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# Exploring the Relationship Between Attribute Discrepancy and Avatar Embodiment in Immersive Social Virtual Reality

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## Abstract

Social virtual reality (VR) is an emerging set of platforms where users interact while embodying avatars. Given that VR headsets track real physical movements and map them onto one's avatar body, the nature of one's digital representation is an important aspect of social VR. However, little is known about how the visual proximity of an avatar to the self shapes user experience in naturalistic, social VR environments. In this article, we use this context to explore how embodiment is influenced by the perceived differences between the physical attributes of a user and the virtual attributes of their avatar. We selected a number of attributes for this measure that have been shown to be important for customization and representation in VR. Participants created an avatar, spent time in social VR, and reported on their experience in a questionnaire. Our results demonstrate a significant negative association between attribute discrepancy and avatar embodiment, the psychological experience of one's virtual body as their own body. We discuss implications for theories of self-representation and suggest urgency on the part of games and VR designers to improve the methods of creating avatars.

**Keywords:** virtual reality, avatars, social VR, avatar customization, avatar embodiment

## Introduction

AVATAR EMBODIMENT, OR when an avatar's virtual body is experienced as one's own body,[1,2] is a key feature of social virtual reality (VR).[3] Social VR is an emerging ecosystem of immersive virtual platforms that allow users to interact with each other through either a VR head-mounted display (HMD) or a traditional desktop or laptop graphical user interface.[4,5] Because of the tracking of head and hand movements afforded by HMDs, users can experience a sense of self-location, agency, and body ownership within their avatar.[2,3]

Previous research has examined the relationship between the appearance of a user's avatar and their psychological experience in both immersive and nonimmersive VR environments. For example, avatar customization has been associated with immersion,[6] identification,[8–10] and emotion during gameplay.[7] In addition, there is a significant link between a user's sense of presence and the distance from the avatar to the self.[11–13] This study expands on this literature by experimentally investigating how avatar embodiment is

impacted when users wear avatars with a greater discrepancy from their physical selves in immersive social VR. We chose to measure avatar embodiment because of the critical role that avatars play in social VR. People find their avatars more personal and emotionally fulfilling in social VR compared with traditional virtual worlds.[14] Therefore, we measured avatar embodiment, as it reflects a key aspect of the user experience on these platforms.

Although a few studies have established a link between avatar similarity and embodiment or presence in VR environments where researchers created the avatars,[12,15–17] this relationship has not been thoroughly investigated in more naturalistic, social, and immersive virtual settings. Whereas this prior work achieves visual similarity through photo-scanning, it is more common for users to customize or create their own avatars in many of the currently available social VR platforms.[18] Research on nonimmersive virtual mediums has also suggested that customizing an avatar increases a user's sense of presence.[19] Therefore, to build a more comprehensive understanding of how the visual appearance of an

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**FIG. 1.** Users socializing in VRChat.[29]

avatar shapes avatar embodiment in VR, there is merit in investigating this relationship using common and psychologically meaningful approaches.

Moreover, as researchers continue to explore social VR as a medium for education[20] and the future of work,[21] real-world design implications exist for understanding how a platform's avatar system shapes user experience. This suggests a need to explore this topic in naturalistic, social settings as opposed to only isolated lab-made virtual environments. To address this, this study explores the question: *How do discrepancies between the avatar self and physical self influence avatar embodiment in social VR?*

Higgin's self-discrepancy theory, which posits how inconsistencies between these different self-states may cause psychological discomfort,[22] serves as the foundation for this inquiry. We measure the discrepancy between the avatar self and physical self by considering perceived differences between an array of specific physical and virtual attributes of user avatars in social VR. Earlier work has shown that hairstyle, hair color, facial characteristics, and body are some of the most important features for avatar customization among users.[23] Users of color have indicated that skin color, eye dimensions, mouth, nose, and hair texture are important for representing racial identity in online games.[24] Gradations of hair color and other nuanced attributes that signal age were important to women in midlife.[25] We investigated how the discrepancy of some of these attributes, among others, influenced users' sensation of embodiment within immersive VR.

Historically, avatar systems in virtual worlds have lacked in providing a racially diverse set of avatar creation and selection options.[26–28] With this context in mind, we explore how attribute discrepancy may differ between white and nonwhite users and whether there are any significant differences in embodiment given these potential disparities.

## Context

This study takes place on two popular social VR platforms, VRChat and Rec Room. Both platforms allow users to socialize with each other in user-generated virtual



**FIG. 2.** Users socializing in Rec Room.[30]

**FIG. 3.** User customizing avatar in Rec Room.

environments (Figs. 1 and 2).[29,30] We used two platforms based on previous work that has recommended stimulus sampling using multiple media as stimuli in experiments.[31,32] This decision was also informed by prior work that has demonstrated how virtual environmental contexts in social VR influence a user's psychological experience.[20] Both platforms include features that make attributes of one's avatar salient including being able to look at your hands from a first-person point-of-view and looking into virtual mirrors.

### Avatar selection

Rec room. Avatars are created with a customization interface (Fig. 3) in Rec Room. This interface allows users select through different menus to modify different aspects of their avatar, including their face, hair, clothing, and accessories.

VRChat. At the time of this study, avatars could be obtained in a variety of ways on VRChat such as selecting from

an in-game public avatar world (Fig. 4) or creating or editing an avatar with software and uploading it to VRChat.

## Methods

### Participants

Participants were students in a summer course about VR at university in the United States. All 96 students were invited to participate in the study at the beginning of the course and 82 consented to participate. Participants who had nonhuman avatars, did not complete relevant questionnaire items, or did not complete this assignment in immersive VR were filtered from the dataset. After filtering, 61 were used for analysis. Ages of participants ranged from 16 to 25 (mean $[M] = 18.69$, standard deviation $[SD] = 2.87$). Additional demographic information of participants is given in Table 1.

Given the nature of the class they were enrolled in, by the time of the study, each student had spent around 1 hour in



**FIG. 4.** User selecting an avatar in VRChat from a public avatar world.

Table 1. Demographic Breakdown of Participants

| | |
|---|---|
| Gender | |
| Women | 33 |
| Men | 25 |
| Prefer not to say | 3 |
| Race/ethnicity | |
| Asian or Asian American | 32 |
| White | 16 |
| Hispanic, Latina, Latino, or Latinx | 4 |
| Bi-/multiracial | 3 |
| Black or African American | 2 |
| Middle Eastern or Northern African | 2 |
| Prefer to self-describe | 1 |
| Prefer not to say | 1 |
| Prior VR experience | |
| Never used social VR | 29 |
| Rarely used social VR | 17 |
| Sometimes used social VR | 11 |
| Used social VR several times a week | 4 |

VR, virtual reality.

headset for the course. Safeguards implemented to ensure privacy and consent included review both by our university institutional review board (IRB) and second university ethics organization, and third-party oversight of the consent process and data collection. Students opted into the study with an IRB-approved consent form or an IRB-approved assent document for participants younger than 18 years. This process required that researchers and course staff were unaware of which students provided consent or assent until after the course finished to avoid any plausible appearance of coercion to participate. All students participated in this study, but only data associated with consenting participants were analyzed.

### Hardware

Participants were provided with Meta Quest 2 headsets (503 g) and two hand controllers (126 g) for use in their personal environment.

### Measures

Avatar embodiment. A 7-point embodiment scale (1 = never, 7 = always) developed by Peck and Gonzalez-Franco (2021) was used to measure avatar embodiment.[a] Participants rated 16 statements, such as ''I felt as if the movements of the virtual body were influencing my own movements,'' to calculate appearance, response, ownership, and multisensory scores. These submeasures were averaged to calculate embodiment (Cronbach's $\alpha = 0.89$). Higher scores indicated a greater sense of avatar embodiment.

Attribute discrepancy. Taking into account features important to users' virtual self representation, we developed a new measure, attribute discrepancy, as the aggregated discrepancy between specific attributes of an avatar and a user's physical attributes. This measure captures how users perceive differences between specific parts of their avatar. This measure, adapted from Ducheneaut and colleagues,[23] invited participants to ''imagine yourself and your avatar standing side-by-side'' and compare the differences in attributes between their physical and virtual body. The attributes included were: accessories, esthetic, body, eye color, eye shape, fashion, gender expression, hair color, hairstyle, hair texture, lip shape, nose shape, and skin color. Nose shape and lip shape were removed from the scope of analysis because no avatars in Rec Room possessed these attributes. These items, each consisting of 5-point Likert scales (1 = very similar, 5 = very dissimilar), were averaged together to calculate attribute discrepancy (Cronbach's $\alpha = 0.81$).

Higher scores meant a greater discrepancy between an avatar's attribute and the participant's actual attribute.

Avatar creation motivation. We assessed each participant's typical avatar creation motivation using an adapted scale from Loewen et al.[33] (Table 2). Their response was used to determine whether their motivation was to create avatars that were ''Realistic,'' ''Ideal,'' or ''Different.''

Analysis of overall avatar embodiment, attribute discrepancy, and avatar creation motivation took into account the entire sample. While investigating differences in attribute discrepancy and embodiment across race, we narrowed the sample to Asian and white monoracial participants for two reasons. First, they were the two largest racial categories within the sample. The number of participants from other racial and ethnic backgrounds was too small for a reliable analysis. Second, the representation needs of Asian users of virtual worlds have not been met to the same degree as the representation needs of white users. Asian users have voiced a desire for the inclusion of avatars with a wider spectrum of skin tone options as well as other attributes such as nose shape and eye shape.[24] Consequently, there is relevance to understanding attribute discrepancy and embodiment differences between these two groups.

### Procedure

Each participant was randomly assigned to either VRChat or Rec Room and completed the study asynchronously in their own chosen remote location. Participants first watched a promotional video about their specified platform and were informed about their platform's security features. Participants then created an account if they did not already have one and signed on in headset. Then, they created or selected an avatar based on the avatar procedures available on their platform with the instructions to ''create or select a human avatar that you would feel comfortable using as your main avatar for prolonged periods of time around other people.'' Afterward, participants completed a task where they completed a set of poses with their body in front of a virtual mirror. The purpose of this task was to induce avatar embodiment by watching their physical movements sync with their avatar's movements.

Next, participants spent 5–10 minutes exploring a designated virtual world, selected by the first author, to experience interacting with a public virtual environment while in their avatar. We capped this task at 10 minutes to ensure that alongside the onboarding, avatar selection, and avatar embodiment task, participants would only spend ~20–30 minutes in VR to minimize simulator sickness. Although a longer period of time would be ideal, given that our participants were mostly VR novices, we tried to remain in the range of our lab's ''30-minute rule,'' which recommends not stay in VR longer than 30 minutes without a break. Finally, participants completed a questionnaire outside VR.

TABLE 2. QUESTIONNAIRE ITEMS FOR AVATAR CREATION MOTIVATION BASED ON LOEWEN ET AL.

| Avatar creation motivation | When you create avatars in social games, generally which of the following statements best describes you? |
|---|---|
| | When I create avatars in games, I tend to create them as similar to myself as possible |
| | When I create avatars in games, I tend to create them as an idealized version of myself |
| | When I create avatars in games, I tend to create them as someone distinctly different from myself |
| | I have never made an avatar outside of this assignment |

*Data analysis*

Our main research objective was to quantitatively examine the impact of discrepancies between a user's avatar self and physical self. To achieve this objective, an exploratory analysis was conducted on the filtered questionnaire data to capture individual avatar creation motivations and investigate the relationship between avatar embodiment and attribute discrepancy. This relationship was examined with a multiple linear regression model that predicted avatar embodiment from attribute discrepancy with platform as a covariate. We used a linear regression because it allowed us to examine how strong the relationship between our variables was of theoretical interest. Although not of theoretical interest, we included platform as a covariate because differences between VRChat and Rec Room may account for some of the variance in embodiment. To compare differences in attribute discrepancy and embodiment between participants from different racial backgrounds, we used two-sample $t$-tests.

**Results**

*Attribute discrepancy is negatively associated with avatar embodiment*

We explored the relationship between attribute discrepancy and avatar embodiment using a multiple linear regression at the level of the entire sample. This model predicted avatar embodiment based on attribute discrepancy and includes platform as a covariate.[b] The results of the regression showed that the two predictors explained a significant amount of the variance [$R^2 = 0.16$, $F(2, 56) = 5.33$, $p < 0.01$, $\eta^2 = 0.07$]. When controlling for avatar platform, attribute discrepancy had a significant relationship with avatar embodiment [$b = -0.31$, $t(56) = -2.06$, $p = 0.04$; Fig. 5].

*Discrepancy in skin tone was significantly different between Asian and White participants*

When comparing attribute discrepancies between participants from different racial and ethnic backgrounds, there is noteworthy difference. Two-sample $t$-tests were used on the discrepancy data between participants who identified as Asian or Asian American and participants who identified as white, as they were the two largest racial categories within the sample. The significant finding that emerged from these tests pertained to skin color. Asian participants ($M = 2.31$, $SD = 1.06$) had a greater discrepancy between their avatar's skin color and their physical skin color compared with white participants ($M = 1.81$, $SD = 0.54$), $t(45.93) = 2.16$, $p = 0.04$, $d = 0.54$ (Table 3). These findings indicate that Asian participants, on average, embodied human avatars with skin tones different from their own significantly more than white participants.

However, there were no significant avatar embodiment differences between Asian ($M = 3.15$, $SD = 1.03$) and white participants ($M = 3.23$, $SD = 1.07$), $t(29.51) = -0.24$, $p = 0.81$, $d = 0.07$.

*Most participants generally create avatars in reference to their physical appearance*

When participants were asked to describe how they generally create avatars on social games, 41 percent indicated creating avatars similar to themselves, 30 percent indicated creating avatars that were ideal versions of themselves, 23 percent indicated creating avatars that were different from themselves, and 7 percent indicated having no experience creating avatars. Given that a majority of participant motivations were to create similar or ideal avatars, it can be said that, overall, most participants in this sample of relatively new social VR users typically use their physical self as a starting point when creating an avatar.

**Discussion and Conclusion**

Embodying an avatar body in immersive social VR is experientially different than avatar embodiment in 2D virtual environments and is a key metric of user experience. Although prior lab studies demonstrated that distances between the avatar similarity can influence avatar embodiment in VR,[12,15–17] there has not been a comprehensive investigation of this relationship in naturalistic, virtual contexts where users customize their own avatars. There is a need to understand how avatars shape user experience in VR contexts outside of bespoke, nonsocial virtual environments made for lab studies. With this in mind, our article investigated how discrepancies between the avatar self and physical self influence avatar embodiment in social VR.
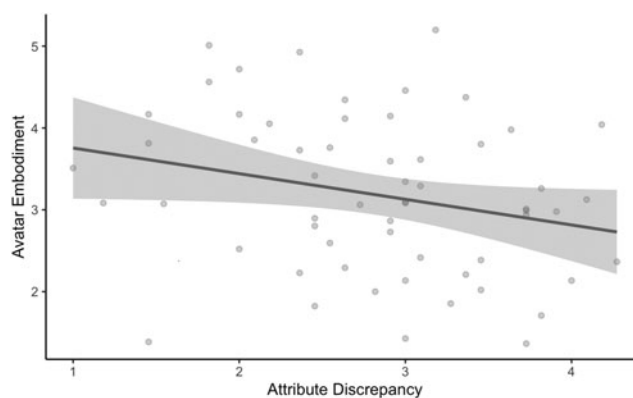


**FIG. 5.** A scatterplot showcasing the relationship between attribute discrepancy and avatar embodiment with a regression line and a 95 percent confidence interval superimposed.

TABLE 3. *T*-TEST RESULTS COMPARING ATTRIBUTE DISCREPANCY BETWEEN PARTICIPANTS

| Attribute | All participants, n=61 | | Asian participants, n=32 | | White participants, n=16 | | df | T | p | Effect size |
|---|---|---|---|---|---|---|---|---|---|---|
| | M | SD | M | SD | M | SD | | | | |
| Accessories | 3.23 | 1.44 | 3.44 | 1.29 | 2.69 | 1.66 | 24.38 | 1.58 | 0.13 | 0.53 |
| Esthetic | 3.43 | 1.37 | 3.53 | 1.46 | 2.94 | 1.18 | 36.36 | 1.51 | 0.14 | 0.43 |
| Body | 3.21 | 1.38 | 3.19 | 1.38 | 3.12 | 1.45 | 28.68 | 0.14 | 0.89 | 0.04 |
| Eye color | 2.79 | 1.52 | 2.53 | 1.39 | 3.06 | 1.73 | 24.99 | −1.07 | 0.3 | 0.35 |
| Eye shape | 3.1 | 1.27 | 3.22 | 1.34 | 3.06 | 1.34 | 31.14 | −1.28 | 0.21 | 0.12 |
| Fashion | 3.48 | 1.43 | 3.31 | 1.47 | 3.56 | 1.36 | 32.18 | −0.58 | 0.56 | 0.17 |
| Gender expression | 1.77 | 1.23 | 1.94 | 1.41 | 1.56 | 1.03 | 39.53 | 1.04 | 0.3 | 0.29 |
| Hair color | 2.38 | 1.44 | 2.47 | 1.5 | 2.25 | 1.34 | 33.36 | 0.51 | 0.61 | 0.15 |
| Hairstyle | 2.85 | 1.25 | 2.72 | 1.2 | 2.38 | 1.2 | 29.96 | 0.93 | 0.36 | 0.29 |
| Hair texture | 2.59 | 1.26 | 2.91 | 1.23 | 2.81 | 1.28 | 29.07 | 0.24 | 0.81 | 0.08 |
| Skin color | 2.13 | 1.02 | 2.31 | 1.06 | 1.81 | 0.54 | 45.93 | 2.16 | 0.04* | 0.54 |

*M*, mean; *SD*, standard deviation.
*$p < 0.05$.

We found a significant inverse relationship between attribute discrepancy and avatar embodiment when controlling for platform. We extend the virtual self-discrepancy literature cited previously to highlight how greater discrepancy between specific attributes may play a role in one's sense of avatar embodiment. However, we cannot rule out the case that one's sense of avatar embodiment could be affecting their perception of discrepancy.[34] Although this study only captured one time point, it is still relevant to understanding what less heavy users of social VR may experience. It is plausible that if someone goes into a social VR experience hoping to create an avatar that is a similar or ideal version of themselves, which was preferred by most participants in this study, but is unable to do so, that can have consequences on how present they feel in their virtual body. This has important implications for understanding the consequences of lack of diverse avatar customization options.

In addition to the pre-existing literature on the topic, our study found that differences between avatar skin tone and actual skin tone were substantially greater for Asian participants than white participants in VRChat and Rec Room. This finding extends previous work by Passmore and Mandryk (2018) that found that Asian gamers expressed a desire for a wider array of skin tone and undertone options.[24] Although our results did not find significant differences in embodiment between white participants and Asian participants, considering that the skin texture of an avatar in VR has been shown to influence body ownership,[35] it is possible that the *degree* of skin tone difference may be an additional factor contributing to embodiment. Further research should be conducted to understand the nuance of race, avatar representation, and embodiment on a larger, more diverse sample. Additionally, this finding reveals an urgency on part of game and VR designers to ensure the creation of equitable avatar customization options.

As social VR continues to be explored in a number of real-world contexts,[20,21] there is growing importance in investigating the psychological experience of its users. The primary contribution of this work is toward understanding how the design of an avatar system can in turn shape how embodied one might feel in their avatar. Within the context of a VR class comprised of young students mostly new to VR, our results suggest that having avatar options that enable users to create avatars that look visually similar to them may help provide a more seamless embodiment experience.

### Limitations

This study was limited by a relatively small sample size that consisted primarily of young participants from a convenience sample who were new to social VR. Our sample size was constrained by the nature of this study being conducted during a class and could cause some concerns surrounding the generalizability of our findings. For the smaller proportion of participants with greater previous social VR experience, it is possible they held different attitudes that may have impacted their perception of discrepancy and embodiment. Prior work has shown self-presence to increase in VR over time,[20] which could shape their results. Future iterations of this study should involve a larger, more diverse sample of participants who come from a greater diversity of backgrounds, social VR experiences, and cultural contexts. In addition, our results might be compromised by their low statistical power.

Lower statistical power increases the likelihood of Type II error and could mean that there is a possibility that our findings were based on chance. Therefore, the reliability of our results should be understood accordingly and future studies should aim to test the robustness of these findings. Participants also spent a relatively short amount of time in VR. Because of this short time, it did not help mitigate the potential attitudinal differences between the new users and power users of social VR. It is also worth noting that due to the content of the class that participants were enrolled in, they had preliminary knowledge about avatars and VR.

### Notes

a. There were additional measures collected at the end of the questionnaire that are not centrally related to this study and are not included here.
b. We ran an additional multiple linear regression including prior VR experience as a covariate and found that there was no effect of prior VR experience on avatar embodiment.

## Author Disclosure Statement

## Funding Information

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