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Immersive role-playing with avatars leads to adoption of others' personalities

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In modern society, where nations and even individuals are divided, building bridges between people of different personalities and backgrounds is essential to achieve harmonious coexistence. In recent years, research has been conducted on the use of technologies to bridge this gap. In this study, the effectiveness of using immersive virtual reality (IVR) technology to play the role of a stranger in helping people learn about and empathize with others was investigated. Specifically, participants were asked to role-play a first-time stranger in an IVR environment after being given prior information about the stranger *via* a preparatory video. The effects of role-playing between acting as a target stranger through his or her avatar in an immersive environment, acting through a different avatar in an immersive environment, and acting through his or her avatars in a non-immersive interface were compared. The results showed that using IVR technology with an exact avatar to play the target person was found to have the greatest effect on the participants' personalities and thoughts as well as increasing their empathy for that individual. This finding suggests that IVR technology may be an effective tool for bridging the gap between people from different backgrounds.

KEYWORDS

avatar, personality, adoption, virtual reality, role-play, third-person perspective, virtual beings

1 Introduction

In present-day society, people with different thoughts and backgrounds are expected to live in harmony. In this context, trying to understand people from diverse backgrounds is important to overcome prejudice toward those who are different from us. However, humans have difficulty inferring the thoughts and backgrounds of others without prejudice. Therefore, recent scientific and technological developments have focused on approaches such as affective computing and computer-supported cooperative work (CSCW), which help promote mutual understanding between people (Grudin, 1994; Tao and Tan, 2005; Sakuma and Inoue, 2021).

One promising technological finding that has the potential for promoting interpersonal mutual understanding is the Proteus effect (Yee et al., 2007), which arises when a person manipulates an avatar with a particular identity in a virtual reality environment and his/her thoughts and actions are influenced by the identity of the avatar. For example, manipulating an avatar with an attractive appearance makes one more aggressive in negotiations with others (Yee et al., 2009). It has also been reported that playing Superman in a virtual environment makes people more prosocial toward others (Rosenberg et al., 2013), manipulating an Einstein avatar improves performance in cognitive tasks (Banakou et al., 2018), manipulating the avatar of a child makes objects appear smaller in size (Banakou et al., 2013), and white people who

manipulate black-toned avatars have reduced discriminatory prejudice against black people (Farmer et al., 2012; Peck et al., 2013; Maister et al., 2015; Bedder et al., 2019). Research has also been conducted to enable people to counsel themselves by observing their own recorded avatars as well as their own words and actions, while they face themselves from the perspective of an objective other (Slater et al., 2019). Furthermore, having participants experience body-swapping with friends has also been studied for its effect on self-perception (Tacikowski et al., 2020). Based on a series of studies on the Proteus effect, playing the avatar of another person in a virtual environment may effectively promote the understanding of different people.

Most previous studies have examined the effects of adopting celebrity avatars (e.g., Einstein, Superman) or other personas of whom participants had clear stereotypical images or whom they knew well. Otherwise expressed, in previous studies, the Proteus effect was considered to manifest based only on pre-acquired background knowledge, and it has not been verified whether effects similar to the Proteus phenomenon are induced when strangers who do not have pre-acquired knowledge or stereotypes meet for the first time.

Previous psychological research has suggested that the technique of acting from the perspective of another person effectively induces feelings of empathy toward the outgroup and an understanding of the thought processes and background of the other person (Chartrand and Bargh, 1999; Wiltermuth and Heath, 2009; McNeill, 2022). For example, synchronizing one's own movements with those of others is known to increase interest in and empathy for others and the group to which they belong (Wiltermuth and Heath, 2009). In the context of a deeper understanding of the other, a counseling technique called psychodrama has also been proposed, in which the counselor deepens the understanding of the client by having the counselor play the role of a character in a drama relating to the client's situation (Blatner, 1988; Kellermann, 1992). Thus, imitating or playing the role of another person has been shown to be important in understanding the psychological state and background of that person.

What about manipulating the body of a particular stranger and then role-playing from that position? In studies of the Proteus effect, it has been found that the effect of role-playing is strengthened by imagining the avatars of others as if they were one's own body (Kilteni et al., 2015; Ehrsson, 2020). Therefore, even when role-playing a stranger, immersive virtual reality (IVR) experiences with the avatar of the other person may help us better understand the thoughts and background of the other person. Regarding the research question of whether it is possible to create a Proteus-like effect on others who one has never met before, two specific issues remain unresolved. First, is it sufficient to express the same opinion as the other person, or is it necessary to embody the other person (avatar)? Second, should this situation occur only in a highly immersive VR environment, and not in a 2D display (desktop-based) environment?

In this study, by creating an immersive experience using virtual reality, we investigated whether the thoughts and background represented by an avatar influences participants who adopt the avatar and whether this concept applies even to a stranger with no prior knowledge of the avatar. We conducted an experiment in which subjects watched a stranger speaking from a third-person perspective and then role-played the stranger from a first-person perspective. For the role-playing, we prepared some conditions: a "Same Avatar in IVR" condition in which the participants embodied the same avatar they observed beforehand in an IVR environment, a "Different Avatar in IVR" condition in which they manipulated a different avatar from the one they previously observed and did not embody the stranger in a similar IVR environment, and a "Same Avatar in 2D" condition in which they manipulated the same avatar they observed, but as a mirror image on a 2D display instead of in the IVR environment. In this case, participants did not embody the stranger. By comparing these conditions, we examined whether manipulating the avatar of a stranger in a highly immersive VR environment actually strengthens the interpretation of the thoughts and background of the stranger.

The hypotheses addressed in this study were as follows.

Hypothesis 1. By role-playing the avatar of a stranger with prior information (observed from a third-person perspective) in an IVR environment, the personality of the participant will resemble that of the avatar.

Hypothesis 2. By role-playing the avatar of a stranger in an IVR with prior information, the participant will sympathize with the opinions of the avatar and inherit the social relationships of that avatar.

Hypothesis 3. With prior information, closeness toward the avatar will be promoted by role-playing the avatar of a stranger in an IVR.

For each of the hypotheses, the participants were asked to indicate the personalities they held toward themselves and the avatar to address Hypothesis 1. We then examined how similar the two personalities were. Specifically, the cosine similarity was calculated to measure the similarity between the participants and the avatar. To address Hypothesis 2, the participants were asked to indicate how much they agreed with the opinions expressed by the avatar in the preparatory video, and for Hypothesis 3, they were asked to indicate the closeness between themselves and the avatar using the Inclusion of Other in the Self (IOS) scale to test the strength of closeness for the other person (Aron et al., 1992). This indicator evaluates the overlap of the circle that represents self and the circle that represents the other. The score increases as the degree of overlap increases with no overlap scored as 1 and significant overlap as 7. This is used to evaluate the inclusion of oneself and others.

2 Materials and methods

2.1 Study design

We studied how role-playing with the avatars of other people, for which prior information was provided, changes under multiple conditions. First, the participants were asked to watch a 5 min preparatory video of an avatar giving a presentation on university entrance exams. This video provided prior information about the opinions and personality of the avatar of the other person. The participants were then divided into three groups under high- and low-immersion conditions and with the appearance of the same or a different avatar. Each group was asked to role-play the avatar they watched (re-enactment of the video content). They were requested to respond to a pre- and post-role-play questionnaire, which was later analyzed.

FIGURE 1
Experimental environment in IVR (left), and experimental environment in 2D (right).

2.2 Participants

Ninety participants (average age: 21.1 years), mostly students at Osaka University who were fluent in Japanese and with an equal representation of both genders, participated in the experiment. The participants were recruited through social networking services and other media. The experiment was conducted using a participant-to-participant design, under three conditions. The first group consisted of 30 participants (G1: Same Avatar in IVR; 30 participants) in an IVR environment with avatars that looked like the one in the preparatory video. The second group operated in an IVR environment, but with an avatar different than that shown in the preparatory video (G2: Different Avatar in IVR; 30 participants). The last group operated in a less immersive environment (G3: Same Avatar in 2D; 30 participants). They manipulated the same avatar as that in the preparatory video but in a less immersive environment where the avatar was mirrored on a 2D display. Before and after the role-playing, the participants answered questionnaires about their personalities and that of the avatar, their agreement or disagreement with the opinions of the avatar, and the qualities of the friends of the avatar.

This study was approved by the Ethics Committee on Research Involving Human Subjects, Graduate School of Engineering Science, Osaka University. Countermeasures against novel coronavirus infection were also observed. Informed consent was obtained from the participants through a written explanation.

2.3 Procedure

First, all the participants were asked to watch a 5 min preparatory video of an avatar giving a presentation on university entrance exams. The video showed the avatar's opinion about the university entrance exam and introduced the friends of the avatar discussing the topic with the avatar.

After watching the video, the participants were asked to complete a preliminary questionnaire. They were first asked to indicate the IOS between themselves and the avatar they had observed in the video (Aron et al., 1992). The participants were also asked to respond to the Ten Item Personality Inventory (TIPI) for themselves and for the avatar they observed. It is a scale measuring 5 factors of the Big Five with 2 items each (Gosling et al., 2003). Using a 7-point Likert scale, they were also asked to indicate how much they agreed or disagreed with the opinion of the avatar regarding the content of the opinions on university entrance exams. Finally, we measured the qualities of the friends of the avatar.

After completing the pre-questionnaire, the participants were asked to role-play the avatar under the three different conditions described above.

For the experiments (G1: Same Avatar in IVR and G2: Different Avatar in IVR), we developed an IVR environment in which the participants wore tracking equipment (Perception Neuron) that measured whole-body movements, and their movements within the environment were displayed on a head-mounted display from a first-person perspective (Figure 1). The left part of the figure shows a participant in the laboratory whose motion is being recorded. The lower left part of the figure shows a screen that is similar to the one that the participant sees through the mirror. In the Same Avatar in the 2D condition, the participants perceived the avatar displayed as shown in the right part of the figure. The participants were also asked to adjust the parameters of a voice conversion system while vocalizing themselves, so that their own voice could be changed to resemble that of the avatar in the preparatory video. The tracking equipment was attached and calibrated with the support of the experimenter. The participants were asked to confirm that the avatar followed their body movements by moving their head, arms, legs, etc. In front of a virtual mirror for a few minutes A dialog script was given for the role-play that lasted no longer than 15 min, in accordance with the time spent using the appropriate head-mounted display.

For comparison (G3: Same Avatar in 2D), the avatar was manipulated using webcam facial-expression recognition software and LeapMotion arm and hand recognition with the participants observing on a typical 2D display (described in detail under "Device").

The avatar of the other (G1: Same Avatar in IVR and G3: Same Avatar in 2D) was designed by a professional character designer. A comparison avatar (G2: Different Avatars in the IVR) designed by the same designer was utilized to preserve aesthetic continuity.

The participants were informed that the experimental task was to manipulate their avatars and record a video with them talking, but in reality, they were only role-playing, and no video was recorded. Role-playing the talking video, although it did not include interactions with others, provided participants with an awareness that their interactions with the avatar could be observed (and recognized) by others.

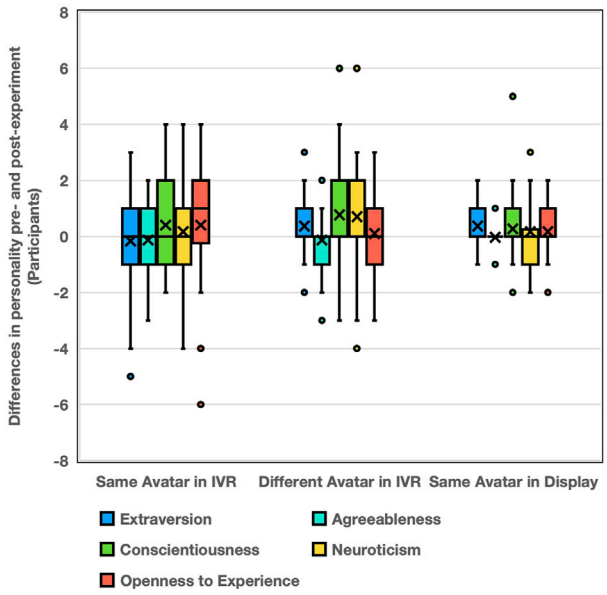

FIGURE 2
Differences in participant's personality pre- and post-role-play (G1: Same Avatar in IVR, G2: Different Avatar in IVR, G3: Same Avatar in 2D). The bars denote the quartile point.

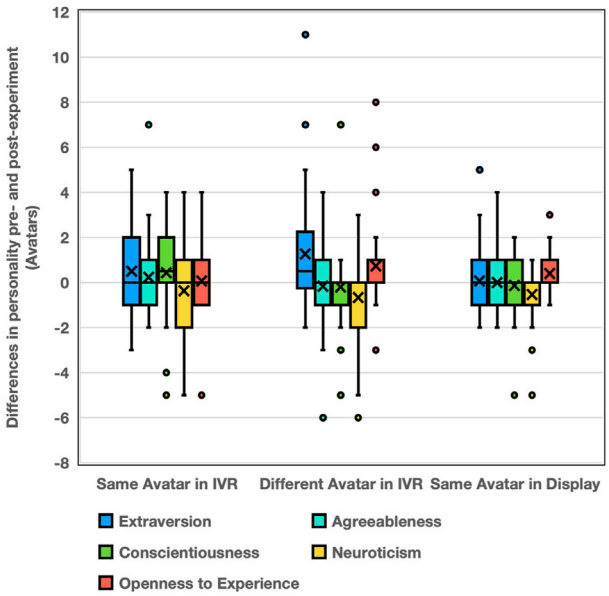

FIGURE 3
Differences in avatar's personality pre- and post-role-play (G1: Same Avatar in IVR, G2: Different Avatar in IVR, G3: Same Avatar in 2D). The bars denote the quartile point.

After the role-play, participants were asked to answer the same questions as those in the pre-role-play questionnaire.

As the purpose of conducting the post-play questionnaire was not clarified, participants were asked to answer the same questions in the post-play questionnaire on the assumption that the (pre-play) questionnaire was not recorded correctly. The experiment was described as solely an experiment to hear evaluations of the system, and participants were not informed that the questionnaire was the main purpose of the experiment. Therefore, we asked them to fill out a post-play questionnaire regarding their condition following the role-play. We then debriefed them after they completed the post-play questionnaire.

TABLE 1 Cosine Similarities in participant and avatar personalities before and after the role-play (G1: Same Avatar in IVR; G2: Different Avatar in IVR; G3: Same Avatar in 2D).

	Cosine similarity (M±SD)		Contrast	
	Pre-	Post-	Z	*p*
Same Avatar in IVR	0.881 ± 0.059	0.915 ± 0.054	4.052	***$p < 0.001$
Different Avatar in IVR	0.892 ± 0.044	0.902 ± 0.081	2.530	**$p = 0.011$
Same Avatar in 2D	0.875 ± 0.051	0.890 ± 0.062	2.448	**$p = 0.014$

Note: M = median; SD, standard deviation.

2.4 Device

As an IVR environment, we built a system that tracks physical movements and presents a first-person view of an avatar that follows these movements. NOITOM Perception Neuron 2.0, with 31 inertial sensors, was used for tracking, and motion data were captured using the Unity plug-in Neuron Animator. An avatar prepared in the VRM file format, the standard for virtual humanoid models, was used for manipulation. A virtual camera was set at the position of the head of the avatar, and the video was fed back to the participants through a head-mounted display (HTC VIVE). The HTC VIVE had two base stations located in the laboratory, and combined with Perception Neuron data, it enabled accurate reproduction of the body movements of the participants in the virtual space. The virtual space replicated the background of the preparatory video. A virtual mirror was placed in front of each participant. This allows the participant to observe the avatar's response to his or her full body and mouth movements; in the IVR conditions, the participant observes his or her reflection in a mirror seen through the HMD, and in the 2D condition, the participant observes his or her reflection in a mirror-like display in the physical world (Figure 1).

For comparison, we used software that recognizes facial expressions and body motions based on webcam videos and arm and hand motions using LeapMotion. Specifically, a Logitech C922N PRO HD stream webcam and LeapMotion were used as input devices, Luppet was utilized as the software, and the movements of the avatar were displayed on a 2D display set up in the laboratory. The display functioned as a mirror, and the avatar mirrored the movements of the participants. Although the avatar moved along with the participants, this was not an IVR experience, unlike first-person manipulation in virtual space.

In both environments, voice conversion was used in conjunction with the system. After the voices of the participants had been captured, they were asked to adjust the parameters of the voice converter for their voices to replicate those of the avatars in the preparatory video. An AT4040 condenser microphone was used for the field recordings.

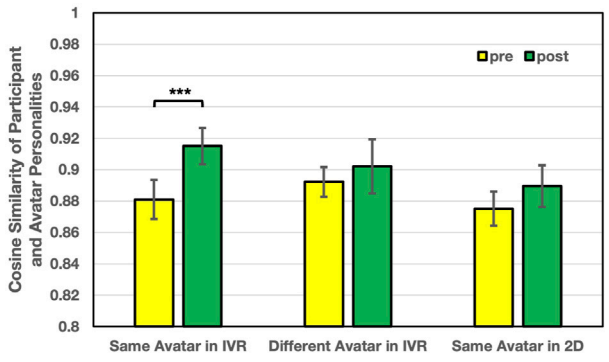

FIGURE 4
Cosine similarity of participant and avatar personalities (G1: Same Avatar in IVR, G2: Different Avatar in IVR, G3: Same Avatar in 2D). The error bars denote standard error, ***$p < .001$.

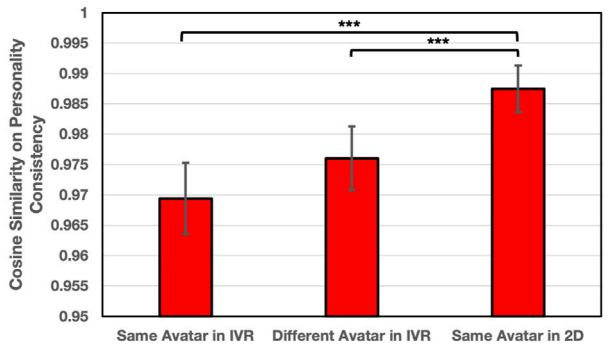

FIGURE 5
Cosine similarity of personalities (consistency of the person) between pre- and post-role-play (G1: Same Avatar in IVR, G2: Different Avatar in IVR, G3: Same Avatar in 2D). The error bars denote standard error, ***$p < .001$.

A Voice Transformer 4 effect processor device was utilized for voice quality conversion, to modify the pitch effect, which adjusts the height of the voice, and the formant effect, which adjusts the peak of the frequency. A Roland Rubix 24 was employed as the audio interface. The converted voice was output through HTC VIVE headphones.

2.5 Measure

To test Hypothesis 1, the participants were asked to complete the Ten Item Personality Inventory (TIPI), a simplified measure of their own personalities and those of the avatars. For personality, we used a simplified Big Five index (TIPI), which covered extraversion, agreeableness, conscientiousness, neuroticism, and openness with seven levels and 10 items (1. Extraverted, enthusiastic; 2. Critical, quarrelsome; 3. Dependable, self-disciplined; 4. Anxious, easily upset; 5. Open to new experiences, complex; 6. Reserved, quiet; 7. Sympathetic, warm; 8. Disorganized, careless; 9. Calm, emotionally stable; 10. Conventional, uncreative).

To test Hypothesis 2, we asked the participants their opinions immediately after watching the video and immediately after completing the role-play. Specifically, the participants were asked seven questions related to the university entrance exams introduced in the video (e.g., the purpose of university entrance exams, difficulty in adjusting the difficulty level of the standardized university entrance exam, the introduction of the admissions committee and its merits.) and were asked to rate their agreement or disagreement with the opinions held by the avatar on a 7-point scale.

Questions were also asked to measure the qualities of the friends of the avatar. The questions focused on five content areas (sociability, intellectuality, adaptability, potential, and honesty) on a 7-point scale of 15 items. As mentioned earlier, the video featured the friends of the avatar discussing the exams.

To test Hypothesis 3, the participants were asked about the IOS scale, which measured the degree of inclusion of the concepts of the participants and the avatar in the experiment. We tested whether the degree of inclusion of the participant and the avatar, which was expressed on a 7-point scale ranging from a very high psychological overlap between the participant and the avatar to no overlap at all, changed after the role-play.

2.6 Data analysis

In the personality analysis, for each of the seven levels of personality tendency obtained, by considering the items (directions) as vectors, the cosine similarity of those vectors was calculated. In a previous study, similarity was computed for Twitter users and their followers by considering each personality dimension in relation to the others (Tommasel et al., 2015). More specifically, the inner product of the vectors of the personalities of the participant and avatar, divided by their respective norms, was the cosine similarity. Cosine similarity is used to measure the similarity of two sentences by replacing their words with a vector of numerical values. Otherwise expressed, the closer the cosine similarity is to 1, the more similar the tendencies of the compared personalities, and the smaller the value, the greater the differences in personality. Cosine similarity was calculated between the personalities of the participant and avatar in the pre- and post-play questionnaires. It was intended to determine the similarity between the personalities of the participants and avatars in the pre-observation period.

Cosine similarity has been used in recommendation systems as a legitimate method of measuring personality similarity (Tkalcic et al., 2009; Hu & Pu, 2011; Tommasel et al., 2015). Another method is to use the average of the absolute value of the differences in the scores of the questionnaire. However, this method cannot distinguish between the similarity of data that are scored in the same way but have different scores, and the similarity of data that are scored in different ways as vectors. We believe that cosine similarity is more appropriate for examining what kind of tendency the participants assume for the personality, rather than the absolute value of the data itself, as in the present case.

Furthermore, the consistency of the participants' personalities was assessed to determine which conditions elicit the most significant psychological change. Cosine similarity was also calculated between the pre- and post-play questionnaires and the personality of the participants in the TIPI questionnaires. It showed the extent to

TABLE 2 Degrees of Agreement with Opinions introduced by the avatar before and after the role-play (G1: Same Avatar in IVR; G2: Different Avatar in IVR; G3: Same Avatar in 2D).

	Degrees of agreement (M±SD)		Contrast	
	Pre-	Post-	Z	*p*
Same Avatar in IVR	4.210 ± 0.891	4.776 ± 0.949	3.856	***$p < 0.001$
Different Avatar in IVR	4.538 ± 0.941	4.976 ± 0.951	3.425	***$p = 0.001$
Same Avatar in 2D	4.238 ± 0.973	4.486 ± 1.141	2.983	**$p = 0.003$

Note: M = median; SD, standard deviation.

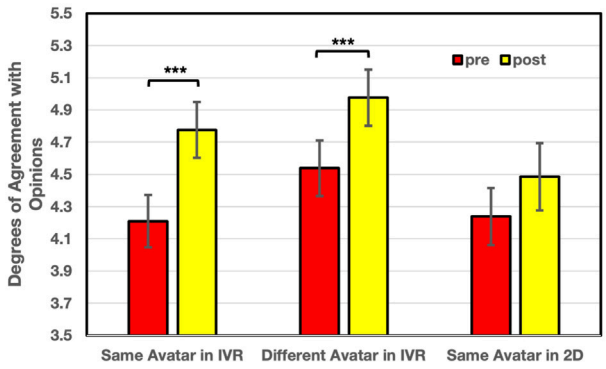

FIGURE 6
Degree of agreement with the opinion of the avatar pre- and post-role-play (G1: Same Avatar in IVR; G2: Different Avatar in IVR; G3: Same Avatar in 2D). The error bars denote standard error, ***$p < .001$.

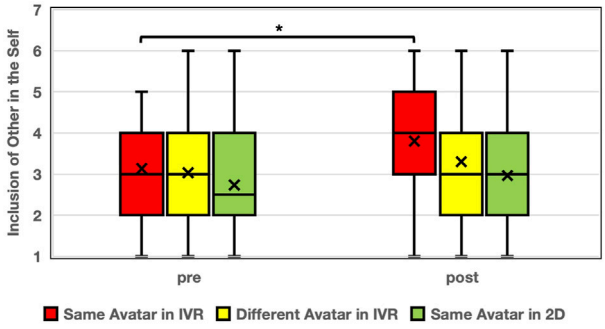

FIGURE 7
Box-and-whisker plots of pre- and post-role-play IOS across groups (G1: Same Avatar in IVR; G2: Different Avatar in IVR condition; G3: Same Avatar in 2D). The bars denote the quartile point.

TABLE 3 Differences in pre- and post-qualities of the friend introduced in the video (G1: Same Avatar in IVR; G2: Different Avatar in IVR; G3: Same Avatar in 2D).

	Sociability (M±SD)	Intellectuality (M±SD)	Adaptability (M±SD)	Potentiality (M±SD)	Honesty (M±SD)	Average (M±SD)
Same Avatar in IVR	−0.100 ± 0.673	0.011 ± 0.483	0.022 ± 0.638	0.056 ± 0.464	0.133 ± 0.562	0.122 ± 1.623
Different Avatar in IVR	0.044 ± 0.469	0.033 ± 0.369	0.111 ± 0.567	0.144 ± 0.820	0.056 ± 0.440	0.389 ± 1.540
Same Avatar in 2D	0.044 ± 0.295	0.189 ± 0.436	0.022 ± 0.310	−0.056 ± 0.710	0.056 ± 0.448	0.256 ± 0.991

Note: M = median; SD, standard deviation; no statistically significant differences.

which the personalities of the participants had changed after the experiment.

3 Results

This section presents the experimental results for each hypothesis. This study used non-parametric tests as normality was not confirmed except for the qualities of friends. The results of the corrected Kolmogorov-Smirnov test are as follows; cosine similarity (pre): $p = 0.018$, cosine similarity (post): $p < 0.001$, agreement with opinion: $p < 0.001$, IOS (pre): $p < 0.001$, IOS (post): $p < 0.001$, qualities of friends ($p = 0.519$).

Hypothesis 1. By role-playing the avatar of another person with prior information (observed from a third-person perspective) in an IVR environment, the personalities of the avatar and oneself will become similar.

For Hypothesis 1, the TIPI was used to assess the psychological characteristics of the participants and the avatar they observed. The differences of these personalities before and after the role-play are shown in Figure 2 and 3. These figures illustrate the distribution of each of the Big Five personality traits. In order to facilitate comparison, we computed the cosine similarity of these data and subsequently examined the closeness of the participants' and avatars' personalities as well as the consistency of the pre- and post-participants' personalities. The cosine similarities between the avatar and participant personalities in the "G1: Same Avatar in IVR," "G2: Different Avatar in IVR," and "G3: Same Avatar in 2D" conditions were calculated using the corresponding items as vectors, as shown in Table 1 and Figure 4. In all conditions, the similarity is higher after

TABLE 4 Inclusion of Other in the Self scale between participant and avatar before and after the role-play (G1: Same Avatar in IVR; G2: Different Avatar in IVR; G3: Same Avatar in 2D).

	IOS (M±SD)		Contrast	
	Pre-	Post-	Z	*p*
Same Avatar in IVR	3.133 ± 1.231	3.800 ± 1.166	2.949	$^{**}p = 0.003$
Different Avatar in IVR	3.033 ± 1.224	3.300 ± 1.242	1.852	$p = 0.064$
Same Avatar in 2D	2.733 ± 1.315	2.967 ± 1.354	1.572	$p = 0.116$

Note: M = median; SD, standard deviation.

role-playing. Analyses were compared using the Wilcoxon-Signed-Rank Test. The effect sizes were compared by performing a test comparing pre- and post-play for each condition. The results showed that there were significant differences in the Same Avatar in IVR ($Z = 4.052$, $p < 0.001$), Different Avatar in IVR ($Z = 2.530$, $p = 0.011$), and Same Avatar in 2D ($Z = 2.448$, $p = 0.014$). The effect size was largest for Same Avatar in IVR. To compare them across conditions, after calculating the difference between the pre- and post-cos similarity in each condition, the Friedman test was conducted among the three conditions and no statistically significant differences were found, $\chi2(2) = 1.667$, $p = 0.435$.

Figure 5 demonstrates how much of the participants' personalities change after the role-play, calculated from the cosine similarity between pre- and post-participant personalities, and how consistent these personalities were. The degree of similarity was high enough under all conditions, that is, the personality consistencies were high (Figure 5). The mean and standard deviation of cosine similarities were as follows (M±SD): Same Avatar in IVR (0.9694 ± 0.0059), Different Avatar in IVR (0.9760 ± 0.0053), Same Avatar in 2D (0.9875 ± 0.0038). The Friedman test was performed among the three conditions, and there was a statistically significant difference, $\chi2(2) = 22.867$, $p < 0.001$. Post hoc analysis was conducted with a Holm correction. There was no significant difference between Same Avatar in IVR and Different Avatar in IVR ($Z = 0.904$, $p = 0.366$). In contrast, there were significant differences between Same Avatar in IVR and Same Avatar in 2D ($Z = 4.518$, $p < 0.001$), and Different Avatar in IVR and Same Avatar in 2D ($Z = 3.615$, $p < 0.001$).

Hypothesis 2. By role-playing another avatar in an IVR environment with prior information, the participants sympathized with the opinions of the avatar and inherited his or her social relationships.

In Hypothesis 2, items related to the opinions expressed by the avatars in the video about the Japanese university entrance exams were presented, and the participants were asked how much they agreed with the opinions on a 7-point, 7-item scale (Table 2). We derived the average of the 7-items and utilized it as a measure of how well the participants agreed with the avatar's opinion (Figure 6). The Wilcoxon-Signed-Rank Test was used in the analysis. Each participant group (condition) was subjected to a pre-to post-test to compare the effect size of each condition. The results showed significant changes in Same Avatar in IVR ($Z = 3.856$, $p < 0.001$), Different Avatar in IVR ($Z = 3.425$, $p = 0.001$), and Same Avatar in 2D ($Z = 2.983$, $p = 0.003$). Although all of these changes are significant, the effect sizes are larger for Same Avatar in IVR, Different Avatar in IVR, and Same Avatar in 2D, in that order. While role-playing alone and reading the script aloud is indicative of a concurrence of opinions, it is more pronounced in an IVR. After calculating the difference between the pre- and post-degrees of agreement in each condition, the Friedman test was conducted among the three conditions and no statistically significant differences were found, $\chi2(2) = 3.155$, $p = 0.206$.

Since normality was confirmed, we conducted an ANOVA test on the qualities of the friend. The Kolmogorov-Smirnov test indicated that the qualities of the friend were normally distributed ($p = 0.519$). Table 3 presents the results of a 7-point, 15-item scale assessing the qualities of the avatar's friends featured in the video. These categories included sociability, intellectuality, adaptability, potential, and honesty. ANOVA with two factors between the three conditions, before and after role-play, showed only the tendency of a main effect before and after the role-play ($F(1, 87) = 2.847$, $p = 0.0951$). No significant differences were found between the conditions.

Hypothesis 3. Closeness (the ability to understand and share the feelings of another) with the avatar is promoted by role-playing the avatar of another avatar in an IVR with prior information.

For Hypothesis 3, the IOS scale represented the degree of inclusion that the participants expressed toward the avatar. The posterior mean levels for the Same Avatar in IVR (G1), Different Avatar in IVR (G2), and Same Avatar in 2D (G3) conditions were all higher than the prior mean levels (Table 4). Figure 7 provides a box-and-whisker diagram of the differences between the groups and shows that the inclusion of concepts (closeness) is higher in those labeled posterior than in those labeled prior in the Same Avatar in IVR (G1) condition for both the mean and interquartile range.

Again, the Wilcoxon-Signed-Rank Test was used to compare the effect sizes by performing a pre-to post-test for each condition, respectively. The results showed the changes in Same Avatar in IVR ($Z = 2.949$, $p = 0.003$), Different Avatar in IVR ($Z = 1.852$, $p = 0.064$), and Same Avatar in 2D ($Z = 1.572$, $p = 0.116$); only Same Avatar in IVR showed a significant change in IOS. Furthermore, the post-play closeness was higher in the Same Avatar in IVR (G1). To compare them across conditions, the Friedman test was performed among the three conditions, and there was statistically significant difference, $\chi^2(2) = 6.700$, $p = 0.035$. Post hoc analysis was conducted with a Holm correction. There was no significant difference between Same Avatar in IVR and Different Avatar in IVR ($Z = 1.420$, $p = 0.156$), and Different Avatar in IVR and Same Avatar in 2D ($Z = 0.645$, $p = 0.519$). In contrast, there were significant differences between Same Avatar in IVR and Same Avatar in 2D ($Z = 2.066$, $p = 0.039$).

4 Discussion

The results of this study confirmed that the participants were influenced by the thoughts and backgrounds of others, even strangers, when they manipulated the avatars of the others in an IVR environment. Interestingly, the results obtained were of two types: those produced by immersive experience and those produced by simply role-playing the other without the immersive experience. This section outlines the results of evaluating our preliminary hypotheses.

1) For Hypothesis 1, in all groups, there was a significant effect on the cosine similarity of psychological characteristics between participants and avatars after role-playing. This indicates that simple role-playing based on the prior information of others

was found to draw personalities closer. However, when comparing the effect sizes, the Same Avatar in IVR (G1) showed lower consistent psychometric properties than the Same Avatar in 2D (G3). This indicates that role-playing by manipulating the same avatar in IVR is more effective in bringing personalities closer together than role-playing the Different Avatar in a less immersive environment.

Personality changed the most from the original in the Same Avatar in IVR (G1). This finding suggests that the proposed method (G1) is the one that participants were most affected by throughout the role-play. This result demonstrates the synthesis of findings from virtual reality and psychological studies of role-playing others in the experimental environment of IVR, where the Proteus effect can occur.

2) For Hypothesis 2, there were significant changes in all three groups, but the effect sizes were in the order of Same Avatar in IVR, Different Avatar in IVR, and Same Avatar in 2D. This indicates that role-playing to imitate prior information can produce agreed opinions. Therefore, in the future, there can be an advantage in using the IVR environment for role-playing in which opinion entrainment occurs. No primary effect was found for changes in the qualities of the friend of the avatar, probably because not enough information about the friend of the avatar was given in the preparatory video.

3) For Hypothesis 3, significant changes were observed only for Same Avatar in IVR (G1) of higher IOS inclusion from pre-to post-intervention. Therefore, closeness may occur significantly in the Same Avatar in IVR condition (G1, proposed method).

Next, we discuss the novelty of the present study in comparison with existing related studies. In the introduction, we stated that existing related studies include the Proteus effect, synchronization of self and others, and psychodrama. The implications of the present study for these previous works are discussed below.

The Proteus effect is the reflection of the identity inferred from the representations of the avatar to oneself (Yee et al., 2007). For the effect to occur, attributes including race and pre-existing stereotypes such as those pertaining to celebrities are required (Yee et al., 2009; Banakou et al., 2013; 2018; Rosenberg et al., 2013). Therefore, it is difficult to establish the Proteus effect for others who are meeting for the first time. The present experimental design, which incorporates role-playing for others who are meeting for the first time, challenged this. The participants were able to acquire prior information about the stranger by watching a preparatory video of the stranger talking and could assume stereotypes accordingly. Then, the participants were asked to act out the preparatory video based on the stereotypes, which enabled them to experience role-playing of others whom they had never met before.

Methods for mutual understanding that can be applied to strangers have been studied in the field of psychology. It is known that synchronizing the movements of people in an outside group promotes interest and empathy (Wiltermuth and Heath, 2009). There have also been cases of psychodrama in which the precise stories and positions of patients are role-played (Blatner, 1988; Kellermann, 1992). By designing such techniques in a highly immersive virtual environment, the objective was to apply the Proteus effect to others who were meeting for the first time. We confirmed the effectiveness of role-playing by imagining others, which is consistent with previous research. However, we also found that the IVR environment increased closeness. Hence, the proposed method has a great potential for serving as an excellent tool for understanding strangers. Although there are previous studies such as psychodrama, none are comparable to our experiments and statistics. We would like to investigate the benefits of VR technology by comparing IVR and non-IVR as in this case.

In addition, by taking advantage of the virtual environment, we were able to give the participants prior information through the preparatory video and have them role-play it. By making the participants feel as if they were being filmed, we could make them feel as if they might be seen by others. Having that sense of being seen by the other person is essential to making them assume interaction with the other person (Haley & Fessler, 2005; Izuma et al., 2010; 2011). This aspect is difficult to control when participants are asked to interact with an experimenter because the topic will change during the interaction, and each participant will have a different experience. Even though the participants did not interact with the experimenter, they felt as if they were interacting with someone else. Hence, although the experiment was controlled, the participants were able to feel as if they were interacting with others. These were the aspects that we attempted to implement in the design of the experiment.

In summary, the effects of role-playing in a highly immersive experience environment (IVR) and with the avatar of another (G1) were as follows. The personalities of the participant and avatar became closer, their perceived personalities changed the most among the considered cases, and empathy was cultivated for the avatar. There were several trends for interaction effects in the analysis and manipulating the avatar of the other person with high immersion (G1) tended to produce stronger effects than manipulating a different avatar with low immersion (G3). This finding is also consistent with what was assumed in the hypothesis. In social psychology, it has been reported that people with similar personalities and preferences form intragroups and build mutually beneficial relationships (Mifune et al., 2010). Hence, in the future, such a system could serve to facilitate mutual understanding with others.

There were also effects that occurred without the manipulation of other avatars in a highly immersive environment (G1). Simply role-playing the other (G1, G2, and G3) resulted in approachable personalities, familiarity, and agreement of opinions. These findings also confirm the effectiveness of the methods for mutual understanding in research on role-playing others and psychodrama. The present experimental design further suggests that the use of role-playing for others who have never met before is a promising approach for achieving an open society with a high degree of relational fluidity. It is well known that a society with high relational fluidity that requires interaction with strangers enhances individual vitality (Thomson et al., 2015). Despite this, it is also known that continuous interactions with strangers entails considerable risk.

4.1 Limitations

There are few limitations to this research. In this study, we reported the results of significant trends from an exploratory

perspective. As such, no strong statistical claims could be made. It is possible that the participants were not strongly immersed in the avatar owing to the short duration of the experiment. In future, designing a strong immersive experience for participants with no prior knowledge of avatars should be considered.

The first is related to the appearance of the avatars, which were designed by professional character designers. Previous studies have examined the effects of physical expression as cartoon characters on public speaking anxiety (Bellido et al., 2021). Research has shown that the avatar's perception of its own appearance has a significant impact on its behavior (Banakou et al., 2009). Notably, the avatar's appearance has an impact on others' perceptions of the avatar as well (Zanbaka et al., 2006; Khan and Sutcliffe, 2014). In this study, these designs were intended to resemble popular digital avatars (anime-style avatars), which are familiar to Japanese participants. The results of previous studies have shown that cartoon-like characters also affect behavior, but it is possible that the results are different from those obtained in studies using realistic avatars. The findings obtained should also be tested with photorealistic avatars in the future if they are to be used to build relationships with strangers in more realistic situations. The avatar information provided to the participants in advance was limited. In the experiment, when the participants met their interlocutors for the first time, they were given background knowledge through a short video. Therefore, the information could have been insufficient for them to play the avatar and be influenced by it. Moreover, neuroscience research suggests that brain activity when thinking about a partner varies significantly depending on the background information provided (Mitchell et al., 2006). In the future, the thoughts and background of the avatar must be conveyed to participants efficiently.

In addition, this study did not examine the extent to which the participants sensed the body of the avatar as their own (sense of body ownership). It is critical to investigate in detail how physicality affects the results, to examine the efficacy of virtual reality technology for these purposes. There is considerable interest in cognitive science regarding embodiment and self-consciousness (Bermúdez, 2011). There is no guarantee that simply embodying without role-playing will have the same effect, and further research is needed. A detailed investigation of how the results could change by increasing the sense of physically being the avatar is required in the future.

Although individual characteristics were not added to the hypotheses in this study, some reports indicate that gender and other individual factors influence VR impressions (Schwind et al., 2017). Particularly, in this study, there was a gender mismatch for female participants because an equal number of male and female participants operated the male avatar. The mismatch between one's gender and the gender of the embodied character can have a considerable impact on the operation.

5 Conclusion

The Proteus effect, in which the identity inferred from the representation of an avatar is reflected in oneself, can be applied to others whom one has never met before, regardless of whether or not they possess stereotypes or attributes associated with celebrities. In this study, we performed applied research in the field of psychology, where interest and empathy are promoted by the synchronization of movements and other factors, to realize an experimental design for role-playing in a highly IVR environment. The results of this study showed that when role-playing with the avatar of another person in a highly immersive VR environment, the personalities of the participant and avatar become closer, the original personality changes considerably, and closeness toward the avatar occurs. Allowing participants to manipulate the avatars of others in an IVR suggests that the thoughts and background of others may influence the participants, even if they are strangers to the participants. The main effect of role-playing with avatars also reaffirmed the effectiveness of this technique in understanding others and in performing psychodrama research. We believe that these findings have significant implications for the use of virtual reality technology to facilitate the harmonization of relationships between people with different backgrounds (Slater et al., 2010).

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving human participants were reviewed and approved by Osaka University's Graduate School of Engineering Science Ethics Committee on Research Involving Human Subjects. The patients/participants provided their written informed consent to participate in this study.

Author contributions

HS designed and performed the experiments, compiled the data, wrote the first draft of the paper, performed the analyses, and contributed to fundraising. HT designed and performed the analyses, and contributed to preparing the manuscript. KO contributed to the experimental design and preparing the manuscript. HI contributed to conceptualization, provided the experimental environment, and drafted the manuscript.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/frvir.2023.101025526/full#supplementary-material

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