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# The impact of realistic avatars on self-other perception in virtual environments

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## Abstract

*This study aims to investigate how swapping realistic avatars between users in shared VR spaces affects self-body ownership and changes perceptions of others. In the experiment, two participants shared the same VR space. Two conditions were presented in random order: one where participants used their own realistic avatar (matched condition) and one where participants swapped avatars and used the other's realistic avatar (swapped condition). During the task, participants were instructed to perform specific physical movements while alternating between observing their own body and the other's. After completing the experimental tasks, participants answered 16 questions on a Likert scale (7-point), addressing items related to immersion in the VR environment, self-body perception, and perception of others. The results showed significantly higher ratings for presence, body ownership, and body awareness in the matched condition. On the other hand, when another person used the participant's realistic avatar, it led to increased distrust and negatively impacted communication. Additionally, several participants commented that they felt more balanced using their own realistic avatar. This suggests that avatar appearance, particularly differences in visual body proportions, may influence somatic perception and the sense of agency.*

## Introduction

With the rapid advancement of 3D scanning technology and AI-based image processing, it has become feasible to generate avatars that accurately replicate an individual's physical appearance for use in virtual reality (VR) environments. These "realistic avatars" have been reported to enhance users' sense of body ownership and presence. In VR, the sense of agency and the sense of body ownership are considered critical components of users' self-body recognition. Numerous studies suggest that the level of realism in an avatar significantly influences these sensations, suggesting that the ability to accurately reproduce a user's appearance may play a key role in advancing VR applications.

Recent years have also witnessed the evolution of VR into a shared platform, enabling communication and collaboration among multiple users in the same virtual space—commonly referred to as social VR networks. In these environments, the appearance of other users' avatars is believed to have a significant impact on how those users are perceived by others.

Against this background, the present study aims to investigate how swapping realistic avatars between users in shared VR spaces affects self-body ownership and alters perceptions of others. Through experimental exploration, we examine the extent to which the embodiment of one's own appearance by another influences interpersonal perception and self-perception. Specifically, the study not only investigates the effects of using an avatar that physically resembles oneself but also considers how impressions of others shift when they adopt an avatar that resembles the user. The findings are expected to inform the development of avatar representation methods in social VR networks and to highlight key factors that can facilitate more effective communication within these virtual environments.

## Background

In recent years, the rapid development of virtual reality (VR) technologies has made it possible for multiple users to occupy the same virtual environment, interacting with one another in real time through avatars. Commonly referred to as "social VR," this phenomenon has found applications in diverse fields including entertainment, education, business, and healthcare, where users can attend virtual events, collaborate on projects, or simply socialize. Platforms such as Meta Horizon, VRChat, and Cluster exemplify this trend, enabling large communities to gather and engage in immersive shared experiences.

In social VR settings, the appearance and functionality of avatars play a pivotal role in shaping user experiences. Research indicates that avatar-mediated interaction can influence not only self-perception and interpersonal cognition, but also the formation and maintenance of social relationships within virtual spaces. In particular, "realistic avatars," which closely replicate a user's real-world appearance, have garnered attention for their potential to enhance immersion and body ownership. As VR continues to evolve and expand its user base, understanding the impact of realistic avatars on user experiences will be crucial for advancing effective and inclusive virtual platforms.

Self-perception in virtual environments has been extensively investigated, particularly regarding the sense of body ownership and the sense of agency. Early demonstrations such as the rubber hand illusion [1] showed that synchronous visual and tactile stimulation can induce the illusion of ownership over a fake limb. Building on this foundation, researchers have examined how digital representations called avatars can similarly shape or disrupt one's self-perception [2]. Numerous studies suggest that the visual fidelity of an avatar is a key factor, and realistic avatars that closely resemble their users often produce stronger sensations of body ownership and agency.

Latoschik et al. (2017) report that photogrammetry-based realistic avatars not only enhance body ownership in virtual environments, but also suggest that the appearance of others' avatars can influence users' self-perception [3]. Waltemate et al. (2018) report that personalizing a user's avatar through photogrammetry-based methods significantly increases body ownership, presence, and emotional response in virtual environments. They also show that higher degrees of immersion, such as those provided by head-mounted displays, further enhance these effects. Their results underscore the importance of realistic, user-specific avatars in social VR and in VR-based therapies that rely on embodied interfaces [4].

Other lines of research have focused on the effects of using avatars that differ significantly from a user's own appearance. A well-known example is the Proteus effect [5], which posits that an avatar's appearance can influence a user's abilities, behaviors, and even self-concept. For instance, individuals who used an avatar modeled after Albert Einstein reportedly demonstrated improved performance on cognitive tasks [6]. Additionally, body-swapping paradigms have explored how exchanging physical or personal attributes—such as gender or age—can lead to shifts in body perception, memory, and consciousness [7]. These findings collectively underscore the malleability of self-perception in virtual environments and highlight the importance of avatar design in facilitating effective communication and collaboration.

Despite growing evidence that realistic avatars can enhance body ownership and agency, relatively few studies have examined how swapping these avatars among multiple users in shared VR environments might affect trust, communication, and interpersonal perception. Previous research on body swapping or the Proteus effect has often focused on changes in self-perception when adopting avatars that differ in appearance or personal attributes, yet the specific scenario where one user's realistic avatar is controlled by another user remains underexplored. This gap is particularly relevant in social VR services, where users frequently encounter and interact with others' avatars.

In light of this gap, the present study aims to investigate how exchanging realistic avatars in a shared VR space influences self-perception and alters perceptions of others. We focus on whether using another person's realistic avatar leads to shifts in trust and communication difficulty, and whether having one's own realistic avatar controlled by someone else diminishes body ownership and agency. By clarifying these effects, we seek to contribute to the design of more effective and user-centric avatar systems in social VR, ultimately enhancing communication, collaboration, and overall user satisfaction in immersive virtual environments.

## Method

### Realistic Avatar

Realistic avatars were created using a full-body 3D scanner to obtain detailed three-dimensional models of each participant (Fig. 1). Rigging was then applied to these scanned models to enable interactive movement, and the final models were exported in VRM format, a file type commonly used for virtual reality applications. The production process, including model rigging, was conducted in collaboration with an external company. In total, avatar models were created for six participants in this study (Fig. 2).

***Figure 1.*** *Full-body 3D scanning process*

***Figure 2.*** *Example of a finalized realistic avatar*

### Equipment and Environment

A social VR platform, Cluster, was employed to enable multiple participants to share a single virtual environment and to facilitate avatar control through full-body tracking. The PICO 4 Enterprise served as the head-mounted display (HMD) to provide visual immersion. The avatar's movements were synchronized with the participant's body movements using motion tracking devices (mocopi, Sony)—a proprietary accelerometer-based sensor system. Sensors were attached to eight points on the body to replicate full-body motion in real time.

In this experiment, two participants shared the same VR space, each wearing a HMD and motion trackers. The VR environment included a virtual mirror that allowed participants to observe their avatars' appearances. The HMD was connected to a PC via a USB cable. The participants stood 2 meters apart, and the distance between them and the PC was also set at 2 meters to accommodate the movements required by the experimental tasks (Fig. 3).

***Figure 3.*** *Experimental environment*

### Experimental Procedure

Two experimental conditions were presented in random order: a matched condition, in which each participant used their own realistic avatar, and a swapped condition, in which participants exchanged avatars and used the other person's realistic avatar. Participant pairs were formed so that the difference in height between the two participants was minimized.

For the experimental task, participants were instructed to perform a series of six specific body movements, each lasting approximately 10 seconds, while alternating their focus between their own avatar and the other participant's avatar. The movements were as follows:

1. Arm Raise and Lower: Raise and lower both arms laterally.
2. Forward Arm Circles: Move both arms in forward circular motions.
3. Back-and-Forth Arm Swings: Swing both arms forward and backward.
4. Arm Swings with Leg Movement: Add leg movements to the back-and-forth arm swings.
5. Single-Leg Stand: Stand on the dominant foot.
6. Waving: Wave one hand to the other participant, who was visible across a virtual mirror.

Six healthy male undergraduate students participated in the experiment. After an explanation of the experimental protocol was provided, informed consent was obtained from each participant. Motion trackers were then attached, followed by a calibration procedure. Once participants donned the HMD, the proper display of the virtual environment was confirmed. They subsequently performed the assigned experimental tasks. Upon completing these tasks, participants filled out a questionnaire for subjective evaluation. Following a short break, the remaining experimental condition was administered. Finally, after both conditions had been completed, interviews were conducted to gather the participants' overall impressions of the experiment.

### *Evaluation*

A subjective questionnaire consisting of 16 items was administered to assess participants' experiences. These items were divided into three main categories: (1) sense of presence in the virtual environment, (2) self-perception, and (3) impressions of others. The self-perception category included questions related to body ownership and sense of agency, whereas the impressions of others category could be further divided into subgroups such as interpersonal cognition, friendliness, social desirability, and perceived activity. Each item was rated on a 7-point Likert scale, and the complete list of questionnaire items is provided in Table 1.

To analyze the questionnaire data, normality was first examined using the Shapiro–Wilk test. Items that satisfied the normality assumption were analyzed with paired t-tests, whereas items that did not were examined using the Wilcoxon signed-rank test. All statistical analyses were carried out in R using the "coin" package.

## Results

Figure 4 presents the mean scores for the questionnaire items that showed statistically significant differences between the matched and swapped conditions. Error bars represent one standard deviation from the mean. Among the self-perception items—which focus on body ownership and sense of agency—scores were significantly higher in the matched condition ("I feel that I exist in the space in front of me" ($z = 2.15$, $p = .03$, $r = .62$), "I feel that my body is moving within the space" ($z = 2.15$, $p = .03$, $r = .62$), "I feel that my body is my own within the space" ($t(5) = 3.4$, $p = .02$)).

These findings indicate that using realistic avatars effectively enhances self-perception, thus supporting observations from previous studies.

**Table 1. Questionnaire Items**

| Item | Question | Group |
|---|---|---|
| 1 | I feel that I'm immersed in the space in front of me. | The sense of presence in the virtual environment |
| 2 | I feel that the events happening in front of me are real events. | |
| 3 | I feel that I exist in the space in front of me. | |
| 4 | I feel that my body is moving within the space. | Self-Perception |
| 5 | I feel that I know where I am within the space. | |
| 6 | I feel that I am moving my body as I want to. | |
| 7 | I feel that my body is my own within the space. | |
| 8 | I can recognize the avatar next to me as a human being. | Interpersonal cognition |
| 9 | I feel that the avatar next to me is another person. | |
| 10 | I feel that communicating with the avatar next to me is easy. | |
| 11 | I feel a sense of warmth in the avatar next to me. | Friendliness |
| 12 | I feel a sense of closeness in the avatar next to me. | |
| 13 | I feel a sense of sincerity in the avatar next to me. | Social desirability |
| 14 | I feel a sense of trust in the avatar next to me. | |
| 15 | I feel a sense of proactivity in the avatar next to me. | Activity |
| 16 | I feel a sense of sociability in the avatar next to me. | |

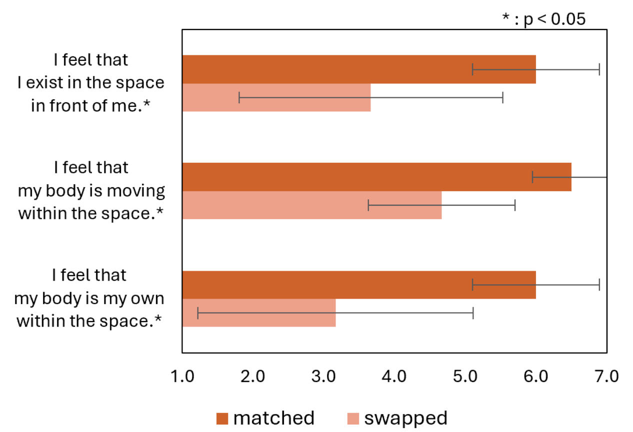


***Figure 4.*** *Scores for items related to body ownership and sense of agency.*

Figure 5 presents the questionnaire items that showed statistically significant differences or noticeable trends between the matched and swapped conditions ("I feel that the avatar next to me is another person." ($z = 1.86$, $p = .06$, $r = .54$), "I feel that communicating with the avatar next to me is easy." ($t(5) = 2.5$, $p = .05$), "I feel a sense of trust in the avatar next to me." ($t(5) = 3.5$, $p = .02$)).

All items in this category received lower scores in the swapped condition, with particularly significant differences observed in items related to interpersonal cognition and social desirability. In the swapped condition, each participant used the other individual's realistic avatar, suggesting that interacting with an avatar resembling oneself may lead to perceived difficulties in communication and a sense of distrust. These findings indicate that adopting another person's realistic avatar could negatively affect communication and collaboration in virtual reality environments.

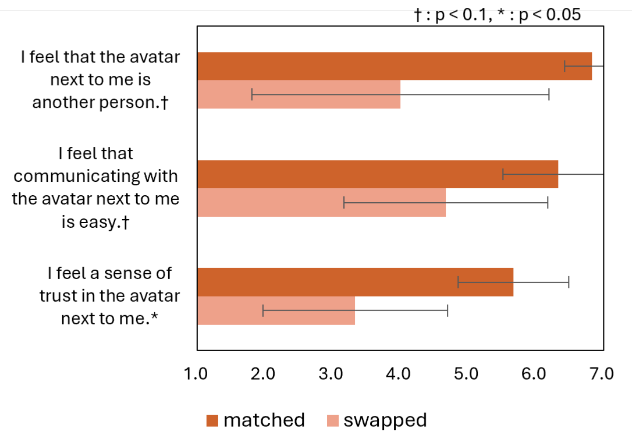


***Figure 5.*** *Scores for interpersonal cognition and social desirability.*

Post-experimental interviews yielded several notable observations. Many participants reported feeling more balanced when using their own realistic avatars. Indeed, in the swapped condition, multiple participants tended to place their foot down during the one-legged stand task. However, the related questionnaire item—"I feel that I am moving my body as I want to"—did not show any statistically significant difference. These findings raise the possibility that perceiving an avatar as one's own body could influence balance control, which may, in turn, be reflected in quantitative measures of movement.

## Discussion

This study explored how swapping realistic avatars in shared VR spaces influences both self-perception and the perception of others. Consistent with previous literature on body ownership and agency, our findings indicate that realistic avatars effectively enhance users' self-perception. This effect was evident in participants' subjective reports of body ownership and agency under the matched condition.

However, a key discovery was that when another person uses one's realistic avatar, levels of trust decline and communication becomes more difficult. These results suggest that familiarity or personal attachment to a realistic avatar could, paradoxically, generate confusion or even discomfort when that avatar is controlled by someone else. Such discomfort may stem from challenges in distinguishing identity cues or from an uncanny mismatch between the appearance of a familiar body and the behaviors of a different user.

Additionally, the analysis of physical movements offers a promising direction for objective evaluation of self-perception in VR. Participants who used their own realistic avatars appeared better able to maintain balance during a single-leg stand task, implying that strong body ownership may translate into more precise motor control in virtual environments.

Despite these insights, the study was conducted with a relatively small pool of participants, limiting the generalizability of our conclusions. Future work will seek to expand the number and diversity of participants by creating additional realistic avatars and implementing more comprehensive motion analyses. Such an approach may uncover more nuanced relationships between visual realism, motor function, and interpersonal cognition in VR. Ultimately, advancing our understanding of avatar representation has the potential to improve communication, collaboration, and even therapeutic interventions that leverage VR for motor function training or social interactions.

## Conclusion

This study examined how swapping realistic avatars in shared virtual reality environments affects both self-perception and the perception of others. The results highlight that using one's own realistic avatar can strengthen body ownership and facilitate better motor control, as evidenced by higher subjective ratings of body awareness and more stable performance on balance tasks. In contrast, having one's realistic avatar controlled by another person undermined trust and made communication more challenging, suggesting that familiarity with a realistic avatar can paradoxically cause discomfort when that avatar is used by someone else. These findings underscore the importance of avatar identity in social VR contexts, where both self-perception and interpersonal dynamics can be influenced by the visual fidelity of avatars.

Nevertheless, the relatively small sample size limits the generalizability of these results. Future research should incorporate a larger and more diverse participant pool, along with more comprehensive motion analyses, to further investigate how visual realism and avatar identity affect communication and collaboration in virtual spaces. By refining our understanding of how users perceive and interact through realistic avatars, we can inform the design of more engaging and user-centric social VR platforms. Ultimately, this knowledge may enhance communication, collaboration, and even body-based training programs that leverage VR for motor function or social interactions.

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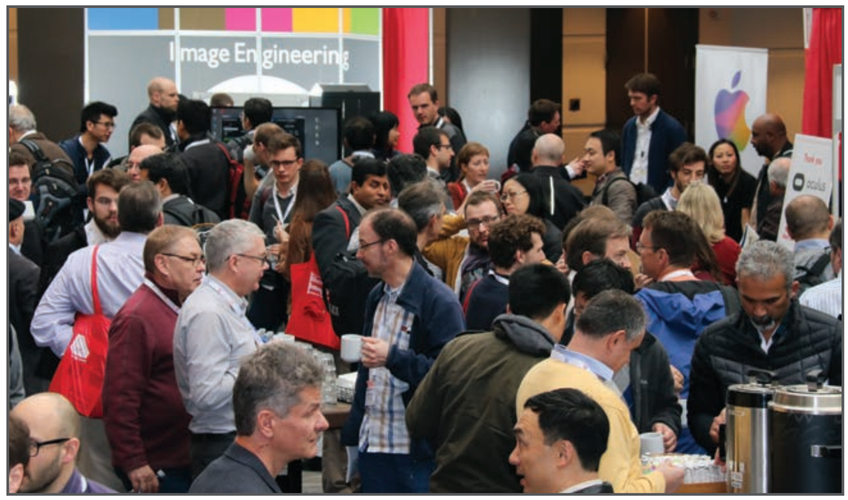



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