Chat and AltspaceVR,

*I think people can improve their social skills. I think that the people who cannot express themselves can just express themselves in social VR without getting scared or worried about stereotypes or anything else. They have so many ways to express themselves - using hands, make faces, getting close to people, etc. I think social VR is one of the best things that has ever happened.*

According to P21, engaging in social VR may actually improve people's social skills for two reasons: a relaxing virtual social space and various non-verbal communication methods to ease nervousness. In offline world, solely depending on non-verbal communication may appear to be socially odd. Yet in social VR, it is a widely accepted and acknowledged mechanism to start and sustain social interaction behaviors. This flexibility, therefore, help many users, especially those who need to improve their social skills, be confident to communicate with others.

Another important trend in social VR is that users often become physically exhausted from talking to someone but still want to continue the social connection. As a result, an emerging need is to stop speaking but still communicating. non-verbal communication appears to be an ideal

solution to fulfill this demand. P17 (Trans Woman, White, 26) told us her strategy when using VR chat:

*I like hands in social VR. I like the idea of giving somebody markers or pens to draw with. Because if I'm tired of speak to someone, i can write to them, do something together with them like dancing, or just sitting next to them. We still feel connected even we are quiet.*

For P17, non-verbal communication made her stay connected to people in social VR without exhausting herself by constantly speaking. For these users, non-verbal communication in social VR affords and blends a variety of offline behavior such as writing, dancing, and physical proximity. This diversity, in contrast to merely voice-based verbal interaction, brings pleasant conform to their social interaction.

### **Effective Protection for Marginalized Users**

Marginalized communities exist in every online social space. In social VR, these individuals include but not limited to LGBTQ, women, users of color, and disabled users. In our study, we found that non-verbal communication became an effective protection for them to avoid unwanted interactions, attention, and behaviors.

Though this paper does not specifically focus on harassment, it emerged in our data that non-verbal communication (e.g., turning off voice or using specific gestures) helped many marginalized users to protect themselves from potential harassment. For example, P4 (Trans Woman, White, 32) and P17 (Trans Woman, White, 26) described that how exclusively communicating without voice made them feel safer and more comfortable in RecRoom and VR Chat:

*Honestly, when I first started out, I wouldn't even talk back. I would just be mute. I was still on meds so my voice still sounded like a man. so I didn't want weird questions about my gender from people I don't know. but I would like wave at them hold up hand gestures and things like that. That's a great way that VR allows people to communicate even if they're not comfortable speaking. Like I can hold the thumbs up or I can give you the piece [building object] that you are waiting for or pat you on the head. Things like that. (P4)*

*In the first six months when I used VR chat, I entirely used it without voice at all. It took a while for me to actually feel comfortable speaking to people. I was just worried about how they would react to my gender identity. But I really enjoyed the fact that I was able to present my identity without a voice. I feel safe. (P17)*

For both users, they felt vulnerable and endeavored to avoid potential harassment or unwanted attention to their gender identity. However, they were facing a significant challenge in social VR - voice as a main communication method. Therefore, when not knowing the climate of the community or the openness of a given user, non-verbal communication was the very way to both not revealing their gender identity and maintaining their ability to express and interact with others. To them, the fact that non-verbal communication in social VR could completely replace verbal communication (vocie) without undermining the social interaction consequences automatically made social VR more friendly and supportive to marginalized users.

Other marginalized users such as women and non-native English speakers also echoed how simply turning their microphone and only interacting via non-verbal behavior prevented them from potential harassment. P25 (Cis Female, Asian, 20) described her frustration with unwanted attention in VR Chat and how turning off her mic made her social VR life much easier,

*I used to only use female avatars. Also if I'm talking to one of my friends, I tend to get more attention than usual because people realize that I'm female. A lot of people will approach me and start talking to me and I'll just stay quiet. I'll turn my mic off and just pretend that I'm either a guy or that I don't have a mic. This is annoying so I'm glad that I can use other ways to communicate without voice.*

This quote highlights the challenges for female users in social VR. As in other online social spaces such as gaming, female users often receive much more attention than they would ever want. This excessive attention, while not always leads to harassment, indeed makes female users feel uncomfortable, unpleasant, and to a certain point, unsafe in social VR. Similar to the two trans woman participants mentioned above, the various communication modalities afforded in social VR allowed these female users still interact with people in alternative ways without revealing their actual gender. To them, this not only made a positive social experience possible but also allowed them to continue their engagement in social VR.

Unlike trans woman or cis female users, non native English speakers often encounter a different type of challenge in social VR. Currently, the primary language used in most social VR platforms is English. Non native English speakers sometimes face interactions that make them uncomfortable, such as intentionally or unintentionally making fun of their accent or culture. They may also face potential harassment such as racism. P10 (Cis Male, Asian, 20) and P16 (Cis Male, Latino, 65), two ethnic minorities, both expressed such challenges and why non native English speakers may decide to switch to non-verbal communication rather than voice in various social VR platforms such as AltSpaceVR and RecRoom :

*With English being the predominant language in social VR, if you do come in with an accent, people may harass you. Or at least, there will be some stigma, some kind of tribalism where people only want to hang out with people who speak the same language and who come from the same country, not you. So an easy solution is not to speak. (P10)*

*Just a few days ago, I was on AltSpace VR. From my accent, some guys might know I'm from Mexico or something. So they started to say all these nasty things about Mexico. It was a very Trump like language so I just muted him. But I feel I may not use voice in the future to avoid such situations. (P16)*

According to both users, verbal (voice) communication in social VR did not lead to positive social interaction consequences for many non native English speakers. Some of them felt being left alone because they did not speak the language as well as native speakers. Some even were harassed because their accent revealed their country of origin. In this sense, the affordance of verbal communication in social VR did not facilitate but severely hurt their social engagement. In contrast, non-verbal communication was the opposite: it helped them work around these potential challenges and harassment since body language, facial expressions, and spatial information are essential to human communication in almost any culture. It also facilitated communication between users who spoke completely different languages. For example, P29 (Cis Female, Black, 21) told a story about how she was able to interact with a user who did not speak English at all, this was in VRChat:

*I think his name was John and he didn't speak English at all. So I used body language and the emojis to communicate with him. It worked quite well!*

Especially, non-verbal communication such as gesture represents a more proactive way for these users to fight back with potential harassment or unwanted interactions. P4 (Trans Woman, White, 32) added about her feelings particularly in RecRoom,

*I'm not beholden to any of those people. I don't. I'm past the point where I have to deal with trolls on the internet. So if someone comes up to me and they are even a little bit like annoying, then I will do this gesture: you hold your hand up, like talk to the hand.*

The "talking to the hand" gesture that P4 mentioned is both symbolic and functional for marginalized users to combat unwanted interactions. It is symbolic because it suggests a stronger and more embodied action to reject potential harassment. On traditional online social platforms, users usually can block harassers with a click or a tap on a smart device. In contrast, this hand gesture in social VR represents a more powerful physical action of "stop." It is also functional because the person who the user used this gesture to will be eliminated from this person's purview, which prevents any other potential unwanted actions from this given person.

However, it should be noted that non-verbal communication in social VR does not always lead to positive social interaction consequences for marginalized users. A typical example is how users with disabilities have difficulties to communicate with someone who is behind them. The reason is that they must physically turn around in the offline in order to turn around in social VR, which they simply cannot do it. P27 (Cis Male, White, 45) complained about his feelings across general social VR platforms,

*There's a lot of failures in Altspace where we can't turn around and see behind the seat. There's a lot of VR stuff where a person has to physically turn around, and that's almost impossible for people with disabilities to do. Like if somebody who's talking behind me and they want my attention, to show my attention I would have to physically turn around and look at them. But I cannot do it. I'm unable to interact with people because of that.*

In P27's case, he was often seen as rude to other users because he simply could not conduct certain non-verbal behaviors such as turning around to look at people in order to show attention. For these physically disabled users, the strength of full body tracking and more embodied body language in fact became barriers for them to socially connect with others in social VR.

Another example is the limited option for deaf users to use sign language. P23 (Trans Woman, White, 21) shared concerns about her deaf friends' struggles in almost all popular social VR platforms:

*I know a few deaf people in VR who may have communicate issues. The controllers are not really good enough yet for doing sign language. I think having a text chat would be difficult because I know some VR games have text chats. But people who are in VR do not look at them because they're in VR.*

In this sense, while non-verbal communication tends to socially benefit many social VR users, currently they seem to be insufficient to lead to positive social experiences for deaf users. Sign language, which is a three dimensional communication mode (hand, body, and facial), is not yet supported by VR devices and social VR platforms. In addition, text chat, while is widely used in the offline world by deaf users as an alternative, appears to be inappropriate in social VR: users either do not pay attention to it or consider them too slow for the real time interaction in social VR.

## 5 DISCUSSION

To answer the three research questions that we proposed at the beginning of this paper, our findings have highlighted: 1) offline non-verbal behaviors such as gaze, facial behaviors, gestural behaviors, and proximity were all being used naturally to communicate non-verbally in social VR (RQ1); 2) users generally perceived non-verbal communication as positive in their social VR

experience because it affords more immersive and embodied interactions for body language, is similar to offline face-to-face interaction, and is a natural way to initiate communication with online strangers (RQ2); and 3) non-verbal communication in social VR allowed for privacy, social comfort, and effective protection for marginalized users despite certain limitations (RQ3). We now use our findings to discuss the implications of this work for extending our current understandings of non-verbal communication in digital social spaces in HCI and CSCW. We also explore potential design implications for better supporting non-verbal communication in social VR.

### 5.1 The Nuance of Non-verbal Communication in Social VR vs. Offline and Traditional Virtual Worlds

In this paper, we build upon existing work on offline non-verbal behaviors in traditional 2D/3D virtual worlds to investigate how studying a unique and novel form of sociotechnical systems (e.g., social VR) may bring in insights on supporting non-verbal communication in new and more nuanced ways.

In doing so, we have conducted two interlinked studies (i.e., an observational study and an interview study). Interestingly, findings from the two studies supplement each other and demonstrate notable similarities and differences in non-verbal communication, especially in terms of its role in online social behaviors. In study 1, gestures were shown to mainly indicate paying attention (e.g., nodding, moving body to indicate social connection). Study 2 extended upon this finding and highlighted that these subtle behaviors were so powerful that participants could use gestures and body language in social VR to practice their social skills and overcome anxiety/depression. The use of emotes and social grooming behaviors (e.g., kissing and waving) was similar in both studies. However, study 1, which focused on AltspaceVR, demonstrated that dancing could be a common greeting at any point in time, while study 2, which covered a variety of popular social VR platforms, pointed out that dancing and gestures functioned as a communication modality to maintain social connection when people were tired of speaking. These differences further highlight the heterogeneity of various social VR platforms and the social norms embedded in them. In addition, Study 1 noted more physical discomfort and social provocation than study 2. In particular, study 1 mentioned the risks of using non-verbal behaviors for harassment, such as poking, pushing, and physical obtrusions of space. Study 2, in contrast, highlighted that participants used non-verbal communication to combat unwanted behaviors and potential harassment by turning off audio or using gestures such as "talk to the hand" to block someone. This leads to a dilemma: using non-verbal communication in social VR can be both a benefit and a disadvantage for some users, such as the marginalized populations (more in section 5.2).

Despite the similarities and differences between the two studies, they collectively highlight the nuance of non-verbal communication in social VR, especially compared to offline behaviors and those in traditional virtual worlds.

*Non-verbal Communication in Social VR vs. Offline.* Our findings illustrate a few similarities between non-verbal communication in social VR and in offline face-to-face interaction. One similarity was the role of interpretation in non-verbal behaviors. No matter in social VR or offline, interpreting cues in someone's non-verbal behaviors was a key communication strategy to understand each other and decide if it was safe or appropriate to communicate with someone. Another similarity was that participants employed comparable non-verbal behaviors such as spatial behavior, hand behavior, facial expressions, and body language no matter in social VR or offline. They often attributed this similarity to the immersive first person view and full body tracking that social VR afforded, which led to natural feelings of spatial awareness and similar social interaction experiences (e.g., pointing or gesturing with finger movements and facial behaviors to convey meaning/emotions).

However, our findings also highlight a major difference between non-verbal communication in social VR and in offline in terms of distinct social norms and expectations. While many previous studies found that non-verbal social interactions in virtual worlds and the offline world shared the same social norms [8, 23, 67, 71], social VR users seemed to follow different sets of norms and expectations. In particular, participants felt more comfortable and natural to employ non-verbal communication (e.g., dancing and fist bump) when approaching online strangers. This method may be perceived as odd, a potential harassment, or a violation of personal space in an offline interaction. Yet, social VR users considered it positive and more effective because it was a less invasive way to start an interaction.

This difference could potentially be due to an updated *proteus effect* [69, 70]. The original *proteus effect* refers to the phenomenon where people conform to their avatars and the mental makeup of said avatar. This representation of self may be a different social identity [61], one without limitations of the offline world, which leads to an unrestricted expression of self [11, 39]. Nevertheless, non-verbal communication in social VR seems to afford a different form of *proteus effect*: while communication is still carried through an avatar, it is actually realized by "mirroring" physical body movements due to full body tracking. On the one hand, the involvement of both the physical body and the avatar subjects interactions in social VR to limitations in the offline world, leading to a more natural and realistic feeling (e.g., natural and comfortable to use gestures and body language). On the other hand, it makes social VR interactions more flexible and less awkward than offline interactions (e.g., only using non-verbal behaviors to initiate interaction with strangers). In this sense, it appears to be easier and more socially accepted to exhibit actions non-verbally than in the offline world.

*Non-verbal Communication in Social VR vs. in Traditional Virtual Worlds.* In general, non-verbal communication in social VR can be felt more effective than in traditional virtual worlds. Existing literature has pointed out that immersive VR is more similar to the offline world than traditional virtual world. For example, Bailenson and colleagues have shown how people behaved identically in immersive virtual reality as they do in offline world in terms of head mimicry, gaze, interpersonal space, and spatial norms [3–5, 14]. Although these studies did not take place in a social VR environment, our findings confirm this work. Participants in our studies also attributed effectiveness of non-verbal communication to the familiarity to offline interactions in social VR. They especially noted that ability of full body tracking and embodied interaction in social VR led to more expressions of self and completely changed how people communicate with one another.

Another reason why participants perceived non-verbal communication in social VR as more effective may be the enhanced sense of embodiment. In VR, the sense of embodiment often refers to the three senses about one's virtual body – ownership, agency, and self-location [38, 47]. In social VR, all three senses seem to be further magnified.

First, a large body of work has demonstrated the influence of a virtual avatar on one's perception, behavior, and cognition [7, 37, 55, 69]. In social VR, one's sense of being physically immersed in the virtual environment is significantly enhanced due to the fact that avatar behavior in social VR can mirror the ways bodies are used in the offline world, leading to a higher awareness of body ownership. Second, the level of joint involvement and user connectedness is also enhanced due to the broad spectrum of natural communication modalities both verbal and non-verbal, which heightens one's agency of his/her virtual body. Finally, social VR avatars are the sole interface between the users and their avatars. This allows users to explore their own identities and the virtual environment in a more straightforward and immersive way, which creates a strong sense of self-location.

In summary, our studies suggest that as social VR affords similarities to the offline interactions, it produces more immersive representations of self, and increased feelings of connectedness, it is

more effective for conveying social meanings than traditional virtual worlds. In some ways, it can even afford more flexible and less awkward non-verbal behaviors than the offline world due to the updated *proteus effect*.

## 5.2 A Double-edged Sword for Marginalized Users

Though participants in Study 2 presented overall positive perceptions of non-verbal communication in social VR, our two studies have collectively highlighted how non-verbal communication can be a double-edged sword for social VR users, especially the marginalized (e.g., women, LGBTQ, users of color, and disabled users). This phenomenon highlights the need to further unpack the complicated role of non-verbal behaviors in online social interactions as well as the importance to design future technologies to better support marginalized users.

One of our key findings is that marginalized users employed non-verbal communication (e.g., muting themselves or using gestures/emojis/body language) to protect themselves from unwanted behaviors but still communicate in a comfortable and socially satisfying means while not speaking. They also used non-verbal behavior to combat communication limitations and potential biases due to the dominance of English in most social VR platforms (e.g., hiding accents or facilitating communication between English with non-English speakers). Innocent and colleagues described similar phenomena in online gaming: "English language dominated worlds...can privilege or emphasise certain points-of-view in that world becomes dominated by a conversation that is separate to itself and in some ways is at odds with nature of the simulation" [33].

However, our studies also demonstrate mixed social interaction consequences resulting from non-verbal communication in social VR. For example, the harassment of women and other marginalized users in social VR is emerging as a major issue [13]. While Study 2 identified non-verbal communication as a protection for marginalized social VR users, Study 1 highlighted how harassers could use aspects of offline non-verbal behaviors such as flirtatious glances, head cants, and general unwanted sexual advances [53] towards others. As offline non-verbal harassment is already difficult to define, it is even more challenging to identify non-verbal harassing behaviors in social VR due to the blurring boundaries between offline and virtuality. A potential harasser could attribute their inappropriate behavior to tracking errors, a bug or glitch in the system, or simply the victim's misinterpretation. This leaves much of the burden to discern unwanted behaviors and harassment to the social VR platforms, potential moderators, and the victim. More research, therefore, is needed for detecting and preventing non-verbal communication as harassment to design safer social VR spaces.

## 5.3 Design Implications for Supporting Non-verbal Communication in Social VR

Grounded on our findings, we identify three potential design implications to further support the nuanced non-verbal communication and marginalized users in social VR. It should be noted that these design implications are neither complete or exhaustive as they are mainly directions emerging in our participants' accounts. Our goal is to push the conversation in an open manner and inform future design directions and equitable social experiences in social VR. We acknowledge that these implications may not be within the business model of the current social VR industry or align with the future trends of VR technologies. Yet, we consider that they may benefit developers/designers who endeavor to design more inclusive VR technology in the future.

*Supporting Facial Track.* Full body tracking is a social VR feature users enjoy but participants in our research mentioned the need for a more complete tracking apparatus, one that includes facial tracking. Early work conducted by Bailenson et al. also supports the claim that highly realistic avatars with real-time facial form are critical to virtual environments [6]. Therefore, supporting facial tracking in social VR would allow for more complex facial expressions and emotional cues

such as remorse, curiosity, unbelief, and optimism. Our participants suggested that adding this feature would make their social VR experiences more realistic and help them better connect to others. However, some participants voiced a concern that this design may lead to potential privacy and security risks, including the protection of the stored facial data and the disclosure of too much personal biographic information.

*More Accurate Hand and Finger Tracking.* Another key area of a design would be the implementation of accurate hand and finger tracking. Realistic hand/finger representation is highly important in social interaction as subtle errors can change the interpretation of the action [36]. In our study, participants stated that more accurate hand and finger movements would support more delicate and subtle communication to express in-depth feelings or share more complicated information. Especially, it would greatly benefit deaf users by allowing them to use sign language. This improved feature, in conjunction with facial expressions, would become an extremely powerful communication method in social VR.

*Alternative Modes of Control.* Lastly, it appears to be necessary to enable alternative modes of control, especially for users with physical disabilities. As most of our participants highly praised full body tracking in social VR, disabled users in fact complained about this feature and demanded for alternatives. In order to design more accessible social VR platforms, it seems to be valuable to allow certain users to control their avatars without physically "mirroring" their bodies in the offline world. In this way, they still can take advantage of non-verbal behaviors in social VR to enhance their social interaction experiences.

#### 5.4 Limitations and Future Work

Regarding our findings and future work, we are not suggesting that the affordance of a broader spectrum of non-verbal communication is always beneficial, nor that non-verbal communication could take over verbal communication. Rather, we endeavor to highlight that for certain populations and under certain conditions, it can have extra benefits.

A few limitations of this study should also be noted. All interview participants were recruited from online forums or social media. There is a potential bias towards social VR users who maintain an active social media account. Another limitation is the lack of even distribution between participants and the platforms they use. While our participants reported their use of diverse social VR platforms, they mainly focused on mainstream commercial platforms including Rec Room, VR Chat, and AltspaceVR, future work should aim to recruit a broader participant pool with more diverse social VR platforms to capture a more comprehensive picture of social VR experiences. Additionally, with questions still remaining about harassment, accessibility, and marginalized communities in social VR, future work should investigate ways to create socially equitable social VR experiences.

## 6 CONCLUSIONS

Recently, commercial social VR applications have emerged as increasingly popular digital social spaces that afford more naturally embodied interaction. How do these novel systems shape the role of non-verbal communication in our online social lives? Our investigation has yielded three key findings. First, offline non-verbal communication modalities are being used in social VR and can simulate experiences that are similar to offline face-to-face interactions. Second, non-verbal communication in social VR is perceived overall positive. Third, non-verbal interactions affect social interaction consequences in social VR by providing privacy control, social comfort, and protection for marginalized users.

From these findings, we suggest that the uniqueness of non-verbal communication in social VR lies in 1) its effectiveness for conveying meanings than traditional virtual worlds and 2) its flexibility and less awkwardness than the offline world due to the updated *proteus effect*. We also highlight

the need to further unpack the complexity of non-verbal behaviors in online social interactions especially for marginalized users and identify three design implications to better support non-verbal communication in social VR: supporting facial tracking, more precise hand and finger tracking, and alternative modes of embodied control for those who are disabled.

We believe that our focus on non-verbal communication contributes towards addressing the two limitations in prior literature, namely, the main focus on a certain virtual worlds and a lab setting as well as only supporting avatar-mediated communication via a 2D screen. As scholarship in modern day social VR is in its infancy [13, 35, 44, 50, 72], we hope that these insights and findings point to potential directions for designing more satisfactory and equitably social VR platforms, which are actively redefining our digital social lives today.

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