Avatar Realism and Social Interaction Quality in Virtual Reality

Daniel Roth*
University of Würzburg
University of Cologne

Jean-Luc Lugrin†
University of Würzburg

Dmitri Galakhov‡
TH Köln

Arvid Hofmann§
University of Cologne

Gary Bente¶
Michigan State University
University of Cologne

Marc Erich Latoschik‖
University of Würzburg

Arnulph Fuhrmann**
TH Köln

Abstract

In this paper, we describe an experimental method to investigate the effects of reduced social information and behavioral channels in immersive virtual environments 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 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 [7], 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 influence interpersonal understanding and the recognition of intentions [7, 8]. 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 social interactions: a *physical task* - a ball game (Figure 1) and a *verbal task* - a negotiation role play (Figure 2). Participants were immersed in a two-person VR environment simulating a simple room. 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 [4] resulted in an end-to-end latency of 128.75*ms*.

We applied a 2 (order: RW first vs. VR first) x2 (scenario: RW vs. VR) mixed design. In each scenario the ball game 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** [5]: We measured simulator sickness to filter participants with too high levels of discomfort.
- **Networked Minds subscales** [3]: *Attentional Allocation*, *Perceived Message Understanding*, *Perceived Affective Understanding* and *Perceived Behavioral Interdependence*.
- **Presence** [6]: *Self-reported copresence*, *Perceived others co-presence*, *Social Presence* and *Telepresence*.
- **Attentional Focus**: After each scenario, subjects were asked to which behavioral cues they paid special attention to during the role play, and which they missed the most (VR only).
- **Task performance:** We measured the time to completion and error rate for the ball game, and agreement, time to consensus and interaction with the environment 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 1½ hours including an average VR time of approximately 11.5 minutes. In terms of collaboration experience, we noticed significantly lower values in VR for *attentional allocation*, *perceived message understanding* and *perceived affective understanding* (Table 1).

In the *verbal task* two couples did not find a consensus in time (5 minutes), limited to the first scenario in sequence. Comparisons for the time to reach a consensus in the role plays showed no significant difference between RW ($M = 153.43s, SD = 37.72$) and VR ($M = 176.29s, SD = 51.73$), $t(13) = 1.754, p = .10$. Mean values of the individual scenarios (no pairwise exclusion) were $M = 159.63s$ for RW and $M = 164.94s$ for VR. As a potential explanation, we observed that participants shifted their attentional focus towards body movement (RW= 10, VR= 23) and speech (RW= 24, VR= 28, Table 2). In both scenarios, RW and VR, 17 subjects interacted with the environment (table or objects) during the role play.

In the *physical task*, the 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 ($M = 24.63s, SD = 4.00$), $t(15) = -8.85, p < .001$.

*e-mail: daniel.roth@uni-koeln.de
†e-mail: jean-luc.lugrin@uni-wuerzburg.de
‡e-mail: dmitri.galakhov@googlemail.com
§e-mail: ahofman4@uni-koeln.de
¶e-mail: bente@uni-koeln.de
‖e-mail: marc.latoschik@uni-wuerzburg.de
**e-mail: arnulph.fuhrmann@th-koeln.de

IEEE Virtual Reality Conference 2016
19–23 March, Greenville, SC, USA
978-1-5090-0836-0/16/$31.00 ©2016 IEEE

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 [9]. 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.

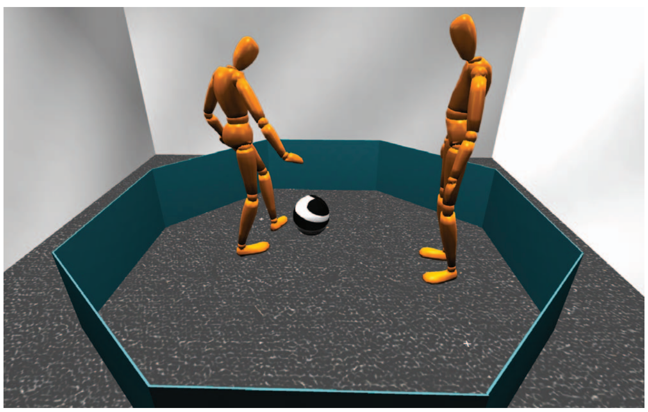

Figure 1: VR ball game. Participants had to pass the (virtual) ball ten times in three repetitions by touching the ball just once with their non-dominant foot. For the RW task we used a regular soccer ball.

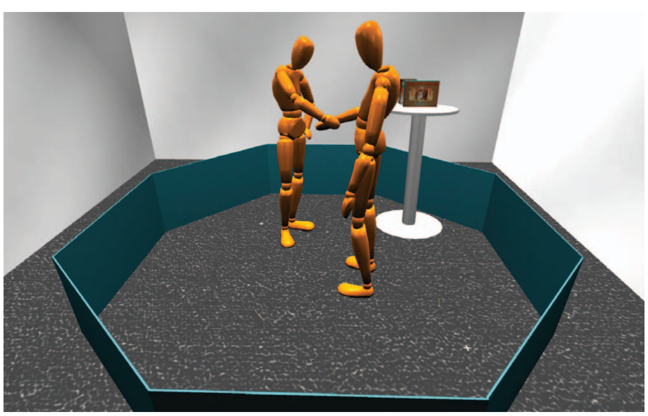

Figure 2: VR negotiation role play. Pparticipants had to negotiate a price of a second-hand TV, or negotiate a pickup point for a shared ride. The table and objects were present as real objects in the RW scenario to compare interactions with the environment.

Table 1: Results of the networked minds and presence subscales.

	Real World		**Virtual Reality**		**P-value**	**Effect**
	M	*SD*	*M*	*SD*	*p*	ηp^2
Attentional allocation	5.85	0.84	4.94	1.30	.000**	0.33
Perceived message understanding	5.77	0.84	5.08	1.17	.000**	0.36
Perceived affective understanding	5.01	0.91	4.29	1.07	.001*	0.27
Perceived behavioral interdependence	5.26	1.00	4.92	1.17	.050	0.11
Self-reported copresence	3.51	0.78	3.37	0.66	.246	0.04
Perceived other's copresence	3.82	0.59	3.62	0.66	.052	0.11

Table 2: Attentional focus. The numbers indicate the sum of subjects that rated the behavior as beeing in special focus (VR, RW) or missing for impression formation (VR). A '-' indicates cues not present.

	Cue in Focus		**Cue Missing**
Behavioral Cue	Real World	Virtual Reality	Virtual Reality
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

References

[1] J. N. Bailenson, N. Yee, D. Merget, and R. Schroeder. The effect of behavioral realism and form realism of real-time avatar faces on verbal disclosure, nonverbal disclosure, emotion recognition, and copresence in dyadic interaction. *Presence*, 15(4):359–372, 2006.

[2] D. Bombari, M. Schmid Mast, E. Cañadas, and M. Bachmann. Studying social interactions through immersive virtual environment technology: Virtues, pitfalls, and future challenges. *Frontiers in Psychology*, 6(869), 2015.

[3] C. H. Frank Biocca and J. Gregg. The networked minds measure of social presence: Pilot test of the factor structure and concurrent validity. In *4th annual International Workshop on Presence Philadelphia*, pages 1–9, 2001.

[4] D. He, F. Liu, D. Pape, G. Dawe, and D. Sandin. Video-based measurement of system latency. In *International Immersive Projection Technology Workshop*, 2000.

[5] R. S. Kennedy, N. E. Lane, K. S. Berbaum, and M. G. Lilienthal. Simulator sickness questionnaire: An enhanced method for quantifying simulator sickness. *The International Journal of Aviation Psychology*, 3(3):203–220, 1993.

[6] K. L. Nowak and F. Biocca. The effect of the agency and anthropomorphism of users' sense of telepresence, copresence, and social presence in virtual environments. *Presence: Teleoper. Virtual Environ.*, 12(5):481–494, Oct. 2003.

[7] A. Steed and R. Schroeder. Collaboration in immersive and non-immersive virtual environments. In M. Lombard, F. Biocca, J. Freeman, W. IJsselsteijn, and R. J. Schaevitz, editors, *Immersed in Media*, pages 263–282. Springer International Publishing, 2015.

[8] W. Steptoe, O. Oyekoya, A. Murgia, R. Wolff, J. Rae, E. Guimaraes, D. Roberts, and A. Steed. Eye tracking for avatar eye gaze control during object-focused multiparty interaction in immersive collaborative virtual environments. In *Virtual reality conference, 2009. VR 2009. IEEE*, pages 83–90. IEEE, 2009.

[9] J. B. Walther, B. Van Der Heide, A. Ramirez Jr, J. K. Burgoon, and J. Pea. Interpersonal and Hyperpersonal Dimensions of Computer-Mediated Communication. In *Handbook of the Psychology of Communication Technology*. John Wiley & Sons, Inc, 2015.