Avatars for Co-located Collaborations in HMD-based Virtual Environments

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Abstract

Multi-user virtual reality is transforming towards a social activity that is no longer only used by remote users, but also in large-scale location-based experiences. Usage of realtime-tracked avatars in co-located business-oriented applications with a "guide-user-scenario" is examined for user-related factors of Spatial Presence, Social Presence, User Experience and Task Load. A user study was conducted in order to compare both techniques of a realtime-tracked avatar and a non-visualised guide. Results reveal that the avatar-guide enhanced and stimulated communicative processes while facilitating interaction possibilities and creating a higher sense of mental immersion for users and engagement.

Keywords: Virtual Reality, Co-located Collaborations, Head-mounted Display, Avatars, Social Presence

1 Introduction

The usage of avatars in social Virtual Reality (VR) appears to be straightforward, as remote users need to be visually represented. But what about co-located multi-user VR? Related to the business sector, location-based collaborative VR provides a variety of possibilities regarding virtual product presentation or industrial training with a local group of users. Such "guide- user-scenario" use-cases, where an expert, trainer or a salesman are together with users, raises the question of whether a real-time-tracked visualised guide is beneficial for users personal experience. We investigate the following question: Does a realtime-tracked avatar-guide in a co-located collaborative interactive virtual environment (IVE) enhance Spatial Presence, Social Presence, User Experience and Task Load for users? In order to be able to answer that question, a comparison has to be made between the realtime-tracked avatar-guide and a non-visualised-guide, using audio.

Slater et al. [7] investigated on small group behaviour while performing a task in shared virtual environment (VE) rather from a technical, than from a social point of view They show that "personal responses to social situations" are also reclaimable, even though the visual representation of each other is limited.

Roth et al. [6] confirm the impeding tendency of non-realistic avatars on social interaction, but point out, that the lack behavioural cues like gaze and facial expression can partly be compensated. Additionally, the effectiveness in a communicative role-play with a verbal task in VR and the same in the real world did not differ. Lugrin et al. [4] also found in a comparing experiment, that user performance and user experience is to a certain degree "not degraded by abstract or iconic visual representations". In the study of Heidicker et al. [1] a fully mapped complete avatar body caused the highest level of co-presence, but an avatar only consisting of head and hands was not significantly worse.

Latoschik et al. [2] measured higher *Illusion of Virtual Body Ownership* with realistic avatars compared to wooden mannequin avatars. Investigating further in the impact of a "self-avatar" in a SVE, Pan and Steed [5] measured quicker task completion times in a collaborative task with two users having a self-avatar compared to two users just having visual representations of controllers.

2 Method

Forty volunteers participated in the study. Answers to specific VR-usage-frequency questions showed that more than half of the participants have used stationary VR devices. After the experiment, three subjective key measurements were performed: Sense of spatial- and social presence, Task load, and User Experience. The first measurement *Sense of spatial- and social presence* has been performed based on the Temple Presence Inventory (TPI) [3], which especially takes a "social component" into account. To measure *Task Load*, the raw NASA TLX was used. User Experience was measured with the User Experience Questionnaire (UEQ)[1]. In addition to the subjective measurements, times and errors have been logged within the system for each participant and task.

The environment is a large modern factory hall with machines. Tree trunks on a conveyor belt and pallets of identical plain wooden chairs indicate the wood processing function of the assembly line. The guide explains the factory and the machines. Participants take over the role as the new factory workers and need to know what is produced.

Figure 1: Exemplary machine with sliders highlighted by audio-guide (with no visual avatar)

The tasks at each machine differ slightly from each other and consist of pushing buttons and sliders (see Figure 1). Every task requires logical thinking, while the guide is only giving technical hints to solve the task and a monitor attached to the respective machine gives a hint to the outcome of the machine.

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[1] https://www.ueq-online.org/

2019 IEEE Conference on Virtual Reality and 3D User Interfaces
23-27 March, Osaka, Japan
978-1-7281-1377-7/19/$31.00 ©2019 IEEE

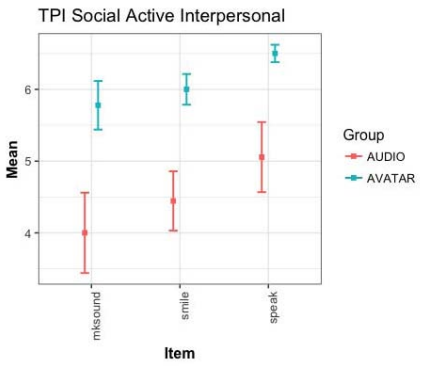

Figure 2: Means and standard errors for Social Active Interpersonal subscale

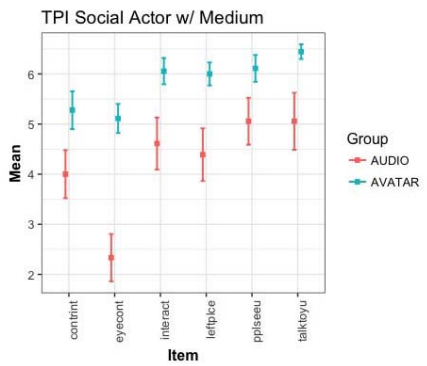

Figure 3: Means and standard errors for Social Actor W/I Medium subscale

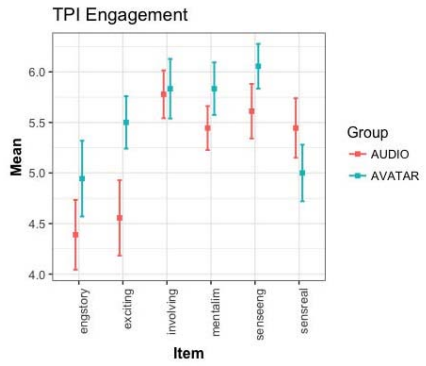

Figure 4: Means and standard errors for Engagement subscale

3 Results

At first, reliability was tested with Cronbach's Alpha for the TPI and UEQ questionnaires. For the two independent samples, significance was found with the non-parametric Mann-Whitney-U rank sum test. Assuming greater means with the AVATAR group, a one-tailed test provided significant results for the TPI items. The AVATAR-group reached higher values in terms of Social Presence. Especially for the subscale "Social Active Interpersonal" (see Figure 2) the AVATAR group reached clearly higher means for the three items "How often did you make a sound out loud [...]" (mksound), "How often did you smile in response to someone [...]" (smile) and "How often did you want or did speak to a person [...]" (speak).

Furthermore, the subscale aiming at "Parasocial Interaction" named Social Actor W/I Medium also showed diverse item means between the two groups (see Figure 3). AVATAR group participants reported a higher "control over the interaction with the person they saw/heard" (contrint), a higher feeling of being able to "interact with the person they saw/heard" (interact) as well as a higher "sense of leaving the place they were" (leftplce). Moreover, the items "How often did you want or did you make eye contact" (eyecont), "How often did you have the sensation that people you saw/heard could also see/hear you" (pplseeu) and "How often did it feel as if someone you saw/heard in the environment was talking directly to you" (talktoyu) were also rated higher than in the AUDIO group.

Besides social presence, the subscale "Engagement" aiming at "mental immersion" reached higher means with the AVATAR group for almost every item (see Figure 4).

4 Discussion and Conclusion

Initially and in line with the expectations derived from related work, the study showed higher results for the AVATAR group in terms of "Social Presence". Especially active interpersonal interactions showed up to be stimulated by an AVATAR-represented guide in a location-based space. This positive effect on participants appeared not only in the will of reacting to the guide by making a sound or smiling as a response, but also as a trigger for self-induced verbal conversation. In this connection the avatar can be interpreted as a catalyst for active social interaction. Not only inter-personally but also through the medium of the virtual environment, the AVATAR-guide tends to be beneficial compared to the audio-based one, as the avatar seems to have a relieving influence on the control of interaction, as well as on interactions themselves. Beyond that the feeling of "leaving the place you currently are and going to another place" was also higher. Therefore, he appears as a massive intensifier for the feeling of "being somewhere new" while he provides an audio-visual as a tracked person compared to just audio. As the better control of interaction and interaction possibilities with the avatar could also carry a certain feeling of security for a user, this might be the reason for the better active interpersonal interaction the AVATAR group showed. The AVATAR group also achieved better results in the questions asking if people participants saw/heard could see/hear/talk to them which again can be attributable to a misunderstanding of the question. According to engagement, the overall story tended to be more engaging and was significantly more exciting for AVATAR group participants. As the story was entirely identical and the only difference was the absence of an avatar for the guide in the AVATAR groups, it stands to reason that the avatar not only has an influence on social interaction but also enhances the presented story, surrounding and exercises subjectively. We have shown that simple avatars controlled only by head-mounted display (HMD) and controller can be considered as valuable social elements in the design of co-located collaborative interactive virtual environments.

Acknowledgments

The experiment was set up in the premises of Burmester Event- und Medientechnik GmbH, who also provided all technical equipment.

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