

Proxemics in Virtual Reality: What Should We Put to the Test in Social VR?

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When approaching another user in social VR, there comes the point where we start to feel uncomfortable and intruded upon. Therefore, users maintain a personal space that is kept clear from others, much like in the real world. Although many determinants on the size of personal space have been identified, the process of maintaining and constructing a personal space in social VR is not well investigated, especially in multi-user environments. In the following, we will present the most important developments within the proxemic research field and raise opportunities and challenges for proxemics in social VR.

CCS Concepts: • **Human-centered computing** → **Virtual reality**; **Collaborative and social computing**.

Additional Key Words and Phrases: Virtual Reality, Social VR, Proxemics

1 INTRODUCTION

When a stranger approaches, there comes the point where we start feeling uncomfortable and intruded upon. Our feeling of an inappropriately large or short distance concerning another person can be conceived as personal space [6, 23]. While several determinants of personal space sizes have been established, the process of managing personal space in social virtual reality (VR) is not clear yet. We will present the most critical advances in the field of proxemics and VR below to motivate challenges inherent to social VR and highlight where social VR may enhance social interaction.

While proxemics in human-computer interaction (HCI) is mainly known for the interaction with ubiquitous devices, cf. [2, 4, 13], proxemics was first introduced in psychology to study the human-human interplay. Here, Sommer [19] was the first to investigate the phenomenon of personal space. He observed that schizophrenic patients chose more distant seating configurations than patients without. Later, Hall [5] described four distinct zones around the user defined by the interpersonal distance (IPD) which replicated in numerous empirical studies [6] and persist across cultures [5, 18, 20].

Personal space is also relevant in VR. In an innovative experiment by Bailenson et al. [1], users had to move through a virtual space to report a letter on an avatar's shirt while the minimum IPD was recorded without the user's awareness. This method offers an unobtrusive and highly naturalistic personal space measure in a controlled environment. Note, however, that this minimum distance may not correspond to the edges of personal space as it could be influenced by target size, body alignment, or user intention. Others have used more elaborate observation approaches, such as proxemic imaging [15] or passing distance [3]; however, they principally suffer from the same measurement issues as Bailenson et al. [1]. In a more indirect approach, Welsch et al. [23] presented participants with different IPDs, and participants rated their comfort level with the interaction distances. Mean distance for the point of minimal discomfort closely resembled IPD as measured by a stop-distance task.

The stop-distance paradigm, which is widely used for other purposes in VR settings, could circumvent some of the limitations mentioned above. For example, Iachini et al. [10] manipulated an avatar's perceived morality by pairing it with moral, neutral, or amoral descriptions. Participants produced the largest IPDs in trials with amoral descriptions, intermediate distances for neutral descriptions, and closest distances when moral descriptions were given. Furthermore, sex, age [9], personality [11], and facial expression [16] affected preferred IPD in VR.

Note that the studies mentioned above have relied on simulating a social interaction in VR. Thus, they tested only one user and did not consider the intricate patterns of communication or proxemics' negotiation within dyadic social interaction. Therefore, they should be regarded as simulated social VR; proxemic research in virtual spaces has to put the concepts obtained in simulation to social VR, i.e., testing with two or more users.

2 OPPORTUNITIES AND CHALLENGES

Tracking. To date, user tracking is one of the hard problems in the real world but important to study IPD, cf. Mayer et al. [14]. While with platforms like Mozilla Hubs, social VR experiences are easy to set up, these platforms are not conceptualized for user tracking or fine-grained experimentation. Thus, while the setup time is reduced to a minimum due to the missing logging capabilities, such platforms are not yet usable for conducting user IPD studies. Thus, researchers still have to implement virtual environments and user logging to do such research which is hard for non-developers.

Multi-User Environment. Indeed, only a few attempts have been made to test proxemic behavior in multi-user environments. In massive-multipayer online role-playing games, players not only respect others' personal space, but they also conform to proxemic patterns of gender [26], much like in simulated social VR and real-world interactions [7].

Social Appearance & Embodiment. Simulated social VR has reliably shown that the appearance of avatars affects judgments of IPD. Sex-effects, shorter distance to female avatars as compared to male avatars [7, 9] resembling real-world social interaction appear, but also more fine-grained effects of social affordances such as sexual attraction [25] on IPD are present in simulated social VR. Additionally, body-shape and its perception seem to affect proxemic behavior [21]. However, social VR offers a new possibility to change the appearance of the self-avatar. For example, one could assume a different gender by changing one's virtual character [8]. How this affects proxemic patterns has yet not been explored in social VR. Moreover, while the effect of missing limbs has been studied for embodiment [12, 17], the impact in a social VR setting is not clear yet.

Trans-cultural. Social VR allows us to meet people in different places, which allows trans-cultural social exchange without travel. Much like in proxemic research that considers effects of culture on social interactions in real spaces [18, 20], proxemic research in social VR may consider how users from different cultures make use of social space and how cultural exchange can be supported. For example, it is well known that people with a Japanese background prefer to keep larger distances to others as compared to German subjects [18], these differences may cause friction or misunderstanding in trans-cultural social interaction [5]. Social VR may enable users with different preferences in distance to seamlessly interact by scaling the distances in social VR individually.

Individual differences and privacy. Lastly, proxemic behavior in simulated social VR can be informative concerning personality. Social anxiety [11] and psychopathy [22, 24] influence IPD, meetings with female and male avatars can differentiate sexual orientation [25] and avoidance of skinny and fat avatars increases IPD in eating disorders [21]. Therefore, proxemic patterns in social VR may enable to derive certain personality traits. This could be used to pair users with regard to their personality or adapt the social VR but may also be exploited for other purposes that are not intended by the user. Therefore, with regard to the utility of proxemics, privacy becomes an issue to consider in social VR, especially when supplemented with other data such as dialogue in social VR, gaze, etc.

3 CONCLUSION

In summary, while many aspects of proxemics in VR have been studied in simulated scenarios. They have rarely been put to the test in social VR. Also, VR allows new ways of computer-mediated social interaction. With this, we highlighted several challenges to push proxemic research in social VR further and highlighted potentials for novel means to make use of space in social VR.

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