Influence of point of view and technology in presence and embodiment

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ABSTRACT

Presence and embodiment have been reported to modulate the experience in virtual worlds. However, while these perceptions are presumably interconnected, little research has been done to unveil the nature of this relationship. In this study we show how presence and embodiment are modulated by the point of view of a virtual body and the enabling technology while being engaged in a virtual task.

1. INTRODUCTION

The sense of presence has been suggested to be the key mechanism that makes virtual reality work. Even though there is no standard definition, presence can be understood as the psychological state in which the virtuality of the experience is unnoticed (Slater, 1999). Presence has been shown to be modulated by both human (demographic, psychocultural, and clinical) and media characteristics (technology used and content of the virtual world). Technology facilitates immersion, it is, the delivery of an illusion of reality to the senses of a human participant, as well as presence (Slater, 1999). As a proof, immersive head mounted displays (HMD) can provide higher level of presence than PC monitors, even though differences can be non-significant (Mania et al., 2001; Baños et al., 2004). However, the relationship between immersion and presence is not one-to-one. Emotional valence has been shown to increase presence even with low levels of immersion (Baños et al., 2004). Embodiment is a multi-component psychological construct that involves body-ownership, the sense that the body that one inhabits is his/her own, localization, the sense that the body is located congruently with the sensory inputs, and agency, the sense that one can move and control his/her body (Tsakiris, 2010).

When interaction in the virtual world is mediated by virtual bodies or avatars, special considerations about presence and embodiment should be made. With regards to the presence, the relationship between self-construal, the extent to which individuals view themselves either as an individual entity or in relation to others, and this sense has been previously revealed (Jin et al., 2009). With regards to embodiment, different studies have also shown how virtual limbs and bodies can come to feel like real limbs and bodies (Slater et al., 2009). Similarly to presence, not only the technical aspects but the characteristics of the avatar modulate embodiment. Hence, the use of a first-person perspective has been shown to elicit higher ownership over avatars (Slater et al., 2010; Pavone et al., 2016), and, furthermore, the characteristics of the embodied avatar have shown to modulate the users' perception of the virtual world and their behaviour (Yee et al., 2007).

Even though presence and embodiment seem to be mutually dependent little is known about the nature of this dependence. The objective of this study was to examine the sense of presence and embodiment elicited while interacting with a virtual environment (VE) using different immersive settings and point of views.

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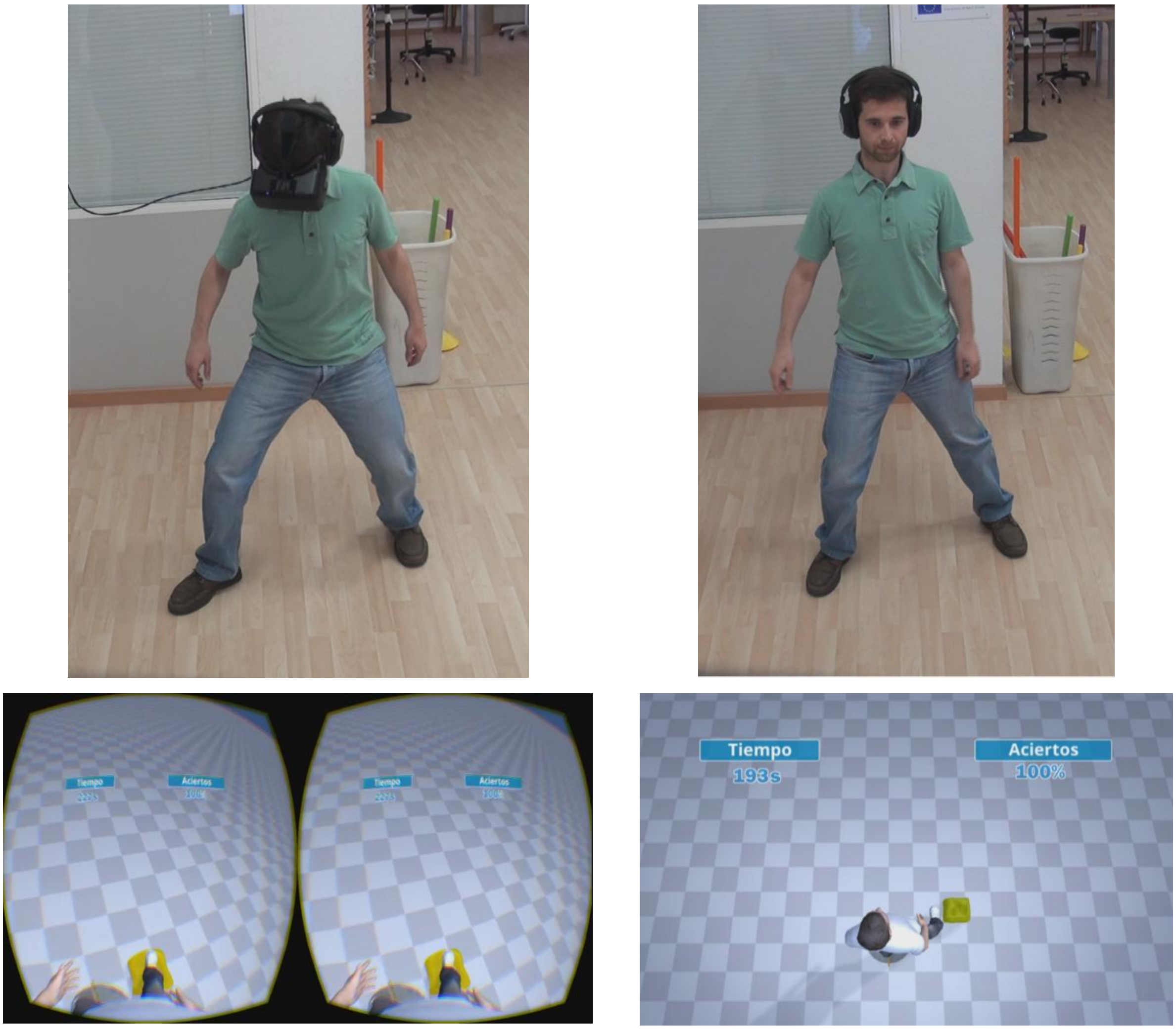
2. METHODS

2.1 Instrumentation

Visual feedback was provided by an HMD in the first-person condition (Figure 1.a) or a TV in the third-person condition (Figure 1.b). The Oculus DK2 (Oculus VR, Irvine, CA) was used as HMD. The device has a resolution of 960x1080 per eye, a field of view of 100º, an update rate of 60 Hz and provides its Euler angles (yaw, pitch, and roll) through a built-in gyroscope and accelerometer. A 60″ LED Screen (LG, Seoul, South Korea) with a resolution of 1920x1080 was used for the other condition. Auditory feedback was provided by a Bluetooth headset HDR 170 (Sennheiser electronic GmbH & Co. KG, Wedemark, Germany). Motion tracking was provided by a Kinect™ for Windows® v2 (Microsoft, Redmond, WA), which provided the position and rotation of the main joints of the participants at 30 Hz. In the first-person condition the orientation and acceleration of the head was retrieved from the Euler angles of the HMD. A high-end computer was used to generate VEs in both conditions. The hardware components of the computer included an 8-core Intel® Core™ i7-4790 @ 3.60 GHz, 8 GB of RAM, and a NVIDIA® Geforce® GTX 745 with 4GB of GDDR3.



(a) *(b)*

Figure 1. *Participants interacting with the exercises and snapshots of the virtual environment in the (a) first and (b) third-person condition.*

The VE consisted of a checkered floor with a darkened circle of 25-cm radius in the middle of the scenario. Different geometric items (cubes, spheres, and cones) of 20 cm^3 volume appeared around the circle in eight different areas defined around the circle. Participants were represented with a male or female avatar that mimicked their real movements in the VE. The point of view in the VE depended on the experimental condition: the VE was seen through the eyes of the avatar in the first-person condition (Figure 1.a) or from an overhead perspective in the third-person condition (Figure 1.b).

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The objective of the exercise was to step on the shapes with the nearest foot while maintaining the other foot within the boundaries of the circle. After each step, the foot had to be repositioned towards the body and enter the circle. Items disappeared after 30 s if they were not reached. In contrast to previous studies with this VE (Llorens et al., 2015; Llorens et al., 2015), the two rear areas were disabled in both conditions because they could not be seen in the first-person condition. 3D auditory cues were provided when items appeared and disappeared. In addition, a cheerful and upbeat background music was used to motivate the participants. During the exercise, the remaining time and the success percentage were displayed in the VE. After the exercise, the total success percentage was shown.

The virtual environment was designed using Unity 3D (Unity Technologies, San Francisco, CA).

2.2 Participants

Twenty-five participants (18 men and 7 women) without musculoskeletal or cognitive disorders were recruited for this study. Two of them experienced cyber sickness during the exercise (in the first-person condition) and were not able to complete the experiment. Consequently, their data were not included for analysis. A total of 23 subjects with a mean age of 28.7±6.4 years old, 23.3±5.8 years of education, and a self-rated experience with videogames of 7.1±2.89 over 10 were included in the study (results expressed in terms of mean and standard deviation). All of the participants provided written informed consent before taking part in this study.

2.3 Procedure

All the participants interacted with the exercise for 10 minutes in the first and third-person condition in counterbalanced order. Two experimenters were in charge of conducting the sessions, equipping the participants, and providing safety, guidance, and comfort. Before each condition, participants were briefly introduced to the technology and the objectives of the exercise.

After each condition, the presence and embodiment experienced during the exercise were assessed using two questionnaires. The presence questionnaire consisted on three items rated on a 7-point Likert scale that evaluated the sense of being in the VE, the extent to which the VE becomes real, and the extent to which the VE is thought of as a place visited (Slater et al., 2000). The embodiment questionnaire evaluated in 10 items rated on a 7-item Likert scale the extent to which the avatar movements answered to the participant movements, the body of the avatar belonged to the participant, and the avatar was in the same location than the participant (Longo et al., 2008). Scores to both questionnaires were averaged and ranged from 1 to 7.

2.4 Data analysis

Scores to the questionnaires after both conditions were compared with independent sample t-tests. The α level was set at 0.05 for all analyses (two-sided). All analyses were computed with SPSS for Windows®, version 22 (IBM®, Armonk, NY, USA). Investigators performing the data analysis were blinded.

3. RESULTS

Significant differences in presence and embodiment were found in both conditions (Table 1). When analysing the different constructs of embodiment, user's perspective and technology proved to influence body-ownership and localization, but no agency.

Table 1. *Scores to the presence and embodiment questionnaires. Results are expressed in terms of mean and standard deviation.*

Construct	Third person	First person	Significance
Presence	4.03±1.25	5.32±0.82	p=0.000
Embodiment	5.05±1.11	5.57±0.81	p=0.008
Body-ownership	4.36±1.40	5.30±1.00	p=0.001
Localization	4.74±1.48	5.36±1.00	p=0.036
Agency	6.04±0.82	6.04±0.69	NS

4. CONCLUSIONS

Users felt significantly higher sense of presence when the VE was displayed in first person and used the HMD. Our results could support previous studies (Mania et al., 2001; Baños et al., 2004) and maybe evidence how the improved features of the current HMDs could intensify these effects, which would support the influence of immersion in presence. This finding could be specially relevant as far as the latest technological advances could modify some old paradigms of VR, which should be revisited with the current technology.

Users also reported higher embodiment of the avatar when it was shown in first person through the HMD. When analysing the constructs separately, differences were only found in body-ownership and localization but not in agency. It is, while participants felt that they were able to move the virtual body regardless of the point of view and the technology, they only felt that the virtual body was their own and that it was located as their real body when they saw the VE in first person though the HMD. Even though the design of the study did not allow to isolate the effects of the point of view and the technology, our results could support the important role of vision on embodiment and, beyond this, the role of the previous experience on its constructs. The congruence in the visual stimulation between the real and the virtual world (life is experienced in first person view), could have motivated higher results on ownership and localization. Interestingly, the congruence in the continuity of a virtual body provided higher sense of ownership while having no effects on agency (Perez-Marcos et al, 2012). These findings should be confirmed in further studies because they may be of great importance when designing virtual experiences.

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