Interpersonal Space in Social Virtual Reality

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Abstract
Research has demonstrated that the sense of interpersonal space as we know it from the physical world translates into virtual reality (VR). This extends into social VR, where the presence of another user's avatar will affect the user. However, previous work that has investigated interpersonal space in VR has largely mirrored reality through the use of full-body anthropomorphic virtual agents. Body representation in social VR avatars has the potential to vary greatly and does not need to conform to the physical reality. For example, in a dyadic relationship in VR, one user can be the size of a giant in relation to another user, or both users can share a single avatar. In this paper I describe the importance of investigating interpersonal space specifically in the context of social VR, and further present two relevant experiences from my work with social VR.

Author Keywords
Virtual reality; social VR; interpersonal space; height; scale; shared avatar.

CCS Concepts
•Human-centered computing → Virtual reality; •General and reference → Empirical studies;
Introduction

Interpersonal space plays a big role in social interaction in the physical world. It can be defined as the distance we maintain from other people in order to feel that our personal space remains unviolated [3].

It is established that interpersonal space as we know it from the physical world is also present in virtual reality (VR) [7]. Consequently, it is also important for social VR experiences. Research has used the VR medium to investigate interpersonal space. For example, VR has been used to explore links between peri- and interpersonal space [3, 4], between the amount and facial emotions of virtual agents [1], as well as how height and hip-to-shoulder ratio link to interpersonal space [5]. It has also been used to demonstrate that interpersonal space is modulated by the age and gender of the other person [4], and that the sense of interpersonal space is retained if one’s body is invisible [2].

A notable commonality in this body of work is how closely the body representations of the virtual agents conform to reality. The stimuli are typically full-body anthropomorphic virtual agents [1, 3, 4, 5] or stereoscopic images and footage of actual people [2, 7]. While these results are useful in establishing VR as a valid tool for studying interpersonal space and provide valuable insight into interpersonal space in general, they do not account for the more unique avatar representations that can exist in social VR, but not in the physical world.

In social VR, avatar representations can vary significantly from those listed above. What happens to interpersonal space if the other person has a more abstract representation, such as a floating head and hands? What if the other person is much larger than the user, or vice versa? What about more extreme forms of co-presence, such as two users co-embodying and sharing control over an avatar?

All of these are options that social VR designers and researchers may want to include in the design of their experience, whether out of practical necessity or deliberate intent to create a specific experience. They are also all options that may significantly influence the sense of interpersonal space in non-intuitive ways. To enable designers and researchers to understand the consequences of using avatars that are further removed from reality in social VR experiences, it is therefore important for research to investigate these phenomena.

The rest of this paper will describe concrete experiences with interpersonal space in social VR in the form of two projects I have worked on leading up to and as part of my PhD research. The first project is a social VR study that was designed to explore vastly different user sizes in a dyadic interpersonal context. The second project is a demo built for the University of Copenhagen’s research into social VR, wherein two users shared an avatar.

Height and Scale

In contemporary room-scale VR systems such as the Oculus Quest, HTC Vive, or Valve Index, the system is aware of the head-mounted display’s position within a calibrated space. Effectively, this means that the user maintains their physical height inside of the VR environment by default. In a social VR context, this translates the many social connotations of height into the VR experience. However, as VR designers, we can also treat the interpersonal scale between users as a design variable.

There are many reasons this may be an attractive option for a social VR experience. For example, it can be used for exploring established interpersonal relationships, such as those between a parent and a child (as suggested in [6]), or for environmental design when you have multiple designers...
In [6] I describe an experimental study design that manipulates user height and scale in a dyadic social VR experience. One user maintains their natural height in the context of a room, another is shrunk to a tiny size (figures 1-2). The normal-sized user guides the smaller user through a maze wherein the height of the walls is scaled dynamically so that the tiny user is physically incapable of peeking over them (figure 2). As could be expected, a pilot implementation of the study saw significant differences in subjective user responses to being the small and normal-sized user, as well as significantly different behavioural patterns in the form of hand gestures and movement patterns.

In the context of interpersonal space, it is specifically interesting to note that the avatars were abstract in the form of a floating head and hands. The smaller user only noted an invasion of their personal space when the hand of the larger user drew very close, even if, based on the relative positions of the hand and head, other parts of the larger body that were not rendered, such as the arm or chest, would be in close proximity to their personal space.

**Shared Avatars**

Traditionally, VR experiences have mirrored the existential premise of having a single person embody a single avatar. However, in social VR experiences, we can challenge that premise. It is possible for multiple users to share the same avatar. This could be useful for a variety of purposes, such as having embodied instructions from a teacher to a student, or to facilitate empathy towards disabled users.

To demonstrate the University of Copenhagen’s research into body representations and co-presence in social VR to the general public, I implemented a social VR experience for the Copenhagen Culture Night event in October 2019 (figure 3). The experience featured a shared avatar. Two users co-embodied an avatar in the form of a floating head and two hands. One user controlled the left hand, while the other user controlled the right (figure 4). The shared avatar was seated in front of a campfire, and the two co-embodied users had to collaborate to pick up a stick, attach a marshmallow to the end of the stick, and roast it carefully over the campfire. This repeated as many times as the users could manage within three minutes.

When the users picked up the stick, the system linearly interpolated the translational and rotational input between the users’ hands to facilitate the shared controls, so that each user contributed 50% of the avatar’s shared motion. To avoid nausea and VR sickness from involuntary head motion, each user retained control over their own viewpoint.

Approximately sixty pairs of users, predominately children aged 10-14, tried the experience. Of these, around two-thirds had prior familiarity with their partner. Evaluation took the form of observations during the experience and brief verbal debriefings following the experience. Not a single person expressed an invasion of personal space despite sharing control of their avatar with another user. It should be noted that the control over the avatar was split evenly between the two users, and that perhaps an uneven control scheme would have a different effect.

**Conclusion**

In this paper, I have described how interpersonal space translates from the physical world into VR. Further, I have described how social VR avatars can differ significantly from established body representations used in research and how this gives interpersonal space in a social VR context certain unique and largely unexplored properties.
I present two preliminary findings about interpersonal space in social VR. First, given a large size difference between users, as well as abstract avatar representations (a floating head and hands), only the visible parts of the larger avatar appear to influence the smaller user's personal space. Second, given two users co-embodying and sharing control over a single avatar, there appears to be no sense of violation of the users' personal space.

The two projects described here represent my early work with interpersonal space in social VR. Controlled studies featuring established measures for interpersonal space are needed to more systematically determine the effects of unique avatar representations on interpersonal space in social VR, and also to empirically support the two preliminary findings presented above. I hope these pages demonstrate how interpersonal space is an important design factor in social VR experiences and serve to inspire readers to consider it in their work with social VR.

REFERENCES