Avatar Realism and Social Interaction Quality in Virtual Reality

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ABSTRACT

In this paper, we describe an experimental method to investigate the effects of reduced social information and behavioral channels in immersive virtual environments (IVEs) with full-body avatar embodiment. We compared physical-based and verbal-based social interactions in real world (RW) and virtual reality (VR). Participants were represented by abstract avatars that did not display gaze, facial expressions or social cues from appearance. Our results show significant differences in terms of presence and physical performance. However, differences in effectiveness in the verbal-based task were not present. Participants appear to efficiently compensate for missing social and behavioral cues by shifting their attentions to other behavioral channels.

Index Terms: H.5.1 [Information Systems]: Artificial—Augmented and Virtual Realities

1 INTRODUCTION

It has been stated, that "*avatar realism is critical to the future of collaborative virtual environment development*" [1]. Steed and Schroeder identified *avatar realism* as one of the main factors that affect interpersonal interactions and co-presence in VR [8], subdividing *avatar realism* into both *appearance* (faithfulness of its representation, e.g. photo-realistic graphics) and *behavioral realism* (realistic and natural physical behavior, e.g. blinks). Despite demands for the improvement of appearance level [2], realism and sensory modalities are still limited in current immersive systems, as user's facial expression and eye gaze are typically not faithfully replicated. These missing cues can have a critical impact on interpersonal understanding and recognizing intentions [8, 9]. However, their exact impacts have not yet been systematically investigated in immersive VR with fully embodied avatars. One important question is: how, and in what context interlocutors will "compensate" for these missing cues, and to what degree their experiences and performances will be affected.

2 EXPERIMENT

We designed an experiment to investigate the effects of reduced social information and behavioral channels in VR compared to the real world in the context of two common collaborative tasks: a physical-based task- a *passing-ball game* (Figure 1) and a verbal-based task- a *negotiation role play* (Figure 2). Participants were immersed in a two-person VR environment simulating a simple room.

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We used faceless wooden mannequin avatars, as we did not want to transmit artificial behavioral or social cues. Participants experienced the simulation in first-person perspective through a head-mounted display (Oculus Dk2). Their movements and motions were replicated to their avatar in real-time (OptiTrack, Unity3D). A video measurement similar to [5] resulted in an end-to-end latency of $128.75ms$.

We applied a 2 (order: RW first vs. VR first) x2 (scenario: RW vs. VR) mixed design. In each scenario the ballgame was performed first. After the ballgame, one of two role plays (negotiate a price of a second-hand TV, negotiate a pickup point for a shared ride) was performed. The two topics were permuted through the sample. The following measures were conducted:

- **Simulator sickness** [6]: To filter participants with too high levels of discomfort.

- **Networked Minds subscales** [3][4]: *Attentional Allocation*, *Perceived Message Understanding*, *Perceived Affective Understanding* and *Perceived Behavioral Interdependence*.

- **Presence** [7]: *Self-reported copresence*, *Perceived others co-presence*, *Social Presence* and *Telepresence*.

- **Behavioural Cue Focus**: We asked to which behavioral cues most attention was paid or which had been missed the most.

- **Task performance:** We measured the time to completion and error rate for the ball game, and agreement, time to consensus and interaction with objects for the role play.

3 RESULTS

The sample included 36 participants (20 females and 16 males, $(M_{age} = 25.25, SD_{age} = 4.46)$. The experiment took about $1^1/_2$ hours including an average VR time of approximately 11.5 minutes. In terms of collaboration experience, we noticed significantly lower values in VR for *attention allocation*, *perceived message understanding*, *perceived affective understanding*, *perceived behavioral intention* and *perceived others co-presence aspects* (Table 1).

In the verbally driven *negotiation scenario* only two couples did not find a consensus in time (5 minutes max), limited to the first scenario in sequence. Comparisons for the time to reach a consensus in the negotiation task showed that there was no significant difference between RW ($M = 153.43s, SD = 37.72$) and VR ($M = 176.29s, SD = 51.73$), $t(13) = 1.754, p = .10$. As a potential explanation, we observed that participants shifted their focus of attention to different cues in VR. Face and gaze cues seem to have be compensated for by increased of attention towards partner body movement, approximately 50 % more in VR than RW (Table 2).

In the *physical task*, subjects performance was lower in VR. The number of errors (pass with the wrong foot, touched ball more than one time) was significantly lower in RW ($M = 0.91, SD = 1.25$) compared to the VR ballgame ($M = 3.281, SD = 1.99$), $t(31) = -6.786, p < .001$. In addition, subjects needed longer to pass the ball in VR ($M = 85.88s, SD = 28.19$) than in RW ($M = 24.63s, SD = 4.00$), $t(15) = -8.85, p < .001$.

4 CONCLUSION

This paper presented empirical results of an evaluation paradigm to improve the understanding of social mechanisms and interaction quality in VR. Our results confirm that social interactions tend to be impeded with non-realistic avatars, a finding that is visible in the subjective ratings (networked minds). In our physical task, the interaction showed significant differences in performance, which could be due to the disturbed visuomotor synchronization caused by latency, as well as the approximation of physicality in the VR condition. However, differences in effectiveness in the communicative role play were not present. Therefore, our results suggest that the absence of important behavioral cues such as gaze and facial expression can partly be compensated, which is in line with research suggesting a functional approach of computer-mediated communication [10]. This is an important finding for VR practitioners and researchers as abstract avatars (such as our mannequin) provide universal generic representations of a human which are simple to be produced and animated.

Future work will explore the limitations and opportunities of avatar abstractness in VR mediated interactions with the integration and comparison of facial expression and gaze, in order to point developers towards appropriate system architectures for social and communicative VR.
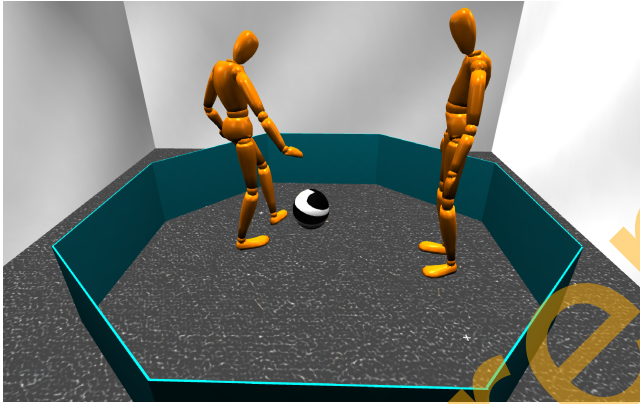

Figure 1: VR Passing-ball game (participants had to pass the ball ten times in three repetitions by touching the ball just once with their non-dominant foot).
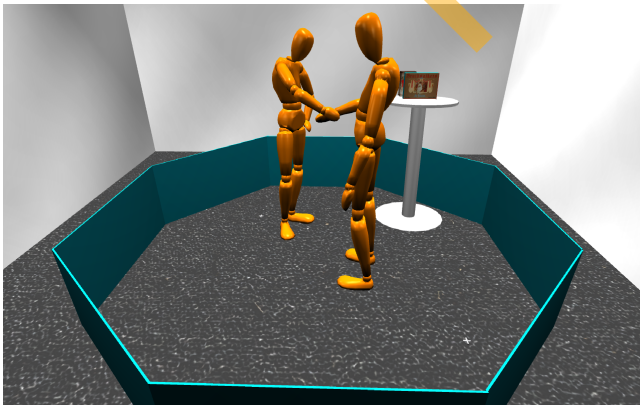

Figure 2: VR Negotiation game (participants had to negotiate a price of a second-hand TV, or negotiate a pickup point for a shared ride).

Table 1: Overall Network Mind and Presence Scores.

	Real World		Virtual Reality		P-value	Effect
	M	SD	M	SD	p	ηp^2
Attentional allocation	5.85	0.84	4.94	1.3	.000**	0.33
Perceived message understanding	5.77	0.84	5.08	1.17 1	.000**	0.36
Perceived affective understanding	5.01	0.91	4.29	1.07	.001*	0.27
Perceived behavioral interdependence	5.26	1	4.92	1.17	0.05	0.11
Self-reported copresence	3.51	0.78	3.37	0.66	0.246	0.04
Perceived other's copresence	3.82	0.59	3.62	0.66	0.052	0.11

Table 2: Overall Behavioural Cue Focus Scores.

Behavioral Cue	Real World	Virtual Reality	Difference
Gesture	17	16	9
Facial Expression	24	-	31
Body Movement	10	23	4
Speech	24	28	4
Gaze Behavior	26	-	31
Others	0	1	1

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