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Being Present In Space: The Role Of Allocentric And Egocentric Reference Frames

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Abstract. The general aim of the present study was to investigate the effect of an interactive aerial view of the experienced environment during the encoding and retrieving of spatial information on the feeling of presence. Our findings showed that this real-time interactive aerial view (both small and large) during the encoding and retrieval of spatial information seems to lead to a greater sense of presence. It is argued that the use of this aerial view, which provides a real-time allocentric viewpoint-dependent spatial representation, would ease the translation of a stored allocentric representation into an egocentric one, and this process, consequently, would help individuals to feel present in space.

Keywords. Presence, Allocentric Reference Frame, Egocentric Reference Frame, Virtual Reality

1. Introduction

Far from being only a technological issue, in recent years the concept of presence has emerged as an interesting topic in different research fields, from psychology to neuroscience. Within this perspective, presence is a broad psychological phenomena not necessarily linked to the experience of a technology: An individual is present in a space –real or virtual– when he/she can successfully act in and perform according to his/her intentions [1]. Therefore, the experience of presence is strictly related to a spatial one; however, the relationship between presence and space is seldom investigated in the scientific literature. First, it is crucial to understand how we organize spatial information to build a cognitive model of our environment. The starting point requires considering the distinction between two reference frames used to organize spatial information, egocentric and allocentric [2]. An egocentric reference frame represents subject-to-object relationships, while an allocentric reference frame constitutes object-to-object relations, which are unrelated to an individual’s orientation. From a neuroscience perspective, Burgess and colleagues provided an interesting

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framework to explain how the continuous interaction between these crucial spatial relationships allows individuals to navigate the surrounding environment effectively and locate themselves in space [3, 4]. When prompted by a retrieval cue, the individual can retrieve the full representation of an experienced spatial environment from long-term memory through the process of pattern completion. This allocentric spatial representation is translated into an egocentric representation in the medial parietal areas using contributions from other cells. Starting with Burgess and colleagues' model, Serino and Riva [5, 6] proposed that it may be critically important to include another neurocognitive process (namely, the *mental frame syncing*) in spatial processing to consider the role of the alignment of viewpoints. When we orient ourselves in an environment or when we retrieve the position of an object in a scene, we must first encode and memorize an abstract structure of the spatial scene, including all relevant landmarks and their reciprocal relationships (namely, an allocentric viewpoint-independent representation). Second, we must impose a specific viewpoint on this abstract allocentric scene (namely, an allocentric viewpoint-dependent representation) to ease its translation into an egocentric representation. The general aim of the present study was to investigate the effect of an interactive aerial view of the experienced environment during encoding and retrieving of spatial information on the feeling of presence. It was hypothesized that this aerial view, which provides a real-time allocentric viewpoint-dependent representation, would ease the translation of a stored allocentric representation into an egocentric one, and this process, consequently, would help individuals feel present in space. To achieve this aim, spatial layouts were encoded and retrieved in a Cave Automatic Virtual Environment (CAVE) because this setup provided the possibility to introduce an interactive aerial view of the experienced environment, in immersive conditions.

2. Material & Methods

A total of 30 participants (15 females and 15 males) from the Institute of Movement Sciences Etienne-Jules Marey (Marseilles, France) participated in the study. Participant mean age was 29.03 years (SD = 8.90). A virtual city was developed as the test environment. At the start of the experimental session, participants were placed in the centre of the computer-assisted virtual environment (CAVE) display of four projection screens: frontal, ground, and lateral projections. Each frontal and lateral screen had a projection surface of 3 meters wide by 4 meters high. The three vertical walls were back-projected, and the ground received direct projection with a 1400 x 1050 resolution and a 60 Hz frame rate. Starting from the centre of the city, participants were required to find a plant that was hidden in the city (encoding phase). The first group of participants navigated in the virtual city within an egocentric frame. For the second group, an interactive small aerial view of the virtual city was always available within the field of view. Finally, the third group of participants had a larger interactive aerial view of the virtual city within the field of view.

In the second phase, named the "retrieval phase," all participants were invited to retrieve the position of the plant they had discovered in the three different conditions beginning from a different starting point: with an egocentric frame, with the small aerial view, and with the large aerial view (see Figure 1). Three retrieval sessions were thus performed by each subject.



Figure 1: In the retrieval phase, participants were asked to retrieve the position of the hidden plant in three different conditions: 1) Retrieval without the interactive aerial view; 2) Retrieval with the small interactive aerial view; 3) Retrieval with the large interactive aerial view

The order of conditions was randomized for each participant. After each condition, the Igroup Presence Questionnaire (IPQ) [7] was administered to measure the feeling of presence experienced during encoding and the retrieving of spatial information. The IPQ consists of 14 items rated on a 7-point Likert scale with three sub-scales: spatial presence (i.e., the sense of being in the virtual environment), involvement (i.e., attention devoted to the real and the virtual environment), and realness (i.e., reality judgment about the virtual environment).

3. Results

To investigate differences in the feeling of presence between groups (i.e., Group 1: egocentric encoding; Group 2: encoding with a small interactive aerial view; Group 3: encoding with a large interactive), three analyses of variance were conducted on the three subscales of the IPQ (i.e., spatial presence, involvement, and realness). LSD post-hoc were used to compare significant differences between groups. Results were summarized in Table 1.

Encoding Phase	Group 1	Group 2	Group 3	F	<i>p</i>	η_p^2	G1 vs. G2	G1 vs. G3	G2 vs. G3
Spatial presence	0.80 (0.88)	1.75 (0.53)	1.64 (0.92)	4.00	*	.235	*	*	N.S
Involvement	0.14 (0.72)	1.10 (1.21)	0.75 (0.90)	2.33	N.S	.152	N.S	N.S	N.S
Realness	-0.97 (0.72)	0.22 (0.80)	0.10 (0.69)	7.29	**	.359	**	**	N.S

Table 1: Differences between the three subscales of the IPQ (i.e., spatial presence, involvement, and realness) after the encoding phase.

Then, three repeated measures analyses of variance were conducted to investigate differences in spatial presence, involvement and realness with Retrieval (i.e. “egocentric frame” vs. “small interactive aerial view” vs. “large interactive aerial view”) as within variable and groups as between variable.

Findings [$F(2,27) = 3.15$; $p = 0.59$, $\eta^2 = .189$] revealed a differences in the experience of spatial presence between the groups in favor of the role of the small [1.66 (0.25)] and large interactive aerial views [1.78(0.25)] when compared to the condition “egocentric frame” [0.97 (0.25)], although it was not statistically significant .

Concerning realness, the analysis yielded a main effect for group [$F(2,27) = 6.06$; $p < 0.05$, $\eta^2 = .310$]. Post-hoc comparisons demonstrated that participants with the small [0.46 (0.29)] and large interactive aerial views [-0.25 (0.29)] experienced significantly more realism when compared to the first group [-0.95 (0.29)]. Moreover, it was noted a main effect of Retrieval $F(2,27) = 7.99$; $p < 0.001$, $\eta^2 = .228$]. Simple contrasts indicated that participants experienced significantly more realness when had the possibility to visualize a small interactive aerial view [0.01 (0.17)] in respect to the larger one [$F(2,27) = 13.67$; $p < .001$, $\eta^2 = .336$; -0.30 (0.18)]. Finally, as concerns involvement, findings showed no main effect of groups, but a significant differences within the retrieval conditions [$F(2,27) = 3.79$; $p < .05$, $\eta^2 = .123$]. Simple contrasts indicated that participants experienced significantly more involvement in the third retrieval condition [0.56 (0.21)] when compared to the first retrieval condition [$F(2,27) = 4.59$; $p < .05$, $\eta^2 = .145$; 0.95 (0.14)] and to the second retrieval condition $F(2,27) = 6.14$; $p < .05$, $\eta^2 = .185$; 0.92 (0.18)]

4. Discussion

To the best of our knowledge, our experimental study was the first attempt to investigate the role of a real-time presentation of allocentric viewpoint-dependent representations on the feeling of presence. Our findings showed that a real-time allocentric viewpoint-dependent representation (both small and large) during the encoding and retrieval of spatial information seems to lead to a greater sense of presence. Specifically, as concerns the encoding phase, our data indicated that the presence of an additional navigational aid conveying viewpoint-dependent information seems to enhance the sense of spatial presence and the judgment about the realness of the experienced virtual environments. During the retrieval phase, our findings showed that the presence of this kind of information influences specifically the involvement and the realness perceived during the virtual navigation. As concerns the difference between the sizes of the "map", only one difference was found: participants judged more similar to the real world (i.e. realness) the presence of a "small" interactive aerial view during the virtual experience. Taken together, these data, although preliminary, suggest that a real-time allocentric viewpoint-dependent representation may lead to more effective organization of spatial information and [8], consequently, may help individuals feel present in the experienced space.

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