When Friends become Strangers: Understanding the Influence of Avatar Gender On Interpersonal Distance in Virtual Reality

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Fig. 1. The Rec Room setup. a) Participants starting the game. b) Participants playing in the game room. c) Collaboration between participants. d) Participant being interviewed in the second room.

Abstract. In this paper, we investigate how mismatches between biological gender and avatar gender affect interpersonal distance (IPD) in virtual reality (VR). An increasing number of VR experiences and online platforms like Rec Room and VRChat allow users to assume other genders through customized avatars. While the effects of acquaintanceship and gender have been studied with regard to proxemic behavior, the effect of changed genders remains largely unexplored. We conducted a user study (N = 40, friends = 20, strangers = 20) where users played a two-player collaborative game in Rec Room using both male and female avatars. We found that with swapped avatar genders, the preferred distance increased between friends but not between strangers. We discuss how our results can inform researchers and designers in the domain of multi-user VR.

1 Introduction

In virtual reality (VR), users can embody avatars to represent themselves that are drastically different from their real selves. Social VR platforms such as Rec Room and VRChat allow the users to engage in immersive social interaction with each other through these avatars online. Interestingly, the virtual avatar can influence how their user is perceived by others and thus how they interact with each other. This creates a need to better understand the effect avatar appearance and how it may impact user behaviour in the context of social VR.

An important factor of social interaction is non-verbal behavior such as gaze, touch and proxemics, i.e., the distance to others [1]. Knowledge on non-verbal behavior change in VR as a function of avatar appearance is important because it guides the way we design VR spaces much like in the real world. For example, in the real world we design meeting spaces at work in such a way that people can comfortably interact at a so-called social distance, whereas homes accommodate for personal distance.

Previous research has studied how the appearance and gender of agents affect proxemics in VR with virtual agents [1, 29, 42, 36]. Specifically, the interpersonal distance (IPD) that users keep between themselves and a virtual, computer-controlled agent has been explored. Female agents produce shorter IPD than male agents. However, the influence of gender and *gender mismatches* (i.e., users embodying an avatar with a gender different from their own) on interpersonal distance in dyadic interaction between VR users has not yet been explored.

Moving from computer-controlled agents to user-controlled avatars also opens up the dimension of *familiarity* that is well-studied in real life [10] but not in social VR. It remains unclear how familiarity links to avatar appearance, i.e., does it matter whether the persons interacting in VR are acquaintances in the real world or whether they do not know each other, and how does avatar appearance mitigate familiarity?

In this paper we close this gap. Our work is driven by the following research questions: **(1)** How do mismatches between biological and avatar genders affect interpersonal distance in VR? **(2)** What is the influence of the relationship between users in the real world on the effects of a gender mismatch?

We conducted a user study (N=40, friends=20, strangers=20), where participants played a collaborative two-player game in Rec Room[4]. Participants embodied avatars of both their own gender as well as the opposite gender. We measured the distance that participants kept to each other, and we especially focused on the distance they chose to stop at when approaching each other (called *preferred distance*).

We found that **(1)** the preferred distance increases between friends as a result of the mismatch between avatar and biological gender; **(2)** the preferred distance is not affected by gender mismatches between strangers; and **(3)** users are largely unaware of changes in their preferred distance.

[4]Rec Room: https://recroom.com/

Our findings are valuable for researchers and designers alike. Researchers should ideally be aware of the real-world relationship between users, and their gender, when studying proxemics and social interaction in VR. Both factors can influence proxemics and ultimately the results, particularly if participants embody avatars with a different gender. Designers of virtual environments can also benefit from this knowledge during the design of a VR experience; we provide a discussion on this at the end of this paper.

2 Background

Our work draws from previous work on 1) proxemics and social interaction, 2) proxemics in VR, and 3) gender swapping.

2.1 Proxemics

Hall [5] proposed that four circular regions of egocentric space, defined by increasing radii, are distinctly reserved for social interactions: intimate space for the partner or family (0–45 cm), personal space only reserved for interaction with close friends (45–120 cm), social space for interaction with strangers (120–365 cm), and public space for the general public (365–762 cm).

Further research has refined this concept and found that a multitude of other factors influence IPD during interaction between two humans such as ethnicity, culture, and age. In non-acquainted pairs, two males keep a greater distance from each other than mixed sex pairs, and female pairs prefer shortest distances [11]. Uzzell and Horne [33] identified that sexual identity and sexual orientation determine the sex effect on IPD, rather than biological sex. This is likely because sexual attraction can modulate IPD to a large degree [37].

Proxemic theory can be used to facilitate interaction and guide the design of space and has thus found use in HCI. For example, McDaniel et al. [22] used tactile rhythms to provide cues for appropriate IPD to blind individuals. Proxemics have also been used to facilitate novel digital play experiences [25], public display interaction [18, 26], and cross-device interaction [9], among others. Marquardt et al. [20] developed a proximity toolkit aimed to provide fine-grained proxemic information and thus to allow for prototyping in proximity-aware devices.

2.2 Proxemics in VR

Prior research sought to understand and compare real-world behavioral concepts to the virtual world [4, 19]. Welsch et al. [38] used VR to investigate how psychopathy impacts judgement on comfortable IPD when confronted with threatening social interactions. They found that psychopathy produces smaller IPD in such situations. Llobera et al. [17] observed that as distance between participants and virtual characters decreases, the level of physiological arousal increases. Therefore, VR can be considered a viable tool to study social interaction as it allows for experimental control but also realism of social interactions [3].

The effects of gender on interpersonal distance were studied using VR by Iachini et al. [15], which showed that the effects of sex seen in the real world are at times present in VR, but there is also evidence that they are sometimes absent [12, 31]. This may be because gender effects on IPD are currently not fully understood.As VR allows for the manipulation of virtual avatars and their gender, it is possible to study the effect of gender independent from the real user gender, and thus attain a more nuanced understanding on gender effects on IPD.

2.3 Gender Switching

Proxemics have also been studied in computer games. A preference for personal space and effects of avatar gender are present in games such as Second Life [7, 40] and thus proxemic theory also carries to this domain. While such games are not VR per se, they share many similarities in that players embody a customizable avatar, explore a virtual world, and socialize with other players.

Gender switching is often observed among online gamers, particularly those of massively multi-player online role-playing games (MMORPGs) [13, 32, 35]. Gender swapping is more often observed among male gamers [13, 35], some reporting advantages of embodying a female in a male-oriented environment [13]. At the same time, women frequently suffer from harassment in online video games [6].

In VR, effects of gender have been studied extensively. For example, Yee et al. [41] examined the behavioral outcome of conflicting gender cues in the virtual world. In VR, gender switching (embodying avatars of different genders) has been explored in the context of sexual harassment [27] and violence [8]. Martens et al. [21] studied the similarities and differences in gender behaviour in a virtual environment by manipulating the participants' gender. However, we are unaware of studies that focus on gender switching and its effects on proxemics.

2.4 Summary

In summary, proxemics have been studied extensively in social encounters both in the real world and in VR. In VR, we know from existing research that a multitude of factors can affect IPD, like the appearance of avatars and the users' gender [14]. However, we currently lack an understanding of how *gender swapping* affects the IPD. It also remains unclear whether real-world acquaintanceship plays a role in gender swapping. Hence, we assess whether there is a difference between groups of friends and groups of strangers, and how they perceive other users in VR with different avatar genders.

3 Study

We ran a user study to understand how users maintain IPD in a VR environment. Participants attended the study in pairs and completed playful tasks together, embodying an avatar of their own gender as well as an avatar of another gender as shown in Figure 2.

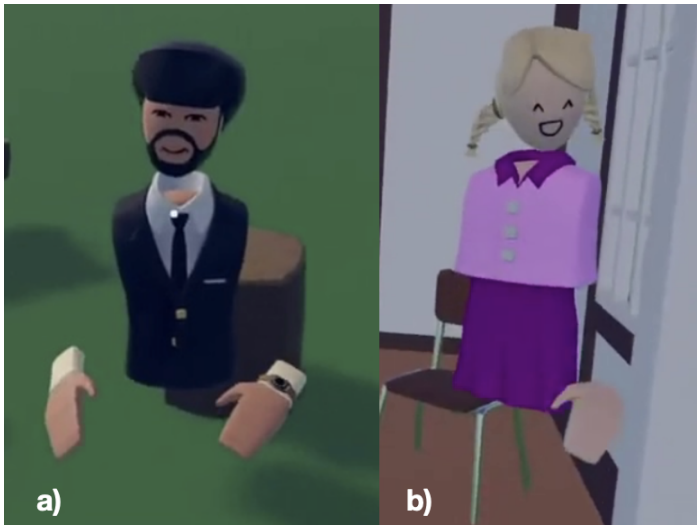

Fig. 2. Avatars used in the study. a) Male avatar. b) Female avatar.

We recruited 40 participants (35 males, 5 females; 15 male-male groups, 5 male-female groups) with an average age of 23.7 years (SD = 7.75). Due to a significantly higher number of males using Rec Room, there exists a possible gender imbalance among the set of participants. A more balanced gender distribution could have been more easily achieved in a lab setting. However, we opted for participant-owned HMDs and Rec Room. We ran the study in Rec Room because such online social platforms are where gender swapping takes place: users interact with each other, strangers and friends alike, and they have diverse avatars to choose from and can change them at will. Also, having users participate from home, with their own equipment, using a familiar online platform, is a far more natural setting than artificial settings typically seen in labs. For an in-depth discussion on the approach we used in this remote VR study, see Rivu et al. [30].

Half of the pairs were friends and half were strangers. Participants used various head-mounted displays, the most popular being PlayStation VR (45%), Oculus Quest (25%) and HTC Vive (10%). Participants were mainly recruited online from the Rec Room community on Reddit and Facebook. The sessions took around 30 minutes, and each participant was awarded 5€.

3.1 Study Design & Tasks

We conducted a mixed within and between subjects design with the following independent variables:

- **Relationship (between-subjects):** strangers, friends
- **Gender (within-subjects):** own gender, changed gender
- **Gender group (between-subjects):** male-male, male-female

Based on the availability of avatar design that Rec Room offers, we instructed the participants to change their avatar to represent either the male or the female gender of the avatar. We ran the study in the online VR platform Rec Room, in which we set up custom rooms where participants played a two-player collaborative game (Figure 1). The game consisted of two tasks. Our game design was based on giving two players the opportunity to interact and move around, which is crucial for studying proxemics. Thus, our game was representative of what users do on such platforms.

The first task was "Find the password" where players needed to find a clue in the room to unlock a door with a three-digit password. Participants needed to collaborate by looking around the room together and picking up objects that might be related to the password.

The second task was a "Guess the color of the drawn object". Out of five differently colored key cards on a table, one would open the back door. One player, who was told the correct color (e.g., red) by the experimenter via chat, had to draw an item on the whiteboard using marker pen (feature available in Rec Room) that would have a characteristic color (e.g., a tomato), matching the color of the correct key card. The second player would guess the color from the drawn object and then pick the key card of that color. An example of the second task is shown in Figure 1c). The two players decided between themselves who would draw. Both tasks were designed to maximize user interaction.

After each completed task, the participants were asked to walk up to each other and congratulate their partner on having done a good job. At this point we measured the distance between users (referred to as *preferred distance*). This type of approach to measuring interpersonal distance is commonplace in proxemics research and psychology [36, 38, 39].

The participants played both tasks in two sessions, thus completing both tasks twice. In the second round the gender of both participants was changed to the opposite gender (counter-balanced). The study was conducted completely virtually and participants attended from their homes. Thus, we had no control over the physical settings and the participants' arrangements. However, we reason that since participants use their own VR setups, and they are Rec Room users, they are familiar with their own physical space and understand the requirements of Rec Room.

3.2 Apparatus

We built two custom rooms for the study in Rec Room (Figure 1). In one room, participants played the game. In the other room, participants were briefed before the start of the study and later filled in a questionnaire and answered interview questions. Each player was interviewed separately.

The experimenter was remotely present, using an avatar of their biological gender. During the tasks, she was outside the room where the game was taking place, but was available through the audio channel. In the instruction phase and the post-study interview the experimenter was visible to participants.

3.3 Data Collection

Demographics and Qualitative Measures The demographics questionnaire consisted of 14 questions where we asked participants about their gender, age, country of origin, prior experience with VR, and relationship to the other player. We also conducted a post-study questionnaire and interview asking about their own perceived behavior and their perception of their game partner after the gender swap.

Proximity Detection Since Rec Room does not allow the users' location to be logged and transmitted, we implemented eight virtual proximity sensors (using the look-at Gizmo and Rangefinder components available in Rec Room) in each corner of the game room. Each look-at gizmo followed one of the players and the rangefinder output the distance (in centimeters) between player and the proximity sensor in real-time on a screen which was placed outside of the game room. Each player had 4 proximity sensors assigned to track them. The output data for player 1 was indexed from A to D, starting clockwise from the upper-left corner (Figure 3). Player 2 was indexed from E to H. During the experiment, the data output was screen-recorded in 30 FPS. The distance data was extracted from the video using the Optical Character Recognition API (OCR.Space).

The distance between participants was determined as follows. Taking the coordinates of 3 points A(x1,y1), B(x2,y2), C(x3,y3) and their distance to player1 (L1, L2, L3), we calculate the coordinates for player1 using three functions:

$$(y4 - y1)^2 + (x4 - x1)^2 = L1^2$$

$$(y4 - y2)^2 + (x4 - x2)^2 = L2^2$$

$$(y4 - y3)^2 + (x4 - x3)^2 = L3^2$$

After obtaining the coordinates for each player, we calculate the distance between them using the distance formula: $d = \sqrt{(x2 - x1)^2 + (y2 - y1)^2}$, where (x1,y1) and (x2,y2) are the coordinates for each player.

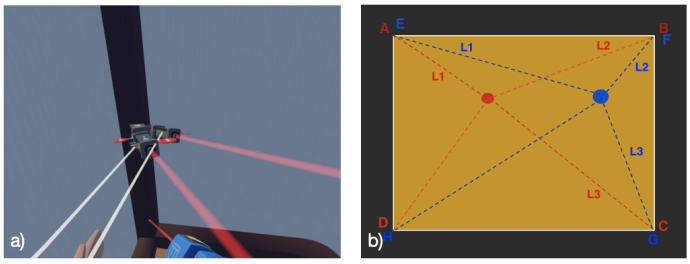

Fig. 3. Position tracking setup. a) Rangefinder to detect distance, b) Layout of position labels for each player between the Rangefinders.

Categories of Distance We measured two distinct categories of distance:

- **Preferred distance:** distance between players at which they congratulated each other after each task.
- **Minimum distance:** overall minimum recorded distance between players. Only idle periods were counted where players remained stationary for more than four seconds. This decision was data-driven. We made an informed decision that if players were stationary even after four seconds, they were not moving and standing at x distance away from the other player which gave us the minimum distance between players.

3.4 Study Procedure

The procedure is illustrated in Figure 4. The study started with participants entering the room where they were instructed. This room was separate from the room where the participants played the game. Participants first filled in the demographics questionnaire and gave their consent for data collection by pressing a virtual button (Figure 1). We then started the video recording, and asked participants to move to the game room. The study was divided into two sessions, with each session consisting of the same two tasks. In each session, participants used an avatar of either their biological or opposite gender. At the beginning of each session, participants were asked to change their avatar before the game starts. At the end of each session, participants were asked to walk up to and congratulate their partner (*preferred distance measure*). Between the sessions, the experimenter reset the room and the clues for the tasks.

Finally, participants moved to the other room to respond to a questionnaire and interview questions. This phase was done individually, so the other participant waited in the game room while the first participant was interviewed. The interview was recorded.

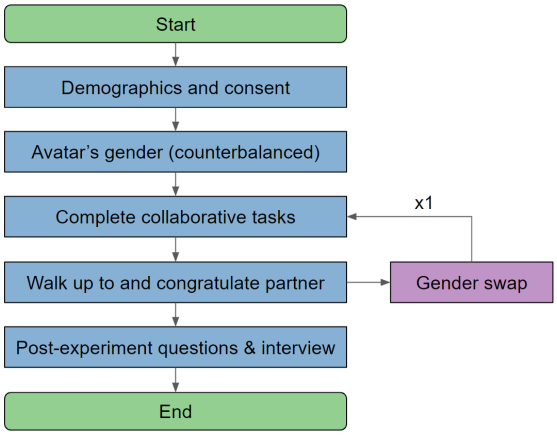

Fig. 4. Study procedure.

Distance (avg)	Male/Male	Male/Female	Friends	Strangers
Preferred distance (own gender)	1.64 m	1.58 m	1.45 m	1.80 m
Preferred distance (changed gender)	1.84 m	1.76 m	2.00 m	1.64 m
Minimum distance (own gender)	1.33 m	1.26 m	1.13 m	1.50 m
Minimum distance (changed gender)	1.11 m	0.79 m	1.09 m	0.97 m

Table 1. Distance analysis consisting of preferred distance and minimum distance.

4 Results

We present quantitative results from our statistical analysis on IPD as well as qualitative insights. Average distances of IPD measured as a function of relationship and gender switch are listed in Table 1.

4.1 Relationship (Stranger/Friend)

Friends (using their biological gender) maintained a preferred distance of 1.45 m which increased to 2.00 m with swapped gender. For strangers, the preferred distance using a biological gender was 1.80 m and 1.64 m with swapped gender.

We calculated a repeated measure ANOVA (Type III; alpha = .05) on both groups showing that for strangers, the difference is non-significant whereas for friends, there is a significant difference in the distance due to the gender swap of the avatars (p=0.031, F = 5.458). The distribution of preferred distance between each study condition is shown in Figure 5. No significant effect was found for minimum distance ($p > .10$).

4.2 Gender Group (Male–Male/Male–Female)

We compared the IPD between M/M groups and M/F groups (due to the high number of male participants, we did not have F/F groups). We ran repeated measures ANOVAs on both groups, in both minimum distance and preferred conversational distance. Neither the main effect of gender swap nor the paired gender was statistically significant (preferred distance: F = 0.003, p = .958, η^2 = 1.575e-4; minimum distance: F = 0.357, p = .558, η^2 = 0.019).

While we did not find an effect, it is known from prior work that generally differences exist between gender groups, although differences can be smaller between mixed groups and homogeneous groups [33], especially in VR [12].

4.3 Perceptions of Gender Swapping

Participants stated whether they believed changing the gender of the avatars had any effect on them in terms of behavior and experience (5-point Likert scale). The majority (72.5%) strongly believed changes in gender did not affect their own behavior or how they perceived their partner (Figure 6). Only two participants (5%), belonging to the friends group, somewhat agreed their behavior changed. The remaining participants somewhat disagreed or were neutral about changes.

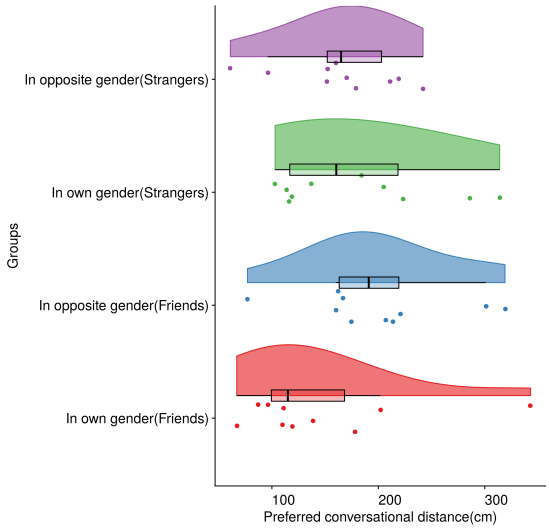

Fig. 5. Preferred distance between each relationship and gender.

Similarly, the majority of participants strongly believed that changes in avatar gender did not affect their experience. However, out of the five female participants, two (40%) strongly agreed that the change in the other player's avatar affected their experience, whereas only three out of 35 male participants agreed (8.5%). This indicates that female players perceive their experience in social VR differently compared to males, but this cannot be reliably inferred due to the low number of female participants.

In the interview, we furthermore asked if the gender of the other person's avatar affected the distance participants chose to keep to them. Almost all participants, 37 out of 40 (92.5%), answered negatively. A few participants believed that this was because the avatars did not look realistic.

4.4 Mismatch of Avatar Gender and Voice

When asked about their attitude towards the mismatch of voice and avatar gender, nine out of 40 participants (22.5%) expressed that they felt weird. Among those, only one person was from the friends group while eight were from the strangers group. This indicates that the mismatch of voice and gender may create more discomfort among strangers. Many found the mismatch acceptable though some believed it could cause confusion during social interaction. P7 stated: "It didn't bother me, but if we were to play paintball, I would be confused, I wouldn't register the voice to a different gendered avatar, so it would cause confusion' (friends group, female). P23 stated: "I don't like it very much, mostly people trying to deceive other people" (strangers group, male).

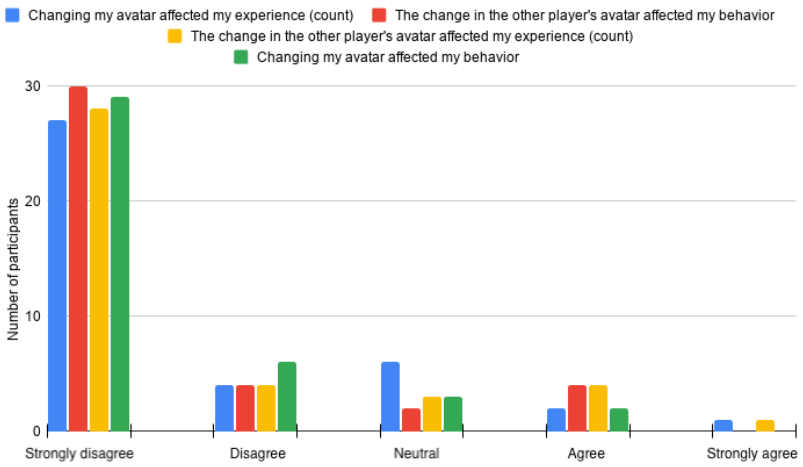

Fig. 6. Post-study questionnaire results.

4.5 Gender Choice

When asked about how they generally choose the gender of their VR avatars, the majority of participants preferred using avatars of their own gender as it is what they identify with. Some participants preferred the male avatar as it potentially reduces chances of sexism and harassment within the social VR community. This again highlights the current attitude women face in online video gaming world [6, 34]. Many participants stated to regularly use different genders. Two participants explained that they don avatars of different gender for a different experience. Three participants said they relate to both avatar genders. For some, virtual worlds allow self-exploration through different avatar appearances.

5 Discussion

Overall, our research shows that IPD in VR is affected by the gender of the users' avatars and the relationship between the users.

5.1 Gender Mismatches Increase the IPD between Friends but not between Strangers

The preferred distance between friends was significantly larger when they embodied avatars with opposite gender. Preferred distance was measured after each task when the participants walked up to and congratulated each other. The appearance (e.g., gender) of the avatar affects how we perceive our friends in VR. We are likely seeing proxemics in action [1, 10, 29, 42]: as a friend becomes less familiar in VR due to the unfamiliar visual appearance, the IPD transitions to what is commonly observed between strangers.

Despite the significant difference with preferred distance, there was no significant difference in overall minimum distance. One reason for this could be that when users are actively focusing on completing a task, changes in avatar appearance are less of a factor.

Between strangers, there was no significant difference in distance despite gender swapping. This is likely because there is no established familiarity between strangers, so gender mismatches are less pronounced. This is supported by the fact that with their own genders, the IPD was significantly greater between strangers than friends, so a more intimate IPD was never there.

5.2 Users are Unaware of Gender Swapping Effects

The majority of participants believed that gender mismatches did not effect their behavior or experience. This strong consensus is interesting as we nonetheless found a clear difference, suggesting that changes in IPD in VR are subconscious. Due to gender mismatch, participants also experienced a mismatch of voices and among the ones who were affected by it, the majority belonged to the strangers group. This is interesting because avatar appearance affected friends more than voice mismatch, whereas strangers are more affected by voice mismatch.

There were also some interesting, generalized remarks about intentionally embodying avatars with a different gender. Some females find donning a male avatar to be more secure, and some see it as an opportunity to explore themselves with different appearances. Some also raised concerns about the intentions of another person if they are donning a different gender.

5.3 Own and Other Gender

We always swapped the gender of both participants, i.e., when two male participants met they were both assigned female avatars in the next round. We found an effect of gender swap on IPD for friends but not for strangers. This leaves room for interpretation on the subjectivity of the gender swapping effect on IPD. One could argue that changing both the own gender but also seeing a change in the other's gender could have produced the estrangement, accompanied with larger distances, among friends because the perceived gender composition changed.

We argue that rather the perception of the other person than the change of the own avatar produced the effect. First, rather the gender composition than the own gender produces variation of IPD. Welsch [38] asked subjects to position virtual characters in a third-person view. They found that both the sex of the approached and the approaching character affected IPD. The real sex of the participant did not contribute to understanding IPD. This interpretation of a mere perceived sex effect runs counter to our data. Second, IPD for female pairs is smaller than for male pairs [12, 33]. Considering that the majority of our sample was male, IPD should have been reduced following a gender swap. We therefore believe that the mere effect of gender composition cannot account for our results; rather the in-congruence of avatar gender and perception of real gender in the other person, estranges friends.

Nonetheless, future work could vary the gender swap independently, i.e., only one person from each pair changes their avatar gender. One could also change other unique features of participants that are familiar with each other. Also, one could add an embodiment phase in which the avatars and thus also the perception of the own avatar gender is reinforced among the users.

5.4 Implications for Research and Design

Researchers should account for the effects of gender mismatches in their studies, as they may affect results. Researchers should ideally report the real-world gender of the participants, their potential relationship with other participants, as well as the appearance and gender of the avatar of each participant. Particularly when participants are friends, gender mismatches may have a strong effect.

Designers have been using proxemics theory to aid in their work [2, 23, 28]. We believe VE designers can similarly use the knowledge from our work to inform their designs. Gender mismatches cause changes in IPD between friends, which should be taken into account when creating collaborative virtual environments. For example, VEs could consider how the interactive functions would remain accessible to users who might be less than ideally positioned due to keeping more distance to others (e.g., standing further away than intended). At the same time, because users are largely unaware of changes in IPD, designers could consider ways to attract and guide users to more ideal positions.

Designers should also consider the level of intimacy that arises from the context of the VE as well as the relationship between VR users. For example, in therapy there may be a therapist present as an avatar alongside the patient. Given the patient and the therapist are strangers, they may be positioned at a greater distance and overtime when acquaintanceship occurs, their selected positions should change. Another context of use can be rooms designed to facilitate corporate meetings and conference. In this context, design guidelines should adhere to the interaction models based on IPD.

5.5 Limitations & Future Work

We swapped genders by switching between pre-defined male and female avatars available on the Rec Room platform. While Rec Room allows changing avatars, there is no option for modulating the user's voice. Thus, when users donned avatars with a non-matching gender, there was a mismatch of voice and avatar characteristics. This may result in unfavorable evaluations [16, 24], increase the need for distance [36], and may be pronounced in people that are familiar with each other. Future work may explore this effect of voice mismatch on proxemics.

Given the low number of male-female pairs, and the lack of female-only pairs, we cannot make strong conclusions for mixed-gender pairs and especially female-only pairs. However, we argue that currently the majority of HMD owners are male [30] and therefore our study provides a representative sample of HMD users and motivates further research in the area. We further plan to explore the effect of gender mismatch in larger virtual groups instead of pairs.

6 Conclusion

In this paper, we explored how gender swapping affects interpersonal distance in VR. We conducted a user study using an online VR platform, Rec Room, with 40 participants (20 strangers, and 20 friends). Participants completed playful tasks in pairs, and used both male and female avatars.

Our findings show that with swapped genders, the preferred distance increases significantly between friends but not between strangers. Also, users are largely unaware of these effects, as they believe that their behavior does not change despite the gender swap.

We hope our findings to (a) raise awareness among researchers that gender mismatches might present an issue in VR studies focusing on proxemics and needs to be accounted for, (b) inform VE designers to account for (unconscious) changes in IPD between users, and (c) provide a starting point for future work, investigating in detail how VR environments could be designed for and adapted to cases where acquainted users might use avatars of various genders.

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