Optimizing social interactions in VR

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Abstract

Technological developments have made Virtual Reality (VR) technologies accessible, and have democratized its use for industrial, cultural or entertainment purposes. VR can be seen as a unique medium: while being immersed together in a virtual environment (VE), people can feel the presence of each other as if they were in the same physical space even if they are far apart in reality. This phenomenon is known as co-presence. The VR medium introduces specific factors influencing on the dynamics of the social interaction. This PhD project aims at understanding that dynamics through the study of co-presence.

1 Introduction

Social interactions can be defined as a reciprocal influence between individuals (Stébé, 2007), influenced by the social and physical environment (Newcomb, 1953). Social interactions are essential for human beings. Social identity emerges from the interaction between the individual and their social environment (Luckmann and Berger, 1989). The onset and development of one's social identity are linked to social representations, which are defined as conceptual constructs stabilizing one's relationship with their environment. They guide one's understanding of the world and helps to adapt to it with the considered right actions and practices (Rouquette and Rateau, 1998). The understanding of one's physical environment rises from one's interactions with this environment. Based on past experiences, the brain "predicts" possible events and the actions to be taken to reduce the probability of "surprising" events (Friston, 2010). Social interactions are as well largely determined by this prediction system. In VR, it is possible to recreate realistic social situations and if they correspond to the brain's predictions, participants will react in a realistic way (their behaviors and emotions will be similar to the ones they would experience in a real situation) (Slater, 2009; Hortensius et al., 2018).

Technological advancements allow for multi-user VR applications, where each user is represented by an avatar, enabling social interactions within the VR. For reciprocal influence in social interaction, it is necessary for users to feel co-presence (Schroeder, 2006; Zhao, 2003), through avatars.

Therefore, this PhD project is guided by three general research questions: Which parameters are essential for communication and social interactions between individuals in reality? Which of these parameters can be reproduced in VR? Which parameters are essential for communication and social interaction in VR?

2 Co-presence in VR: experiments

To better understand the dynamics of social interaction in VR, understanding co-presence is necessary. To achieve this, we have created a collaborative VR application (Fig. 1) with a shared goal. Two participants viewed and reproduced a virtual pattern, aiming to gain points by correctly replicating the patterns. The participants were physically located in separate rooms. In the VE, each of the participants was represented by a full-body avatars, sitting in front of each other, separated by a virtual glass. This application allowed us to measure social behavior through hand movements and task performance (score and completion time) as objective measures, in addition to subjective questionnaires measuring, e.g., social presence (Harms and Biocca, 2004), motion sickness (Keshavarz and Hecht, 2011), emotions (Russell et al., 1989), mental state sensibility (Baron-Cohen et al., 2001) and embodiment (Gonzalez-Franco and Peck, 2018).

Figure 1: First-person view during the VR collaborative task.

2.1 Impact of Social Representation on Co-presence in a VR Collaborative Task

The objective of our first experiment was to objectively measure co-presence. To achieve this, we established an experiment designed to induce variations in co-presence by changing the social representation of the virtual partner, using the VR application described above. Abric's study (Abric, 1989) indicates that a change in behavior is observed when the social identity of a partner is changed (e.g., between human and machine). In one condition, participants were told collaborating with a student situated in another university (human condition), and in the other condition they were told they were interacting with an AI controlling the avatar sitting in front of them (AI condition). In reality, participants collaborated with each other in both conditions.

The main results indicate significant differences in co-presence levels between the AI condition and the human condition. However, no significant differences were observed in terms of task performance. Though, no other significant differences were found in the questionnaires. We suggest that the social representation of AI explains these results,

Figure 2: The avatar appearance tested in the experiment, from left to right the meshed avatar to point-cloud avatars with decreasing number of points. Equivalence for Male avatar were enable.

leading to differences in co-presence and not in performance (score and completion time). This aligns with the studies of Abric (Abric, 1989) and Poinsot (Poinsot et al., 2022). Additionally, a correlation test demonstrated a correlation between co-presence and elements of social interaction, and not with task performance, confirming that co-presence is subjective and that performance cannot be used to objectively measure co-presence.

2.2 Metaphor for Representing Human Movements: Does the Avatar Appearance Really Matter?

Based on this first experiment, we studied how co-presence varies as a function of how participants' movements are represented (avatar appearance) during the same collaborative task. For this new experiment, the VR device was different (Quest Pro instead of Quest 2), as well as the relationship between participants (known virtual partner instead of unknown or AI). We compared point-cloud avatars with meshed avatars, varying the number of points, resulting in four different avatar versions (Fig. 2). Each avatar was animated and used the same motion capture system.

Initial results show differences in terms of embodiment, especially in External Appearance (Gonzalez-Franco and Peck, 2018), and no differences in social presence, emotions and performance.

3 Towards a First Attempt to Describe the Dynamics of Social Interaction in VR

Our two studies help us to better understand co-presence: a subjective feeling linked to social interaction. By defining co-presence as "being there together" in the VE, we suggest that multiple factors contribute to shape this perception.

First, as presented in the introduction, each individual has their own "internal model" (Friston, 2010): identity, social representations, predictions and *qualia*. Each individual has a unique experience of the world and therefore, their own beliefs about it. Secondly, the specificity of VR introduces various factors that can impact the experience: **Hardware** (e.g., beliefs about it or prior experience with it, ergonomics, or brand); **VE**

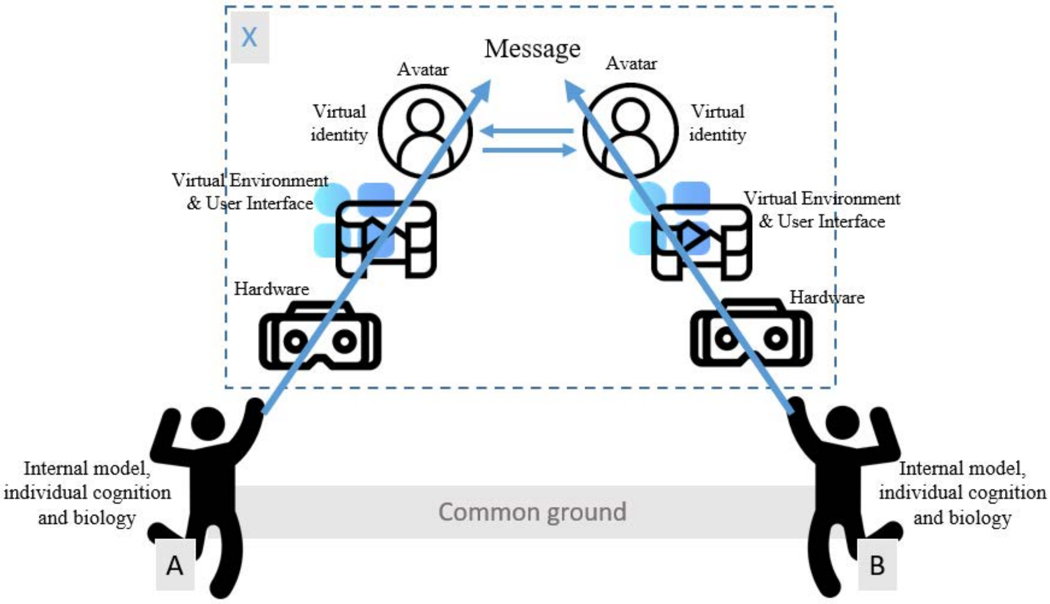

Figure 3: Dynamics of social interactions in the VR proposed model, inspired by Newcomb's ABX model (Newcomb, 1953).

and User Interface (e.g., complexity, colors, shape); **Virtual identity** (e.g., avatar appearance, movement fidelity, embodiment, Proteus effect (Yee and Bailenson, 2007)). Each factor has a reciprocal influence with individuals: the internal model influences the perception of each factor, and each factor can influence the user (e.g., Proteus effect, cybersickness, presence, etc.). Finally, social interaction can be modelled by considering the relationship between interlocutors, the physical and social environment and the common ground (Tomasello, 2010).

Hence, we propose a model representing the dynamics of social interaction in VR, following up on Newcomb's ABX model (Newcomb, 1953) (Fig. 3). In VR, social interactions do not occur directly between the two actors (A and B), but through their avatars. We therefore propose a sequence of factors impacting this interaction, accounting for the user's experience of VR. The resulting message is constrained and influenced by the entire preceding sequence; its form and content are impacted. If one aspect (A,B or X) changes, the entire dynamics changes as well.

4 Conclusion and perspectives

The feeling of co-presence results from a set of influencing factors specific to the VR experience and personal experience, implemented in a dynamics of social interaction mediated by VR technology. Optimizing social interactions in VR requires an understanding of whether there are different levels of impact from these factors. We can suppose that the avatar plays an important role: social interaction is effective through it, as well as the understanding of others: verbal and non-verbal communication.

A potential direction involves applying the Proteus effect (Yee and Bailenson, 2007) in reverse: using abstract avatars that allow users to project their own body perception onto a minimal, neutral digital body, thus reducing bias introduced by avatar appearance.

To conclude, this work aims at understanding better social interactions in VR. With a social psychology perspective and the study of co-presence in a collaborative task, we have proposed a model of the dynamics of social interaction in VR. The following questions can be addressed and will be studied: How to validate or upgrade this model? Can it be used as a reading grid for developers, or to analyze and help make the analysis of mediated social interactions more systematic?

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