Social presence and place illusion are affected by photorealism in embodied VR

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Figure 1: Experiment conditions. The Realistic (*left*) and Simple (*right*) characters making eye-contact with the participant, embodied in the VR environment in a corresponding style.

ABSTRACT

Photorealism of virtual characters and environments is becoming more achievable in Virtual Reality (VR). With this development comes the need for further investigation into the role it plays on people's responses to characters. Whether or not these improvements make any difference to the perception and response towards the virtual character was the central question of the present study. In order to evaluate this, we designed a within-subjects experiment, where participants were embodied in a high-fidelity virtual body in VR and were observing an animated character, rendered in photorealistic and simplified style. The character displayed a simple interactive behaviour with the participant (eye-gaze) and was designed to express an emotional reaction to induce an empathetic response in participants. Our goal was to evaluate if photorealism alone is enough to increase self-reported and behavioural signs (interpersonal distance or proximity) of social presence, place illusion, and empathetic concern for the character in virtual reality. This was found to be the case for self-reported social presence and place illusion, while empathetic concern depended on the order of condition. behavioural measure proximity was not affected by render style.

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CCS CONCEPTS

• **Computing methodologies** → **Perception**; **Virtual reality**; *Animation.*

KEYWORDS

proximity, render style, embodiment, virtual reality

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1 INTRODUCTION

With the ever evolving field of computer graphics, we are becoming close to using near photorealistic characters and animating them in real-time for game and VR/AR applications. High-budget computer games, such as Red Dead Redemption 2 (2018) showcase incredible real-time animation, and powerful engines such as Unreal Engine 4 promise an almost instantaneous production pipeline for the generation of high-fidelity character animation. Little is known, however, how these changes will affect the viewers, particularly what would be the benefits of using such realistic characters in 3D graphics applications. In our current study, we focused specifically on characters in virtual reality (VR), since photorealism has only recently been made possible on this medium, while the immersive component of VR gives the opportunity to use more reliable and ecologically valid measures, such as analysis of users' behaviour in VR.

A vast body of research in VR showed that even simple environments and representations of a virtual character can evoke strong sensations of being present in a real environment (place illusion) and that a virtual character is alive and present in the virtual space with them (co-presence or social presence). Place illusion is created when the user interacts with the environment and receives an appropriate response [Slater 2009]. Social presence is elicited when the virtual character exhibits interaction cues, even as minimal as eye-contact [Bailenson et al. 2003]. Visual fidelity (realistic appearance and animation) of the character was not found to play a significant role in increasing social presence [Garau 2003; Nowak 2001]. However, the user's social presence can be reduced if the character's behaviour and appearance realism do not match [Bailenson et al. 2005; Garau et al. 2003; Zibrek et al. 2018]. It was also found that emotional reactions towards characters, rendered in visually realistic styles, can be more complex [Volante et al. 2016] and raise more empathetic concern [Zibrek et al. 2018] compared to non-realistic representations. Appearance can therefore affect the experience in the environment and with the character in VR.

Our current study investigates the effect of photorealism on social presence, place illusion and emotional reactions towards an expressive virtual character in VR. We created two render styles of the environment and character: realistic (which displayed the highest level of photorealism in our study), and simple (where photorealistic render effects were removed), while keeping the shape and animation the same. We investigated whether photorealism increases place illusion, social presence and concern (empathy) for the character. Our previous study [Zibrek et al. 2019], using the same character and environment, found that place illusion was higher in the photorealistic condition, while social presence and empathetic concern were not affected. Our new results show an increase in self-reported social presence in the photorealistic condition and some indication of an increase in empathetic concern as well, which was not found previously.

Since the previous study was limited in terms of space (it was run in a science museum on visitors of the exhibit), we were not able to use the behavioural measure of proximity (interpersonal distance between people) as an additional sign of social presence [Biocca et al. 2003]. In this paper, we present a laboratory study, where we measure proximity as the minimum passing distance around the character, indicating the level of comfort with the character. We changed the experimental task to accommodate this measure by embodying the participant in a virtual body. To avoid potential mismatches in the realism of the environment and the participant's virtual body, we accurately tracked the full body motion of the participant, using a high-fidelity virtual body, scaled in real-time to fit the participant's body proportions. We found that the feeling of embodiment was not affected by photorealism (as also reported in previous work [Lugrin et al. 2018]). However, we unexpectedly found that photorealism did not affect the minimum distance that the embodied participant approached the virtual characters (proximity behaviour).

1.1 Background

VR can be used as a tool to study the responses to virtual characters. For example, people can be tracked as they are walking around the character, and the minimum distance they keep towards it can be recorded. This measure (proximity) is used to study interpersonal relations observed in real human interactions, such as social status (see Latta [Latta 1978]), but proximity has also been established as a measure of co-presence or social presence with the virtual character [Bailenson et al. 2001, 2003, 2005]. Social presence is a feeling that a virtual person is actually present with the user in a virtual environment [Schultze 2010] and the user behaves with the character as if it was alive. To measure social presence, the proximity task can take the form of avoidance behaviour (e.g., the user needs to complete a task which requires moving around the virtual character [Fink et al. 2007]), moving towards it to read a label appearing close to the virtual character [Bailenson et al. 2003; Zibrek et al. 2017], or stopping distance, where the user has the control to stop the character when it gets to close to the user [Bönsch et al. 2018]. Social presence can also be measured with questionnaires or other observed behaviour of the user (e.g., mimicry).

It is not certain how appearance realism of the virtual character affects people's perception. While appearance realism of virtual characters is frequently investigated in terms of affinity, where a mismatch in elements of appearance could result in a negative reaction from the viewer [MacDorman et al. 2009; Zell et al. 2015], other studies, found that a realistic render style of the character was considered appealing, even when moving [Carter et al. 2013; McDonnell et al. 2012; Zibrek et al. 2018]. Increasing anthropomorphism levels of the virtual character was also positively correlated with co-presence, as shown by Nowak et al. [Nowak 2001]. Avoidance behaviour was also previously reported to be affected by a kind of appearance realism - people avoided crowds of virtual soldiers to a greater extent than a crowd of zombies, seemingly because zombies do not exist in real life [Bruneau et al. 2015]. However, no direct impact on people's responses was found in other studies, where the changing parameter was only visual realism of virtual humans [Bailenson et al. 2005; Garau et al. 2003]. A general finding suggests that appearance and behaviour realism of a character should match, as this enhances the naturalness in behaviour towards the character [Garau et al. 2003], and increases social presence [Bailenson et al. 2005]. A similar result by Zibrek et al. [Zibrek et al. 2018] found that certain personality traits were more appealing on particular stylizations of the character, e.g., a neurotic personality type was appealing when expressed by a character rendered in a realistic style, while the self-reported co-presence was higher for a Disney-style version of the same character, expressing an extroverted personality.

In order to increase the feeling of illusion of being present in the virtual environment, the user can be embodied in VR [Slater 2009]. Virtual embodiment was also found to be important for distance perception [Mohler et al. 2010; Ries et al. 2008] and collaboration style [Pan and Steed 2017]. The realism of the virtual body does not seem to be related to the feeling of embodiment (see for example the study of Lugrin et al. [Lugrin et al. 2018]) and the study of Slater and Steed [Slater and Steed 2000] used a very simple inverse-kinematics body for the user's avatar representation to induce a stronger feeling of presence in virtual space. Based on these studies, the avatar's appearance realism is not as important as the presence of the body. However, a study from Waltemate et al. [Waltemate et al. 2018] showed that participants exhibited higher presence in a virtual environment when the avatar was created based on their own body scans.

Another mark of a social response is emotional response and empathy. Empathy can be described as matching of affective experience between a participant and a target individual as described by Rameson and Lieberman [Rameson and Lieberman 2009] and can be tested with brain imaging techniques [Rameson and Lieberman 2009], behavioural response [Bouchard et al. 2013] or subjective reports [Davis 1983]. Research was conducted to investigate the effect of character rendering realism on empathy. A virtual patient rendered in a realistic style was more likely to induce negative emotional response [Volante et al. 2016], due to the difficulty of interpreting the facial expression of the character. A study conducted in VR [Zibrek et al. 2018], investigated the level of concern people expressed towards virtual characters. In a negative emotional scenario, the concern was higher if the character was rendered realistically, showing a possible positive correlation between empathy and visual realism of the characters.

Our previous study [Zibrek et al. 2019] investigated the effect of photorealism on a large sample of people who were visitors to a public exhibition, and found people reported higher place illusion, while unexpectedly, no effect on social presence was found and the empathetic concern was highest for the most stylized character. In our current study, we used the behavioural measure (proximity) while the participant was embodied in VR in a controlled laboratory setup, as embodiment would give additional immersion in VR, while proximity was used for the behavioural measure of social presence.

1.2 Stimuli Creation

We used a scripted emotional performance to a fictional situation from one female actor (Sad scenario from our previous study [Zibrek et al. 2019]). The purpose of this script was to induce an empathetic response in participants (see supplementary video of the actor's performance). The actor's body motion was captured using a Vicon optical system, consisting of 13 Vantage and 8 MX T40 cameras. 53 markers were attached to the main joints of the actor. For facial capture, we used a Technoprops head-mounted video-based system, and a Sennheiser microphone to record the actor's voice. Faceware Analyzer and Retargeter were used for facial animation. Faceware software was also used for retargeting the facial animation on the character.

We used the same virtual character and environment as in our previous study [Zibrek et al. 2019]: freely available photorealistic game-character model from Unreal Engine Marketplace [UEP 2018]. The animation and audio were kept the same as well. The character was displayed in Unreal Engine 4.19. (UE4). As in our previous study [Zibrek et al. 2019], the character had a simple eye-contact behaviour enabled, to give the illusion of being aware of the participant's presence in the virtual room [Bailenson et al. 2001].

We only used two of the three render styles from our previous study [Zibrek et al. 2019], as we were only interested in the effects of photorealism (Realistic style) in contrast to a simpler representation of the character (Simple style) and the room. For the Simple style, we removed the realistic lighting effects, shadows, and other shaders that created a realistic appearance, and material information (i.e., texture and normal maps, and set specular level to zero), but retained the color appearance (see Figure 1 (right)).

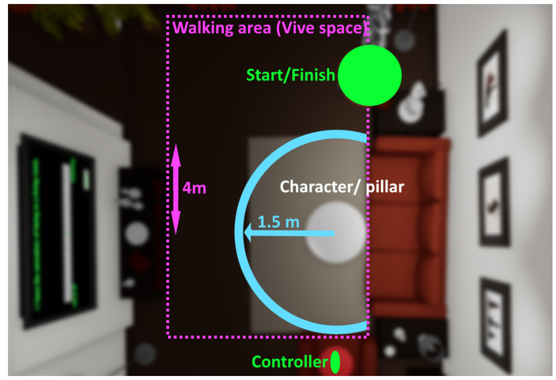

Figure 2: Top view of the virtual room.

1.3 Proximity Setup

The 21-camera Vicon motion capture system was used for tracking the participant's body movement and the HTC Vive system to track the participant's HMD and global position in space, for which the tracking area was set to 2×4 metres. We used two separate computers to process the Vicon motion capture data and for the VR Unreal scene. The two tracking spaces, Vicon and Vive were perfectly aligned by matching the position of the Vive motion controllers in the Vicon tracking space to the exact location in the Vive tracking space. When a participant was wearing the HMD, their virtual body was in the same position as their real body.

The virtual room was designed to enable a reliable measurement of the proximity task. The rooms had a tracking space, free of virtual obstacles, such as furniture or walls, of $1.5m$ radius surrounding the center of the room, where the virtual character was standing. One side of this radius was obstructed by the virtual couch so participants would be forced to take a longer route around the virtual character to the armchair where the controller was placed, in order to complete the task. See Figure 2.

1.4 Embodiment Setup

Real–time full–body tracking of participants was achieved with Vicon's Shogun software. The software solves the skeleton in real–time, while the body mesh of the skeleton template adjusts automatically to the skeleton size. This enables a precise and realistic display of the body motion of the participant, since both motion and size are similar to the participants actual body. The scaleable virtual body mesh (male or female) was then streamed into Unreal via the LiveLink plugin. The appearance of the body template was a dark grey tight-fitting suit with white stripes to retain body shape information, with no facial features as they could not be animated with our setup (see Figure 3).

The equipment consisted of the Vive headset and controllers, headphones, and a chair which was placed in the same position as the virtual armchair in the virtual environment. The participants had to wear a tight fitting lycra motion capture suit, shoes, and headband, with 53 markers placed on these items. The finger and facial motion could not be captured with the motion capture setup therefore we excluded it and informed the participant about this.

1.5 Experiment Design

We created a within-subjects experiment, where all participants saw both realistic and simple style conditions, while the order of which condition they saw first was randomized. Each condition had two parts - the training and experiment room. While the training room was designed for the participant to get used to the environment and to embody in the virtual body, it also served as a proximity comparison, where instead of the character, the room contained a pillar of the same diameter and position as the character (see subsection 1.6.2) .

This within-subjects design is also different than our previous study [Zibrek et al. 2019], where one participant saw only one condition. The reason for the current design, where each participant saw both render styles, is due to the way we measured proximity. Proximity behaviour varies greatly between people [Fink et al. 2007; Hall 1979], therefore comparing differences of the behaviour depending on the conditions should be done within-subjects.

1.5.1 Participants. Twenty-seven participants applied for the experiment, 11 females and 16 males, with an average age of 27 (±5) years. University department ethics approval was secured for the experiment and participants were invited to read and agree to the approved consent form before starting the experiment. While we were able to collect data from 27 participants, 8 of them were excluded from our analysis due to technical difficulties. There were two main reasons for the dismissal: headset not displaying the environment or dropping frames, and motion data not displaying properly in the environment. These issues were caused due to the amount of streamed data and equipment overheating problems, which resulted in inability to use the equipment or lagging/freezing of the HMD display. The participants were dismissed if the issues could not be solved within the 1 hour time which was dedicated to the experiment as stated in the ethics form. All the remaining 19 participants had no technical issues, therefore their data was used in the analysis.

1.5.2 Procedure. Participants were first asked to sign the consent form and answer some demographics questions. When finished, they put on the motion capture suit and performed a series of motions for the calibration of their virtual skeleton. After, they were introduced to the experimental task: they will explore a virtual living room displayed on their HMD, and they will first see the training room, then the experiment one. They will then repeat both rooms again (we did not inform them that the render style will change).

They were informed that they were allowed to receive help from the experimenter if they got stuck at any point with completing the tasks in the environment but that this support should be avoided when not in the training condition, if possible. They were then shown the controller and explained how to use it to answer questions and with the help of the experimenter, they were then given the headset, and a set of headphones to put in their ears (see Figure 3).

1.5.3 Training Room. In this room, the participant was introduced to his or her virtual body and familiarized with the task. They saw a virtual body which matched theirs in size and in gender (female or male body shape). They could take time observing themselves in the mirror and look down at their body while performing body motions (see Figure 3) and then move through the room to retrieve the controller, with which they turned on the virtual television. The questions were displayed on the television and not floating in space or placed some other way in the environment in order to provide a realistic feeling of being in an actual living room. The questions asked about the participant's body ownership and place illusion. A white pillar was in the environment, with the same location, diameter and height as the virtual character they would observe in the next room. Their HMD position was tracked while they were moving through the space and the distance they walked from the pillar was also recorded.

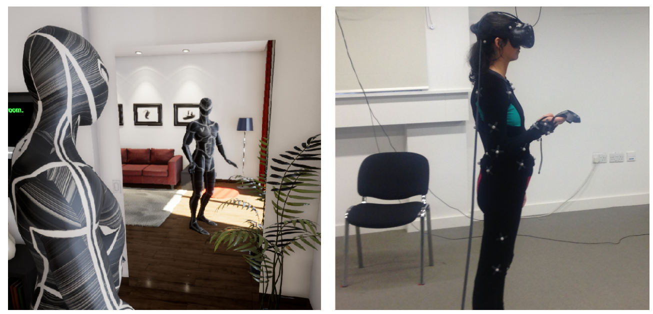

Figure 3: *Left*: embodied male participant observing himself in the virtual mirror. *Right*: female participant wearing a motion capture suit and a HTC Vive headset.

1.5.4 Experiment Room. When they returned to the initial starting position, marked with a red spot on the floor, the virtual character was loaded in the room and started talking when the participant's HMD rotated towards it. After the sound stopped, the participant's HMD position was tracked through space again, this time with the virtual character following the participant with her head and eye rotation (i.e., look-at function activated). When they reached the controller and turned on the television, they answered an additional question about their concern for the virtual character as well as reported their body ownership and place illusion. After they answered all the questions, they returned the controller, walked back to the red spot and the experiment self-terminated.

1.6 Measures

We used a combination of subjective and behavioural measures for our experiment. Both measures were recorded in the VR environment.

1.6.1 Subjective responses. We designed a questionnaire, which was displayed on the virtual TV in the environment. The questions were rated on a 7–point Likert scale, ranging from *1 – Not at all* to *7 – Extremely*. The first *Concerned* scale measured empathetic concern for the character ("The girl[1] I just observed made me feel concerned.") and was a modified item from IRI questionnaire [Davis 1983]. The following questions about Body Ownership and Place Illusion were adapted after the studies of Slater et al. [Slater et al.

[1]We used a less formal term "girl" as we determined that it would fit better to her young appearance than more formal descriptors (woman, female, character, etc.)

2009, 2010]. The Social presence questionnaire was taken from Bailenson et al. [Bailenson et al. 2003]. Table 2 in the Appendix shows the questions used in the experiment.

1.6.2 Behavioural Measure. For the behavioural measure, we used proximity, which is the minimum distance a person takes to the virtual character when performing a task. The task in our experiment is similar to the design used by Lee et al. [Lee et al. 2018]. The participant was instructed to pick up the motion controller which was placed in the armchair behind the virtual character or pillar (Figure 2). This way, when leaving the starting point, the participant had to avoid the obstacle. When moving, the HMD position was tracked in space and the minimum distance towards the obstacle was recorded before the HMD passed it. We also recorded the passing distance on the way back to the starting point. According to the literature [Bailenson et al. 2003], people approach other people from the back more closely than the front, therefore we wanted to assess if this was the case in our sample as well. We also analyzed the minimum distances the participant kept towards the pillar in the training as opposed to the character in the experiment room. If the distances the participant kept towards the pillar and the character were significantly different, we would conclude that the virtual character was perceived differently than just an object/obstacle in the environment.

2 RESULTS

To explore the most robust effects of Render Style (Realistic, Simple) on people's subjective responses, we analyzed the subjective scales separately. The measured scales were: Concerned, Body Ownership, Place Illusion and Social Presence. We also analyzed possible effects of demographics (Gender, Familiarity with CG characters, Gaming Experience, Native speaker) on the dependent variables, however, as we did not find any effects of the participants' demographics, they are not further discussed in our analysis.

Scales Social Presence and Body Ownership consisted of multiple subscales or items. When tested for reliability, Cronbach's alpha for the 5 Social Presence items for the Realistic Render Style was: $\alpha = 0.78$ and for Simple: $\alpha = 0.84$. We therefore averaged over the scores and used the final result in the analysis. Similarly, for Body Ownership, we averaged over the 3 items due to sufficient reliability (Realistic: $\alpha = 0.76$ and Simple: $\alpha = 0.83$).

To compare the Concern responses depending on Render Style, we conducted Student's T-tests for dependent samples. If the variables were not distributed normally, we used Wilcoxon's Signed Rank test for comparison. We also explored potential effects of between-factor variable Condition, which would tell us if the order in which style was seen first made a difference to the responses of participants. As the compared groups were small and of unequal size (12 participants who saw Simple first and 7 who saw Realistic first) we used a non-parametric Mann-Whitney U test. To estimate the effect sizes, Cohen's d (T-test) or Rank-biserial correlation (Mann-Whitney and Wilcoxon) were calculated.

For Proximity, the minimum distance, expressed as Euclidian distance of the current camera (user) position and the virtual character position in the virtual space, was calculated. We conducted an ANOVA with within–subject factor Level (Training Realistic Room, Realistic Room, Training Simple Room, Simple Room). The data was tested for sphericity and possible breaches corrected for with the Greenhouse–Geisser test.

Table 1: Descriptive statistics for Minimal Distance for 4 experiment levels: Means, standard deviations (SD), and standard error (SE). Realistic T. and Simple T. are training conditions, while numbers in the parenthesis signify passing back distances.

	N	Mean (*cm*)	SD	SE
Realistic T.	19	70.01 (78.03)	11.95 (15.82)	2.74 (3.63)
Realistic	19	69.95 (73.36)	15.31 (13.56)	3.51 (3.11)
Simple T.	19	73.12 (71.68)	22.53 (16.30)	5.17 (3.74)
Simple	19	66.97 (75.49)	22.53 (14.18)	4.12 (3.25)

2.1 Proximity Analysis

To better represent the complexity of the Proximity value, we analyzed the behavioural response based on two types of values: Minimum Distance, which was calculated as the minimum distance between the center of the virtual character and center of the HMD position just before the participant passed the character. We recorded the minimum distance while the participant was returning back to the starting point and passed the character.

We did not find any significant differences for proximity (see Table 1). There was also no significant difference between both forward and passing back distances, or training and experiment measures of Proximity. When tested for correlation with Social Presence, the subjective responses did not correlate with the Proximity measures, as would be expected. In conclusion, the Proximity measures did not detect any differences in behavioural responses to realism levels.

2.2 Body Ownership

The participants reported a sufficient feeling of Body Ownership (Figure 4), with the mean rating of 5.2 ($SD = 1.3$). We found no significant effects or interactions of Render Style on the variable Body Ownership. The feeling of embodiment was therefore not intensified with photorealism.

2.3 Social Presence

We found a significant difference in Social Presence, where participants felt more present with the Realistic virtual character than the Simple one ($t(18) = 2.45, p = 0.025, d = 0.56$), see Figure 4.

2.4 Place Illusion

Wilcoxon Matched Pairs Test showed a significant difference between the Realistic room and Simple room ($Z = 2.02, p = 0.04, r = 0.46$), where the realistic environment increased the place illusion, see Figure 4.

2.5 Condition

We also tested if the responses were different depending on which style of the character participants saw first (between-subject factor Condition). We found this to be the case for the variable Concerned

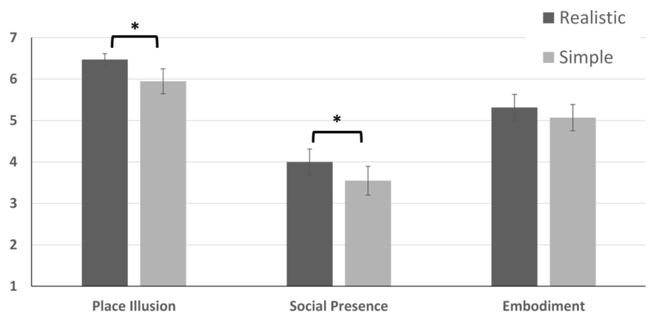

Figure 4: Differences in average subjective responses depending on the *Render Style* for Place Illusion, Social Presence and Body Ownership. Star labeled lines point to significantly different means ($* = p < 0.05$).

($Z = 2.16, p = 0.031, r = 0.60$), where participants who saw Realistic character first, reported less concern for the Simple character than the participants who saw the Simple one first. This result indicates that concern for the Simple character was relative to the Realistic condition which was seen before it.

3 GENERAL DISCUSSION

In our study, we investigated if photorealism could increase social presence, place illusion and concern for a virtual character in VR. We did so by measuring people's subjective and behavioural responses to a photo-realistic virtual character in a corresponding environment, and a simplified version of both. We also embodied the participant in the room by using real-time full-body motion capture. While we did find confirmation for the effect of photorealism on self-reported social presence and place illusion, no differences in proximity were found depending on the render style condition. In addition, people did report less concern for the stylized character but only if they saw the photorealistic style first.

The result that social presence and place illusion were affected by the change of render style of the virtual character and environment has not been consistently shown in previous research investigating the importance of appearance realism in virtual reality, apart from anthropomorphism [Nowak 2001; Nowak and Biocca 2003] and matching behaviour and appearance [Bailenson et al. 2005; Garau et al. 2003]. Our study is one of the rare studies showing an increase in social presence with a virtual character and place illusion based only on higher rendering quality of the character and environment. A recent literature overview on social presence by Oh et al. [Oh et al. 2018] provided a possible explanation for this: when individuals are only given limited communication options (in our case it was a specific interaction by passively listening to the character), the technological features of the environment might have a stronger influence on the level of social presence a person feels. Many applications include limited communication, e.g., observing characters in immersive movies or theatre. Therefore, for these use cases, higher render quality could increase the feeling of presence in VR and with the character.

We expected photorealism will also increase people's empathetic concern, however this only happened when participants saw the stylized character first. Why this effect was present is uncertain. It could indicate that emotional concern for the stylized character was under cognitive control and of comparative nature, while the realistic one was not. Since the sample size was small and the effect size was medium, future investigation with a larger sample and multiple response scales is needed to confirm this finding.

Despite the reported presence with the character and the illusion of being in a living room, the behavioural measure of proximity did not confirm any differences in participant's comfort or discomfort of approaching the character depending on the render style. This result could be attributed to a number of factors. While we followed some standard practices of proximity measure [Fink et al. 2007; Lee et al. 2018], we could not effectively control the conditions as specified in the mentioned studies due to the nature of our task. In Lee et al. [Lee et al. 2018], the participant trajectories were averaged over a number of trials in the same condition, while for our task we could only record one trial in the same environment due to the conversational character (i.e., repeated trials could desensitize participants to the emotional content of the character, which could influence the proximity measure). We also wanted to keep an element of exploratory behaviour present for the participants to have a more natural experience of the situation, however, with this we sacrificed some of the control for an accurate proximity measure. This made analysing other characteristics of the recorded motion of participants (e.g., walking speed, body torque) prone to more errors so we opted out of investigating it. In future, considerations about the trade–off between naturalness of behaviour and control of environment should be explored.

We also found no effect of photorealism on the strength of the feeling of embodiment, as expected. A newer study by Waltemate et al. [Waltemate et al. 2018], showed however, that virtual presence increased if the virtual body was taken from the actual scans of the participant. A future study, using the scanned body of the participant, should therefore be considered.

There are also some limitations to this study. The only available model we could use was a stereotypical game-industry female model; future work should investigate more variances in appearance of both male and female models. Also, our sample size was not as large as in our previous study [Zibrek et al. 2019]. There are also limitations with within-subjects experiment designs, namely the training and transfer from one condition to the other. While investigating order effects, however, the only variable affected was empathetic concern for the character. The results of social presence and place illusion were not affected by condition order, therefore we conclude that the higher ratings in the photorealistic condition were not affected by the cognitive comparison to the stylized condition.

4 CONCLUSION

We found photorealism increases the self-reported measures of social presence and place illusion in VR, while no effect on the behavioural measure of proximity was found. We also found a possible link between empathetic concern and render style. The generalization of these findings applies to characters of limited interaction with the user, e.g., immersive movies.

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A APPENDIX

Table 2: Subjective response questions arranged by group and variable name. Each statement could be answered on a scale from 1 – "Not at all" to 7 – "Extremely".

Group	Variable Name	Statement
Emotional Response	Concerned	*"The girl I just observed made me feel concerned."*
Body Ownership	Mirror	*"I feel like the body I saw in the mirror was my own body."*
	Own Body	*"When I look down on my body I feel like the virtual body is my own body."*
	Agency	*"I feel as if the movements of the virtual body are caused by my movements."*
Place Illusion	Room	*"I have the sensation of being in a living room."*
Social Presence	Item 1	*"It feels as if I am in the presence of another person in the room with me."*
	Item 2	*"It feels as if the girl is watching me and is aware of my presence."*
	Item 3	*"The thought that the girl isn't real crossed my mind often."*
	Item 4	*"The girl appears to be alive."*
	Item 5	*"The girl is only a computerized image, not a real person."*