Proximity in VR: The Importance of Character Attractiveness and Participant Gender

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Abstract

In this study, we expand upon recent evidence that the motion of virtual characters affects the proximity of users who are immersed with them in virtual reality (VR). Attractive motions decrease proximity, but no effect of character gender on proximity was found. We designed a similar experiment where users observed walking motions in VR which were displayed on male and female virtual characters. Our results show similar patterns found in previous studies, while some differences related to the model of the character emerged.

Index Terms: Computing methodologies—Computer graphics—Graphics systems and interfaces—Perception; Computing methodologies—Computer graphics—Graphics systems and interfaces—Virtual reality

1 Introduction

Understanding the determinants of proximity towards virtual characters in VR has important implications for the design of interactions with avatars and agents for immersive environments. Proximity is the minimum distance people keep between each other when being together in a physical space and if it is breached, people will feel discomfort (see [4]). Proximity is affected by familiarity and cultural background. While gender of people was also found to affect proximity, no consistent patterns of the gender dyads have been described in real-word studies [1, 7].

VR allows tracking of exact distances of users through time and virtual space, therefore determinants of proximity can be accurately controlled [2]. When investigating gender dyads, experiments of Iachini et al. [5, 6] demonstrated that proximity was larger when participants were approached by virtual males and smaller with virtual females. They also found that female participants preferred further proximity from characters than male participants. A recent study in VR [8] using an androgynous virtual model to which walking motions of male and female actors were applied, did not detect the effect of character gender on the proximity. However, the effect of participant gender was found. In addition, they also showed that attractive motions reduced proximity distance [8].

In our study, we followed the procedure of [8] and applied a subset of their motions to realistic virtual models. We were interested if the addition of visual characteristics will reveal the effect of character gender on proximity, previously found by Iachini et al. [5], but not by Zibrek et al. [8]. We were also expecting that the attractiveness of character will be negatively correlated with proximity, as shown by Zibrek et al. [8].

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Figure 1: Female and male walking characters used in our study. Characters from left to right: F1, F2, F3, F4 and F5 (left image) and M1, M2, M3, M4, M5, M6 (right image).

2 Stimuli Creation

We designed our stimuli by using a subset of motions from motion captured actors in Zibrek et al. [8], which included walking animations of actors, rated predominantly (above 75%) as female or male (for details on the motion capture see [8]). Our final set of stimuli consisted of 6 male and 6 female actors.

The animations were exported to Unreal Engine 4.23 to a set of characters from the Rocketbox library of either male or female appearance, with respective motions applied, see Figure 1. Animation from one actor was retargeted to one character model in order to preserve the character's identity. This also reduced the exposure time in VR since all possible combinations of motions and models would explode the number of stimuli and increase fatigue and possible simulation sickness. The characters' facial expressions were neutral in order to prevent the effect of emotional expressions on proximity [3]. We used the same virtual environment as [8]: simple room with some furniture, to give reference of the distances with the size of standard objects in the surrounding. Participants were embodied in the environment with one of the Rocketbox characters, corresponding their gender, and which was not featured in the stimuli set. They could only move their hands while the feet were planted to the floor and their HMD was adjusted to the eye-level of the virtual characters.

3 Participants and Procedure

Eighteen participants (9 males, 9 females) took part in this experiment (in the initial set of 19, one participant did not identify as male or female, therefore this data was not included in our final analysis). The participants were mostly European (15), with an average age of 27 (min 21, max 38). 69% were experienced users in computer graphics and had around 1-5 exposures to VR. Ethical approval for the experiment was given by the committee for the evaluation of legal and ethical risks. After signing the consent form, the participants put on the head-mounted display (HTC Vive Pro) and were shown how to use the controllers to indicate their responses in VR. When resetting the HMD position, they could see the body of their virtual avatar.

In the first part of the experiment, the participants observed a

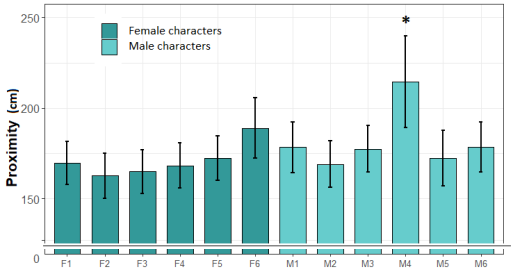

Figure 2: Average Proximity per Character. Vertical bars denote standard errors of means. The star shows statistical significance on the level of $p < 0.05$

character walking towards them, starting at the distance of approximately $9m$ away. The order of the characters was randomised for each task, with three repetitions of each walker (36 animations in total). Participants indicated by pressing the trigger on any controller as soon as the distance between them and the virtual character made them feel uncomfortable. In this moment, the Euclidian distance between the location of the centre of the mass of the character and the location of participant's HMD was recorded as the proximity measure.

In the second task, participants saw the same set of randomized characters and rated them by how attractive they found them on a scale from 1 (not attractive at all) to 7 (extremely attractive). The scale was displayed on a virtual table in front of the participants and they selected the answer by using controllers. The term "attractiveness" was explained prior to the task as the enjoyment of observing the character, and participants were asked to pay attention to the character's appearance as well as motion.

4 Results

4.1 Proximity

After checking the assumptions, a repeated-measure ANOVA with within-subject factors Character Gender (female and male) and the between-subject factor Participant Gender was conducted. We analysed the effect of Character (12 virtual models) with the between-subject factor Participant Gender using the Aligned Rank Transformation on the data prior to performing the ANOVA. Post-hoc tests were analysed using the Bonferroni correction.

We found a main effect of Character Gender on Proximity ($F(1,16) = 8.60, p = 0.010, \eta_p^2 = 0.35$), and Participant Gender ($F(1,16) = 8.44, p = 0.010, \eta_p^2 = 0.35$). As anticipated, female participants chose further proximity distances than males, overall. We also found that male characters increased proximity as opposed to female characters. However, after finding a main effect of Character ($F(11,176) = 4.53, p < 0.001, \eta_p^2 = 0.22$), the post-hoc revealed that M4 had the largest proximity ($p < 0.005$, for all male and female character comparisons) (see Figure 2). By removing M4 character from the analysis, the effect of Character Gender was not present anymore.

4.2 Attractiveness

We averaged Proximity distances and ratings of Attractiveness across participants to get average estimates of Proximity per Character. Pearson's product-moment coefficient showed a strong negative correlation ($r = -0.90, p < 0.05$), showing that attractive characters were allowed to approach the participants closer than less attractive characters. M4, which strongly affected Proximity distance, was also rated as least attractive. However, removing the attractiveness data of M4 still preserved the negative correlation ($r = -0.72, p < 0.05$).

We also found the effect of Character Gender on the Attractiveness ratings ($F(1,16) = 11.197, p = 0.004, \eta_p^2 = 0.41$), and again, M4 was the character whose attractiveness ratings were significantly different from all other characters ($p < 0.02$ for all comparisons). Importantly, we did not find an effect of Participant Gender on attractiveness ratings, showing that all participants rated characters similarly.

5 Discussion

Our results replicate the findings of Zibrek et al. [8] which found that the gender of the observer affects proximity in VR. We also found confirmation that attractiveness is negatively correlated with proximity in VR and an effect of character gender on proximity but a closer investigation showed that this was due to one particularly unattractive character (M4). This suggests that rather than gender, the individual characteristics of virtual humans are relevant for the proximity behaviour of users in VR. We also recorded larger proximity distances compared to [8] (females:$164cm$ vs.$209cm$, males: $92.5cm$ vs.$143cm$, respectively). This could be an indication that the current pandemic magnified the proximity distances of people.

Our study is a preliminary work into the investigation of proximity of virtual humans in VR, where a larger sample of participants would provide additional information about the effect of gender on proximity in VR. It would also be beneficial to randomize motions across different character models in the experiment in order to better understand how motion and appearance interact in the perception of virtual humans. Pre-testing the character stimuli set for gender and attractiveness on a separate participant sample would be of great importance, as this would make the conclusions about proximity more reliable and generalized. It would also be informative to use a male to female dimension scales as opposed to binary classifications of gender. A more natural environment setting in VR (interior of a building, train station) where characters are interacting with the participant in a natural way would also be an interesting future study. This would determine how the proximity of the users is affected in a more ecologically valid setting and would provide useful design guidelines for VR environments.

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