Chill or Warmth: Exploring Temperature's Impact on Interpersonal Boundaries in VR

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ABSTRACT

This position paper outlines a study on the influence of avatars displaying warmth or coldness cues on interpersonal space in virtual reality. Participants will engage in a comfort-distance task, approaching avatars exhibiting thermoregulatory behaviors. Anticipated findings include a reduction in interpersonal distance with warm cues and an increase with cold cues. The study will offer insights into the complex interplay between temperature, social perception, and interpersonal space.

Keywords: Interpersonal space, social proximity, temperature, environment

Index Terms: Human-centered computing—Human computer interaction (HCI)—HCI design and evaluation methods—User studies; Human-centered computing—Virtual reality

1 INTRODUCTION

Interpersonal space (IPS), defined as the spatial distance individuals maintain during social interactions for comfort, plays a crucial role in shaping our social experiences [4]. For instance, global events, like the COVID-19 pandemic, can prompt changes in interpersonal distances, like an increase of it due to contagion fears [7]. At the same time, situations that increase feelings of comfort, like seeing an avatar with a happy face, decrease the interpersonal space [14].

Cultural variations further contribute to the complexity of IPS, with individuals from warmer climates exhibiting different preferences compared to those from colder regions. In particular, people coming from warmer countries are more likely to stay close to strangers than people coming from colder countries [16]. Drawing on the Grounded Cognition theory [2], which underscores the interplay between cognitive functions and environmental factors, this paper emphasizes the necessity of incorporating such considerations in psychological studies, particularly in the realm of social space.

The integration of environmental variables into research on interpersonal space is facilitated by virtual reality (VR) technology, enabling the creation of standardized conditions that mimic real-world scenarios without compromising reliability. Previous studies employing VR have demonstrated its efficacy in investigating interpersonal space [9], utilizing both active and passive conditions [8]. Specifically, in *active* conditions, participants' task is to walk toward the avatar and to stop at the minimum distance they would feel comfortable for an interaction. Conversely, *passive* conditions encompass still participants and the avatar approaching them. Such tasks are known as Comfort-distance tasks. Notably, active conditions, where participants approach avatars or confederates, closely resemble real-life interactions.

This position paper describes our planned research that aims to extend the exploration of interpersonal space within VR to include the impact of temperature. By doing so, we will develop our understanding of how environmental factors influence interpersonal dynamics, contributing valuable insights to the broader field of social psychology.

2 RELATED WORK

Previous studies have highlighted how the word "warm" is not only related to the concept of physical temperature, but it can encompass a more general sense of comfort [10]. Expressions like "a warm person" or "a warm welcome" evoke positive attitudes, prompting an exploration of whether physical warmth can shape our perception of social environments. For instance, Williams and Bargh have shown that asking participants to hold a cup filled with a hot drink increases participants' positive ratings towards strangers and their probability of choosing a gift for a friend instead of choosing it for themselves [17].

More recently, Fay and Maner have demonstrated that wearing a warm back wrap reduced the participants' desire for social affiliation during cold days [6]. Such a result shows how physical warmth can substitute social warmth and emphasizes their connection. Zhong and Leonardelli provided additional evidence by showing that social exclusion led participants to perceive ambient temperatures as colder and express a heightened need for warm drinks and food than participants who experienced social inclusion [18].

In continuation of this literature, Ruggiero et al. investigated the impact of physical temperature on interpersonal distance using a VR experiment. While aligning with previous findings for women, the study yielded unexpected results for men, warranting further exploration. The question of whether the actual temperature of an environment influences interpersonal space remains unanswered [15]. However, the human capacity to perceive ambient air temperature raises the possibility that merely being in a warm environment, distinct from holding a warm object, could significantly affect preferred interpersonal distances.

The question of whether the actual temperature of an environment influences interpersonal space remains unanswered. Nonetheless, previous research has shown that humans are extremely capable of perceiving the temperature of the air surrounding them [3], raising the possibility that merely being in a warm environment, distinct from holding a warm object, could significantly affect preferred interpersonal distances. Simultaneously, it is plausible that the temperature cues conveyed by individuals we are required to approach exert an influence on interpersonal distance. A study conducted by Cooper and colleagues supports this possibility, revealing that observing individuals immersing their hands in warm water leads to a subsequent increase in participants' own hand temperature [5].

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Hence, our objective is to build an immersive scenario within VR where progressive levels of complexity will be added. In this scenario, the avatars that participants interact with will gradually exhibit indications of either warmth or coldness within an initially neutral environment. Subsequently, we plan to replicate a virtual environment that explicitly conveys sensations of warmth or coldness. Finally, we intend to conduct experiments within a climate chamber, wherein the actual environmental temperature will be systematically manipulated.

3 METHODOLOGY

In this section we outline our planned study to investigate the effects of avatars displaying warmth or coldness cues on interpersonal space.

3.1 Participants

In accordance with the recommendations from a priori power analysis for a t-test with an effect size of 0.5 and a power of 0.8, a cohort of 30 participants will be recruited (15 males and 15 females). Exclusion criteria will involve any history of discomfort or vertigo during VR use. Inclusion criteria will encompass normal or corrected-to-normal vision.

Additionally, participants will be required to complete the Empathy Quotient (EQ) questionnaire [1] to assess their empathy levels and the Body Perception Questionnaire (BPQ) [13] to evaluate their awareness of internal bodily states. These measures aim to discern the potential impacts of individual traits on susceptibility to external behavioral cues.

3.2 Material

The experimental setup will employ an immersive head-mounted display (HMD) equipped with an integrated eye-tracking system, such as the Meta Quest Pro or the HP Reverb G2 Omnicept Edition. The inclusion of eye-tracking technology is deemed essential to monitor participants' direct gaze toward the avatar during the task. We will use the Unity engine for rendering. The avatars will be both males and females, they will have an average height and body shape and will have an age comparable to the average age of college students.

3.3 Procedure

Before starting the experiment, participants will read the consent form and give their verbal consent. Following this, participants will be equipped with the HMD, immersing them in the VR environment. Within this VR setting, participants will be exposed to a room featuring an avatar positioned at a distance of 3 meters. An initial period of free visual exploration will precede the commencement of the experiment. The avatar will subsequently exhibit thermoregulatory behaviors indicative of warmth or coldness (e.g., sweating/shivering, unzipping/zipping a jacket, or combinations thereof). Participants will be instructed to approach the avatar and halt at the minimum comfortable interaction distance (comfort-distance task). The spatial distance will be measured and a new trial will begin.

Once the comfort-distance task will be over, participants will be invited to fill in the EQ and BPQ questionnaires. The strategic decision to position the questionnaire as the final step aims to mitigate potential cognitive biases, such as participants speculating on the significance of their empathy levels during earlier stages of the experiment.

During the baseline experiment, we anticipate a total of 12 conditions, 6 with a female avatar and 6 with a male one:

- Avatar sweating,
- Avatar shivering,
- Avatar unzipping the jacket,
- Avatar zipping the jacket,
- Avatar sweating and unzipping the jacket,
- Avatar shivering and zipping the jacket.

Each condition will be presented 4 times in a randomized order for a total of 48 trials.

The baseline experiment sets the stage for subsequent variations, including avatar-avatar interactions, direct avatar-participant communication during thermoregulatory behaviors, and alterations to the virtual room setting (e.g., open window with warm or cold outdoor views). Alternatively, the task could directly take place in a virtual outdoor environment. Lastly, the experiment will be replicated inside a climate chamber where also the actual environmental temperature can be manipulated.

4 HYPOTHESES

Considering the documented influence of others' thermal experiences on individual temperature perception [5], we posit that seeing an avatar show signs of warmth will elicit a generalized sense of warmth in participants. This could trigger a sense of comfort in the participants and subsequently result in a reduction of their preferred interpersonal distance. Conversely, the manifestation of coldness by the avatar could evoke negative affective responses, consequently expanding the perceived interpersonal space [11].

We anticipate the increasing significance of these findings with the incorporation of additional factors, including participant-avatar interaction dynamics and the introduction of a virtual environment with explicit warm or cold cues.

However, the prospect exists that the observation of an avatar sweating may instigate feelings of disgust or unease, prompting an expansion of interpersonal space as a coping mechanism to restore comfort [12]. Simultaneously, watching an avatar in a cold environment might stimulate a higher desire for social proximity, aligning with observations from the study conducted by Fay and Maner in 2019 [6].

5 CONCLUSION

This position paper highlights the connection between interpersonal space (IPS) and temperature and proposes a study design to investigate the influence of avatars displaying warmth or coldness cues on IPS. Building on previous studies associating "warm" language with comfort, the experiment encompasses a VR comfort-distance task with avatars executing thermoregulatory behaviors. Anticipated findings include a reduction in interpersonal distance with warm cues and an increase with cold cues. This experiment could offer insights into the complex interplay between temperature, social perception, and interpersonal space.

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