Social Interaction in VR

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Summary

Social interaction is one of the most popular use cases of virtual reality (VR). Virtual worlds accessed through VR headsets can immerse people in diverse places and present its users however they wish to be represented. The affordances of this technology allow people to connect with themselves, others, and their surroundings in unique ways. Research has shown that social norms found in the physical world transfer over to virtual worlds. People respond to virtual people in a manner similar to how they would treat people in the physical world. Although virtual worlds and the physical world share similarities, they have many differences. Virtual reality is not—and does not necessarily need to be—a veridical representation of the physical world. Virtual reality has the ability to transform everything, such as what people look like, how they behave, where they are, and how they see things. Cues related to people, such as their visual appearance and nonverbal behavior, or place, such as the surrounding environment and perspective, can be augmented, filtered, or suppressed. These transformations also lead to significant psychological and behavioral effects, affecting how people build trust, engage with others, or communicate nonverbally. Whereas some of these transformations may be unintentional, such as technological by-products, other transformations can be intentional. As a result, it is critical to understand how social interactions occur differently in these transformed environments.

Keywords: virtual reality, social interaction, social VR, avatars, virtual environments

Subjects: Communication and Technology

Introduction

Social interaction is at the heart of the human experience. People are constantly interacting with one another verbally and nonverbally, and these interactions can shape who they are on both a low and high level. Researchers have spent decades, if not centuries, studying such interactions and how they influence people as individuals, pairs, groups, and societies. Some of the most foundational theories in understanding people come from how they exist as social beings, as evidenced by the field of social psychology, a domain dedicated to unearthing how people are influenced by and interact with other people.

With the development of technology, new mediums have provided unique ways for social interactions to take place. One such medium is virtual reality (VR), a powerful tool that can transport people to different places, change how people feel about themselves and their connection with others, and enhance the way people feel during an experience. How people experience virtual worlds through VR is very different from how people experience the physical world.

Social VR, or the "metaverse," is one of the most popular applications in VR that allows users to interact with and meet one another in virtual spaces. Given the unique and powerful affordances that VR provides, such as spatiality and presence, using VR to connect others and foster relationships makes it a great use case. The act of being with one another and taking part in verbal and nonverbal communication supports intimacy and builds trust (Lombard & Ditton, 1997). Furthermore, social interactive entities are critical, as a lack thereof can lead people to feel greater loneliness in a virtual world (Liszio et al., 2017). Given these properties, researchers within the field have posited that the greatest potential of VR lies in its social power to bring people together (Lanier & Biocca, 1992).

Many of the available commercial platforms in VR, such as VRChat, Horizon, and ENGAGE, are dedicated to serve a social purpose and have been specifically designed to shape social interaction (McVeigh-Schultz et al., 2019). In these platforms, users, represented by digital beings known as avatars, can interact with one another, play games, travel to different worlds, and build together. While social interactions can and have existed in various forms across mediums, including face-to-face communication, text-based applications, and video conferencing platforms, VR creates a novel landscape in which unique properties are introduced that transform these interactions. Consequently, it is critical to understand how these social interactions take place and are shaped by the medium. This is especially true and urgent given the rise of the metaverse and its predicted prevalence in society in the coming years.

The goal of this article is to understand what research reveals about social interactions in VR. The first section covers a more general scope of research in this domain. How do people behave in networked virtual environments? Do people treat each other the same way as they would in the physical world? The second and third sections narrow the focus more specifically on research that addresses one of two aspects of the social experience: people and place. How does transforming these two factors influence people's perceptions and behaviors and ultimately how people interact with others? How do changes to the visual appearance and behaviors of the self and others shape interactions? How should "place" be understood differently, given that every space and perspective can be rendered uniquely for each interactant? The final section discusses what the limitations are and the avenues for future research.

Early Research on Social Interactions in VR

To understand social VR, one can turn to research conducted in immersive virtual environments or collaborative virtual environments. These virtual environments are typically accessed through head-mounted displays (HMDs), which are headsets equipped with external or internal sensors. When a user wears an HMD, these sensors track their body and location in three-dimensional (3D) space and use this information to map them onto a virtual scene. When a user moves around in the physical world, so will their avatar.The virtual scene is updated and redrawn several times per second to create a nearly seamless experience. Most HMDs provide 6 degrees of freedom, meaning that any rotations around the forward-and-backward axis, side-to-side axis, and vertical axis (i.e., roll, pitch, and yaw) are tracked and rendered in the virtual scene. The technological capacity to generate realistic experiences and immerse users into these virtual worlds allows for *presence*, the subjective experience of being present in the mediated environment.

Moreover, such computer-generated simulations of environments allow multiple people to meet and interact in 3D space and have become increasingly popular for social interaction. Researchers and practitioners have spent the past few decades exploring how the ways in which people and the environment are represented in VR shape social experiences. Does being in a virtual environment transform how people perceive and behave? Do people act in unrecognizable ways, or are social norms retained?

Consider an earlier study conducted by Bailenson et al. (2001). These researchers set out to see if people would respond to a virtual agent (i.e., a virtual being controlled by a computer) in a manner similar to how they would treat people in the physical world. In their study, participants were immersed in a virtual environment along with a cylinder or an agent with varying levels of gaze realism (e.g., closed eyes, blinking, and blinking with head-turning). Participants were instructed to walk around the cylinder or agent and remember features of their front and back. A tracking system kept a record of the participants' position and orientation in the virtual environment. The authors found that, in these scenarios, virtual social cues *are* important: participants avoided direct contact with the agent and gave them personal space. In particular, they respected these social norms more for the humanoid representation with realistic behaviors than for the cylinder or agents with less realistic gaze behaviors. This finding suggests that people don't treat virtual others as though they are nonsocial beings—social norms and cues still persist as long as the other person can show social cues.

Other researchers report similar results. Hoyt et al. (2003), for instance, replicated classic social psychology experiments in VR and found that people performed worse in tasks when an avatar was observing them, suggesting that the presence of other virtual beings can influence behavior. Another example is a study by Garau et al. (2003), which shows that aligning visual and behavioral realism of avatars is critical in improving the quality of communication. Finally, another study by Garau et al. (2005) found that people respond more socially to visually responsive agents, suggesting that people can respond to agents as social actors even in the absence of verbal interaction. These studies highlight that virtual beings are not merely an animation. Even in a virtual world with virtual beings, people socially behave the way they would in the physical world.

Since these studies have been conducted, technology has improved exponentially—VR headsets are able to update scenes with incredibly high refresh rates (for a review of HMD performances, see Angelov et al., 2020), render more behaviorally veridical features like mood and expression (e.g., Thies et al., 2018), and incorporate other features beyond visual or aural that may enhance the virtual experience (e.g., olfactory cues, Li & Bailenson, 2017; taste, Karunanayaka et al., 2018; and tactile feedback, Gallace & Girondini, 2022). Within the social interaction space, researchers have continually worked toward understanding how social interactions take place in virtual environments and discovered other critical components (for a guide on how to use VR to study social interaction, see Pan & Hamilton, 2018).

Beyond simply tracking and rendering verbal, nonverbal, and other cues as they are performed, VR systems can also transform them. Virtual reality can change appearances, environments, perspectives, and other aspects of the virtual experience. Because the virtual environment must be rendered individually for each user, it can be rendered differently for each interactant. In other words, not everything that is rendered needs to be veridical or presented in the same way for all interactants. Virtual reality systems can intentionally augment, filter, or suppress cues to reshape interactions to play out in certain ways. This is the central argument of the transformed social interaction framework (Bailenson et al., 2004), which posits that the physical appearance and behavioral actions of avatars can be edited idiosyncratically for all interactants, ultimately impacting and shaping the types of interactions that arise. The framework lays out three dimensions that a virtual system can transform: sensory abilities to complement human perceptual abilities, situational context to change the spatial or temporal structure of a conversation, and self-representation to strategically decouple the actual and rendered appearance and behaviors (Bailenson et al., 2004).

Such studies and frameworks suggest that social norms and cues persist in VR and that users are sensitive to visual and behavioral cues. However, these cues can be transformed either unintentionally, as a by-product of imperfect technological systems, or intentionally, by developers and designers, to shape how people interact. The coming sections delve deeper into two aspects fundamental to social interactions: people and place.

People

How Are People Represented in VR?

Avatars are visual representations of users in a virtual environment. Avatars serve two primary purposes: (1) avatars allow users to feel embodied in the virtual environment, meaning that a person psychologically experiences the virtual body as their own, and (2) avatars provide a visual communication partner. Avatars play a critical role for both an individual and their communication partner, as they can impact cognitive performance (Steed et al., 2016), trust formation (Pan & Steed, 2017), prosocial behaviors (Herrera & Bailenson, 2021), and more. Avatars are particularly important in social VR, as it is through their aesthetics, movements, voice, and behaviors that people are able to make sense of others.

Across various social VR platforms, avatars vary in terms of how they look (e.g., highly photographically realistic or cartoon-like), how complete they are (e.g., has or does not have a face, torso, legs, and arms), and how they can move (e.g., can smoothly move around or teleport into specified regions). The study by Kolesnichenko et al. (2019) revealed that avatar design practices differed across social VR platforms and that these differences, subtle and large, had a significant impact on how people interact with one another and form social relationships. In their study, the authors interviewed designers, engineers, and developers of six popular social VR platforms, such as Rec Room, High Fidelity, and VRChat. Through these interviews, they set out to understand how design decisions of avatars and their mechanics shaped user experience and social experiences. These design decisions included factors such as how users could move around in a space, how users could build their avatars, and how avatars could express emotions. For example, the authors note how designers had to carefully consider the teleporting mechanism, as features such as how much distance could be travelled through teleportation allow users to engage in behaviors such as violating people's proximity zones or running away from moderators (i.e., people who ensure the comfort and safety of users in a public space) who are trying to ban them.

Another example comes from how platforms determine avatar appearance. Kolesnichenko et al. (2019) reported that, for some platforms, the decision was driven by performance constraints. Avatars' visual fidelity, aesthetic, and art style were constrained by device interoperability. For other platforms, the decision was based on protecting users from harassment. In these platforms, avatars were intentionally designed to appear more neutral and approachable and not take on hyper-sexualized appearances. Furthermore, platforms varied in how much freedom and options users have in creating their avatars. Platforms such as VRChat gave users the freedom to experiment with their avatars by allowing them to upload their own built avatars. Other platforms, such as Anyland, encouraged users to explore the self and made the avatar-building process more creative by having them begin as empty skeletons and having a body shop that allowed users to visit and share others' handmade avatars.

Beyond avatar aesthetics, how users could express their emotions and intentions through nonverbal means varied across platforms. As a result of these design decisions, new social norms unique to each respective platform would arise. In Rec Room, for example, avatars could select a nonverbal expression emoji, such as "sad," "smile," or "love," and these options would change depending on the social context or environment (e.g., "forward," "enemy," or "watch out" during a quest). Likewise, in VRChat, users would pat each other's avatar's head as a gesture of appreciation or hug. The work of Kolesnichenko et al. (2019) sheds light on how design decisions of avatars and their mechanics are tied to users' social experience. On a broader scale, this work highlights the significance of identity and appearance of both the self and others.

Why Does Appearance in VR Matter?

Visual appearance in virtual worlds is important because not every aspect of the physical self can be represented accurately or to the fullest extent. Details of the physical self are lost or represented in simple ways (e.g., body types, age, nonbinary genders). As a result, what details do remain become salient. In particular, sociodemographic information such as ethnicity or gender is made more obvious in avatars, eliciting certain behaviors and beliefs about the communication partner (Peña et al., 2021). Previous research in the computer-mediated communication and human–computer interaction domains has shown that having limited cues may cause individuals to focus more on the differences among group members, which in turn interferes with how they bond with others (Lee & Nass, 2002; Wallace & Maryott, 2009; for relevant theories, see the social identity model of deindividuation effects [Lea & Spears, 1991] or the optimal distinctiveness theory [Brewer, 1991]).

From these inferred social beliefs rise phenomena such as ostracism—the social experience of being ignored or excluded. Kassner et al. (2012) used VR to study the negative effects of social ostracism. The authors recreated Cyberball, a game in which a group of people toss a ball to one another. In this game, players can be either included (i.e., receive a somewhat equal amount of ball tosses) or ostracized (i.e., receive no ball tosses). While in VR, participants played with two agents and were either included or ostracized by the agents. The results showed that experiencing ostracism in VR had a negative impact on the participant's mood and threatened their four basic fundamental human needs: the need to belong, the need for control, self-esteem, and meaningful existence. Furthermore, the authors reported that these negative effects in VR were quite powerful—more so than they were in face-to-face interactions. The authors raise the concern that those who are chronically ostracized in the physical world can develop severe physical and psychological problems if they also experience ostracism in virtual spaces. This is especially relevant for social VR, as these platforms provide spaces and interactions that are meaningful for many and allow them to live mundane everyday experiences (e.g., sleeping) in new, social ways (Maloney & Freeman, 2020).

Transforming What People Look Like

In virtual worlds, people can take on completely different appearances. These transformations can be drastic, such as turning people into animals (Ahn et al., 2016), or subtle, such as adding an extra finger onto people's hands (Hoyet et al., 2016). There are a myriad of studies that have investigated how differences in visual appearance influence the self, others, and interactions (for a review, see Weidner et al., 2023).

Typically, people are able to customize their avatars in social VR platforms. However, as reported by the interviews by Kolesnichenko et al. (2019), some platforms prioritize performance over aesthetics, resulting in developers reducing the number of polygons rendered in avatars. This reduction of detail suggests that people's differences may not be captured in their final appearances. However, the few features that *are* rendered become highlighted and may act as cues for common social categories, and intensify the group identification process (Kim & Park, 2011) or work against group identification by causing a need for uniqueness (Kim, 2009).

Consider the study by Han et al. (2023), who investigated how sharing visual similarity with group members influenced people's nonverbal behavior and attitudes. In their study, participants met in medium-sized groups for 8 weeks wearing either customized self-avatars (i.e., avatars that looked like themselves) or uniform avatars (i.e., avatars that looked like everyone else in the group). These uniform avatars were designed to be as gender- and race-neutral as possible. These groups met in a social VR platform called ENGAGE, and along with an instructor, they participated in discussions and various activities. The results showed that when participants were in a uniform avatar, they had lower motion synchrony (i.e., similarities in moment-to-moment nonverbal behaviors between participants), reported feeling lower presence in their body, and perceived the virtual environment and others as being more cartoon-like. However, having a uniform avatar resulted in greater enjoyment. Based on these results, the authors suggest that, depending on the context of an interaction, visual appearance can be manipulated to serve specific purposes. If the goal of the social interaction is to unify people and foster group cohesion, using uniform avatars may not make sense, as it lowers motion synchrony. Oppositely, if the goal of the social interaction is to allow people to enjoy their virtual experience, having uniform avatars may allow people to focus less on their individual role in a group setting and more on enjoying the task at hand.

In the study by Han et al. (2023), participants were transformed to take on a uniform avatar. This uniform avatar was quite simplistic in that it was bald, gray in skin color, and ambiguous in gender. However, the chances of running into such an avatar and feeling a sense of connection with it may be rare. Instead, what if the others looked like *you*?

A study by Shih et al. (2023) addresses this question. The authors were motivated by the similarity–attraction effect (Byrne, 1972), which posits that people tend to be more influenced by those who look like them, compared with those who do not look like them. In their study, participants created an avatar based on their physical appearance. Then they were tasked to do a modified version of the Desert Survival Problem, which is a game in which a participant decides what items are the most important in surviving the aftermath of a plane crash. Then, in a social VR platform, Horizon Workrooms, the participants discussed their choice with a confederate, who asked if the participant wanted to change their choice. During the discussion, the confederate's avatar was identical, moderately similar, or dissimilar to the participant's avatar. This process of item selection and discussion was repeated two times, such that each participant underwent all three avatar conditions. The authors measured the persuasiveness of the confederate, operationalized by the number of item pairs that the participants changed. The results showed that there was an effect of similarity on persuasiveness—participants changed their choice most often when interacting with an avatar that looked moderately similar to themselves, compared with when they interacted with an identical or dissimilar avatar. The authors discuss how this may be due to participants feeling intimate with similar avatars, whereas identical avatars may have obstructed their sense of agency and caused confusion.

That study shows the potential of transforming avatars such that they are somewhat similar to, but not identical to or completely different from, a given user. There are, however, questions and implications that arise from this form of transformation: what happens if multiple people in a social scene look moderately similar? What are the implications of transforming other users in this way, such that unique identifiers and qualities (e.g., skin color, weight, age, and gender) are suppressed? Several scholars have addressed the effects and potential harms of embodying avatars that don't accurately represent the user's physical appearance. The study by DeVeaux et al. (2023), for example, investigates how discrepancies between the avatar self and physical self influence avatar embodiment in social VR applications like VRChat and Rec Room. Participants were instructed to create an avatar that they would feel comfortable using as their main avatar for a prolonged period of time around other people. Once their avatars were designed, they engaged in various activities in VR to have the experience of embodying their avatar. Afterward, participants were asked questions about their experience embodying their avatars and how discrepant its appearance was from their physical one. Results showed that there was a negative association between attribute discrepancy and embodiment. In other words, the more different their avatars looked from their physical self, the less embodied the participants felt. As the authors point out, there are critical implications for this, given that platforms often have limited options for users of certain races. They also state that Asian participants, in particular, reported a greater difference in their avatar skin tone and actual skin tone, and suggest that factors such as degrees of skin tone may contribute to sense of embodiment. That work highlights how avatars can have a significant impact on users' experience and suggests that this effect will result from a lack of equitable customization options.

How Are Behaviors in VR Represented?

Behavioral realism refers to how naturalistic and similar an avatar's behaviors are to those found in the physical world. Consider a scenario in which, during a conversation, the other person does not open or move their mouth when responding, shift their body back and forth, or even blink every few seconds. While this scenario may be awkward or even physically impossible in the physical world, it can be quite normal in virtual worlds given that headsets do not pick up and render all nonverbal behaviors that are performed. The behavioral realism of virtual beings, such as how fast they move, where they are looking, and how they move their head, has been shown to be a critical component in people's experiences in VR (Randhavane et al., 2017).

For example, Aburumman et al. (2022) investigated the importance of head nodding. Head nodding, much like interpersonal distance and gaze, plays a role in social interactions, as it signals turn-taking and interest to a communication partner (Argyle, 1972). In their study, participants interacted with two different agents: one who had naturalistic nodding and one who did not. In the first portion of the experiment, participants went through multiple blocks in which they listened to the agent speak or engaged in a dialogue with them. This allowed the participants to familiarize themselves with the two agents and their behaviors. Following this, the participants played a game in which they had to escape a maze. Throughout the maze, there were points at which the participants could approach one of the agents and get advice on how to complete the maze. The authors used the number of times a participant approached each agent to measure trust and liking. People went toward the nodding agent more often, suggesting that they are perceived as more trustworthy and approachable.

Beyond providing cues that are critical for trust and engagement, behavioral realism is critical during the nonverbal communication process. Herrera et al. (2018) found that if an avatar's body parts did not reflect the physical body's movements, people moved these body parts less thanthe people who embodied static avatars. Such static avatars hindered people's actual physical behavior and their ability to communicate nonverbally. These studies underscore that, in addition to the visual realism and aesthetic of what avatars look like, the behavioral realism of the self's and others' avatars is important during social interactions.

Furthermore, such nonverbal cues may help us make inferences. Patotskya et al. (2023) explored how people avoid others in virtual environments based on movement patterns that exhibit certain personality traits. Their research stemmed from the finding that personality traits are characterized by body movements, such as neuroticism with rapid movement and indirect gaze, and emotional stability with calm and controlled gestures (Neff et al., 2011). In their study, participants walked through a metro and had to choose to exit using one of two doors.

Obstructing each door was either a neurotic or an emotionally stable agent that the participants had to pass in order to exit. Across multiple trials, participants went through nine possible scenarios. In some conditions, the metro was empty and without agents in order to extract information about obstruction-free walking trajectory; in some conditions, the participants were to exit through an agent-obstructed door because it was the only one open; in some conditions, the participants could choose which agent-obstructed door to exit from. This yielded nine possible combinations of conditions. Results indicated that participants more readily chose to exit through the door blocked by the emotionally stable character. Participants also left more space between themselves and the neurotic agent when exiting. These findings suggest that people rely on other virtual interactants' nonverbal cues to make sense of them and use them to inform decisions.

Transforming How People Behave

In virtual worlds, much like appearance, people's *behaviors* can be transformed such that they are suppressed (i.e., not rendered at all), made more convincing (i.e., behaviorally realistic), or augmented (i.e., new, unperformed behaviors are incorporated).

For example, in a study by Herrera et al. (2018), the authors manipulated the behavioral realism of nonverbal behavior. They examined how the behavioral realism of hand movement affected dyadic interactions between two strangers in a virtual environment. Here, behavioral realism was operationalized by the ability to move one's physical hands and have the movement mapped onto the virtual hands. Dyads were in a full-bodied avatar with no hand tracking, in a full-bodied avatar with head and hand tracking, or in a floating head with hand tracking. Together, the pair played a game of 20 Questions to guess a given word. The results showed that people who were able to control their virtual hands using their physical hands rotated their head and hands more than those who could not. There were no significant differences in outcomes such as interpersonal attraction, social presence, or self presence between avatars that had no behavioral realism and avatars that had behavioral realism. However, when avatars that had low levels of behavioral realism were compared with avatars that had high levels of behavioral realism, higher behavioral realism led to greater feelings of interpersonal attraction and self-presence. The authors concluded that being represented by an avatar that limits people's nonverbal abilities in the virtual world leads to reduced nonverbal behavior in the physical world.

Across social VR platforms, how people are presented, as well as how much control people have over what is presented, varies. Unique behavioral traits that color interactions, such as tics, expressions of emotions, or expressions of personality, may be suppressed, influencing both virtual and physical world behaviors. Fortunately in VR, it is possible to insert behaviors to make up for what may be lost (e.g., Roth et al., 2018c, were able to inject artificial mimicry to induce mimicry). As a result, beyond transforming one's ability to exhibit certain behaviors, VR systems can transform behaviors that were *not* exhibited. In other words, VR systems can manipulate a scene to show behaviors that were not actually present. For example, in another study, Roth and colleagues argue that virtual beings' behaviors can vary in the degree to which they are replicated and expressed and that "a lack of variation and contingency in displayed behavior, or distortions in its dynamics, will be interpreted as a meaningful signal, no matter whether intentional or not" (Roth et al., 2018b, p. 103). They posit that technological systems can monitor and repair inadequate nonverbal behaviors, such as lack of eye contact, and synthesize more appropriate ones. In their study, four types of gaze—natural gaze, hybrid gaze (a combination of natural and social gaze), synthesized gaze (a combination of random and social gaze), and purely random gaze—and their effects during dyadic interactions were compared. The results showed that, compared to random gaze, the natural gaze led to greater rapport scores, interpersonal attraction, and perceived behavioral naturalness. Furthermore, natural gaze was deterred by artificial manipulation, whereas random gaze benefitted when manipulated to incorporate social gaze behavior. Given that gaze can be captured and exhibited in various ways inside social VR, how behaviorally natural or convincing it is can affect social outcomes.

Places

What Does "Place" in VR Look Like?

In VR, people exist and can move around in a 3D virtual environment. Virtual reality can transport people to anywhere in (and out) of the world. With a few clicks of a button, people can find themselves underwater or on the surface of Mars. However, beyond the environment and its configuration, there are other creative ways to transform how people exist in virtual worlds. Whereas some changes can be straightforward ones to the design of the space, other changes can be more creative, such as changing perspectives and having different interactants see either the same or different angles of the same scenario.

Why Does the Environment in VR Matter?

In 2019, McVeigh-Schultz and colleagues interviewed industry experts on how commercial social VR platforms were designed. From these interviews, the authors unveiled that the aesthetics and architecture of the virtual environment are intentionally designed to stimulate social activities and shape social expectations. For example, the designers of Facebook Spaces made tables circular to allow people to have similar eyelines during a conversation. Another example is AltspaceVR's use of the campfire to create a place where people could come together and share stories. These campfires were accompanied by items that allowed for activities like roasting marshmallows or grilling burgers that served as social catalysts. The authors note the critical role of *place* in social interactions and how environmental factors can shape expectations, behaviors, and cultures.

The virtual environment has been shown to have transformative effects: it can influence walking behavior (Kim et al., 2022), group formation (Williamson et al., 2021), physiological arousal (Browning et al., 2020), and more. As the work of McVeigh-Schultz et al. (2019) reveals, place matters, and it has the power to shape how people interact with one another.

Transforming Between Places (What People See)

First, consider the design of a virtual environment. Miller et al. (2021) investigated how the contextual environment influences team dynamics during the design process. They chose to examine two places: a conference room and a garage. Both environments were places where design occurs in the physical world and differed in terms of formality and signaled tolerance for failure. In their study, triads met inside a social VR platform called High Fidelity. Together, the participants engaged in various tasks such as decision-making and concept-generation. Results showed that triads were more in synchrony during sessions that took place in conference rooms. The authors speculate that this may have been due to the height of the ceiling, which may have encouraged a reduction of risk. They conclude that virtual environments in which collaboration occurs should be selected mindfully, as they can inform or constrain activities.

A study by Han et al. (2023) found similar results. In their study, groups of participants were placed in 192 different virtual environments that varied in visible space and setting. These environments were either constrained or panoramic (i.e., people could see wide and far) and indoors or outdoors (i.e., surrounded by nature). Across 8 weeks, groups met inside one of these environments to take part in discussions and activities. Results showed that the beneficial effects of being in large environments and nature translated in VR: being in a spacious, panoramic environment led to increase in motion synchrony, reports of greater perceived restorativeness, entitativity, pleasure, arousal, self and spatial presence, enjoyment, and realism. In spacious environments, people may have the freedom to look around and allow their mind to wander. Meanwhile, a constrained environment may have led to feelings of confinement and acted as a stressor, influencing social interactions in a negative way. Furthermore, being in outdoor environments surrounded by nature led to greater perceived restorativeness and enjoyment. The authors suggest that this could be due to the novelty of the environmental context in which the group interaction took place. Given that many social interactions often occur in indoor environments, such as classrooms, conference rooms, and common spaces, this opportunity to meet with others in between boulders, near ponds, or surrounded by a forest may have provided an experience that is not common or easily accessible, leading to novelty and, in turn, greater enjoyment.

These two studies suggest that the environment can be transformed to account for what kind of tasks are being performed to promote specific outcomes. In VR, space is free. Environments can be easily designed without much cost or time, such that they are infinitely tall, wide, bright, dark, decorated, textured, and more.

Transforming Within Places (How People See)

Second, consider the perspective. Wang et al. (2023), for example, explored how an asynchronous situation could be transformed to ease the assimilation of individuals into a virtual scene. In their exploratory study, they took VR recordings of people interacting in a small group and manipulated the gaze and proxemic patterns. These manipulations would be tailored to a *belated guest*—a person entering a VR meeting after it has happened and be able to rewatch the scene.

Except, the scene would be reconfigured to allow the guest to be part of the social scene, as the gaze and proxemics would be transformed for this belated guest. Here, each person entering the virtual environment had a tailored perspective, such that the gaze and proxemics were not representing the scene as it happened but were transformed to fit this new belated guest.

Such are the strengths of VR: even within the same, shared space, *how* a person is seeing the experience can be transformed. For example, VR allows us to simultaneously share the same perspectives, together. In other words, people can see the same exact object or scenario from the same exact angle. In the physical world or in other technological mediums, this is difficult—or even impossible, as this would require people to overlap and be on top of one another in the same spot. In VR, however, users can be in the same place simultaneously.

Hoppe et al. (2021) developed a technique in which they were able to socially redirect people such that they were in the same location and able to share perspectives while still preserving the face-to-face arrangement. The authors conducted a user study to evaluate the effectiveness of this transformation and had dyads perform a collaborative task solving cube puzzles. The results showed that this technique yielded greater social presence and feelings of teamwork compared to a system in which participants shared the same location but had overlapping avatars. Such transformations of perspectives can enhance collaboration and social interaction without the awkwardness of overlapping bodies or violation of physical space.

In a similar vein, Hasenbein et al. (2022) transformed perspectives within a learning context. In their virtual classroom, the seating position of a student was manipulated such that they were either sitting in the front of the class close to the instructor and the lesson screen, or in the back of the class with many rows of classmates in between themselves and the instructor and the lesson screen. The authors used eye-tracking to show changes in attention and found that different seating configurations led to different focus-of-gaze transitions on their virtual classmates, teachers, and the lesson content as well as different gaze distributions. The results showed that students sitting in the front were more focused on the instructor and lesson screen, whereas those sat in the back were more focused on their classmates. Moreover, gaze was more uniformly distributed across the lesson screen and classmates for students sitting in the back. The findings here highlight that differences in perspective (i.e., front versus back of the virtual classroom) lead to different outcomes. From an educational standpoint, instructors can transform *where* students are sitting to create different dynamics in their classroom. As demonstrated by the system of Hoppe et al. (2021), it is fairly easy to modify people's perspectives such that multiple people are experiencing something from the same angle. In a classroom, all students could simultaneously experience sitting in the front or the back.

Future Directions and Conclusion

Research, conducted either in or out of the laboratory, has shown that social interactions in VR are shaped by, and can be transformed by, multiple different factors. What the self and others look like, and where people are, matters. Furthermore, these transformations can be done in various ways and scales, from glaringly obvious modifications to make others look identical to you, to subtle changes that inject more eye contact in an interaction. These transformations can be simple, such as transporting you to a room with taller ceilings and more space, or they can be complex, such as modifying perspectives such that the virtual experience is uniquely tailored to each and everyone.

Such transformations can be powerful and impact perceptions, attitudes, and behaviors and ultimately shape the type of social interaction that takes place. However, there is always room for more research in this domain. Up until now, the focus has been on dyadic, triadic, or small- to medium-sized group interactions. Han et al. (2022) note that this is a limitation for past studies that investigate group interactions. Although small groups are equally important in understanding social interactions, when groups of more than two convene, head and body orientations become unique nonverbal signals to communicate attention and other nonverbal cues (Bailenson et al., 2002; Roth et al., 2018a). Especially given that most commercial social VR platforms have groups larger than two, in order to understand how psychological processes and behaviors change when interacting in a virtual environment with multiple virtual beings, it is important to examine how transformations affect people on a larger scale. In the same vein, given the rising popularity of platforms that incorporate artificial intelligence into their interface, it is also worth investigating how responsive, interactive agents may inject themselves into the social scene. Consider an environment with avatars and naturalistic, convincing agents. How will these agents shape social interactions in positive and negative ways? How will these interactions transform as groups become larger and both avatars and agents intermingle in the same space?

Furthermore, change over time is another feature to highlight. Very few studies in the past have been able to look at change over time (e.g., Bailenson & Yee, 2006; Han et al., 2023; Khojasteh & Won, 2021; Moustafa & Steed, 2018). Given that these social spaces are not solely used for one-off interactions but are spaces where long-term relationships can develop, more research is needed to understand how people's perceptions and behaviors transform over time. In the same vein, more research is needed to understand individual differences in comfort and expertise with VR. In the near future, most people will probably not be first-time VR users. How do the experiences of savvy users differ from those of novice users?

There are other features unique to VR that are worth exploring. Specific types of communities, practices, and norms have been formed and shaped by design artifacts in VR. For example, consider what Zheng et al. (2023) describe as *immersive dwellers* or *mirror dwellers*. These are individuals who wear avatars (oftentimes ones that are expensive) and spend hours staring at themselves in front of mirrors in public spaces and attract attention. Such behaviors are most likely a result of being able to embody avatars that can take on various appearances. Being able to look like and control a body that looks different from your physical self is not something that people can do every day. The ability to do so is a unique affordance of VR and one that might lead to new social behaviors such as mirror dwelling. What other social norms and interactions are shaped, either intentionally or unintentionally, by the affordances of VR?

Lastly, there is the seemingly similar but quite different domain of augmented and mixed reality (AR and MR, respectively) which demands further attention (Bailenson et al., 2024). Such new forms of technology are also VRs, though how they are accessed (e.g., through an AR headset) and how they are presented in tandem with the physical world are different. The biggest difference is that these other forms of realities integrate or superimpose digital content with the physical environment. Within these contexts, how "people" and "place" are defined, understood, and transformed differ, as new additional layers of the virtual and physical are introduced. For instance, whereas in VR the whole world can be within the developer's control, as whatever is seen by the user is entirely virtual, in AR and MR systems, there are aspects of the visible physical world that are out of the developer's control. For example, consider a scenario in which one interactant is sitting in a dim room and the other in a brightly lit room. The AR system adapts accordingly and renders the virtual object and avatar to match the shading, shadows, and colors. Or consider a scenario in which one room is cluttered with mess, and another room is squeaky clean. In both scenarios, both interactants see versions of their communication partner's avatars that make sense in their respective physical environments. However, both interactants would be seeing two different versions of the same interaction because of the influence of the physical world. This may lead to discrepancies in how each user perceives and experiences the virtual content. In a social context, such discrepancies in information may impair trust, engagement, and other fundamental factors. This opens up a whole other Pandora's box of questions: how are interactions transformed if one person is in a dark room and the other is in a bright room? What if one person is in a colorless room and the other is in a colorful room? Such questions don't have straightforward answers, as they are challenging or impossible to test in the physical world without the help of AR or MR.

Other questions arise: what will social interactions look like when people see other virtual beings standing in their bedroom? Or what will social interactions look like when people interact with family or friends who have been filtered to look a different way? Although many researchers have investigated these topics (i.e., see work by Miller et al., 2019, on how people perform, behave, and socially connect with AR agents in a physical context; similarly, see work by Rivu et al., 2020, on how communication can be assisted using gaze information in AR; lastly, see work by Pescott, 2020, on how Snapchat AR filters influence the ways in which children form their identities and perceive others), there remain more questions to be answered on how such technologies will shape the ways in which people interact with one another, in both virtual and physical worlds.

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