

The Role of Immersion and Narrative in Mediated Presence: The Virtual Hospital Experience

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Abstract

The “mediated sense of presence” is a technology-induced illusion of being present in one (simulated) place when one is actually present in another (physical) place. Typically experienced in virtual worlds, mediated presence is generated by different technological, cognitive, and emotional factors. The aim of this study was to test how to optimise the virtual experience by manipulating some of these factors. Specifically, we tested if an immersive technology and/or a meaningful narrative context influence the users’ sense of presence, providing a more compelling experience than a non-immersive and non-contextualized virtual space. Eighty-four students, randomly divided into four groups, were asked to find a blood container inside a virtual hospital in an immersive or non-immersive condition and with or without an emotionally related narrative. Two presence questionnaires and heart-rate variations were used to measure the effects of the four conditions on the users’ sense of presence. Results showed a significant effect of narrative, $F(8, 73) = 30.346, p < 0.001$, and level of immersion, $F(8, 73) = 10.913, p < 0.001$, and a significant interaction between narrative and immersion, $F(8, 73) = 2.062, p = 0.05$, both on the presence questionnaires and on the heart-rate variations. Moreover, considering the factors immersion (I) and narrative (N) together, we found that the I–N condition generated the highest level of presence. We argue that both immersion and narrative are important in creating an effective virtual reality experience because they contribute differently to increasing the sense of presence. Immersion increases the place illusion, while the narrative contributes to generating an emotional response and strengthening the subjects’ sense of inner presence.

Introduction

VIRTUAL REALITY (VR) is a computer-simulated environment where users can explore and interact with an artificial reality whilst feeling that they are in a place different from where they are physically. A VR system is made up of hardware, software, a user interface, and human factors such as perceptions, cognition, and emotions.

From a technological point of view, VR can be *immersive*, where the user interacts with it using a head-mounted display (HMD) and a tracker position sensor, or *non-immersive*, where the HMD is substituted by an external monitor. The HMD is a display device that presents computer-generated images to each eye separately, giving the illusion of a three-dimensional space and depth of field. Worn on the head or as part of a helmet, it covers the user’s eyes, isolating them from the real world. When coupled with a tracker position sensor, the HMD also becomes an input device that transmits the

user’s movements to the computer that continuously update the virtual environments according to the user’s point-of-view. Being the key element that distinguishes VR from the other existing media,¹ immersion provided by the HMD is supposed to play an important role in creating a successful virtual experience.²

As stated by Dourish,³ VR is a technology that allows physical and virtual spaces to exist in parallel. But VR cannot be considered just as a pure technology.⁴ VR is also an experiential interface whose contents are three-dimensional environments (virtual worlds) where subjects interact between themselves and with the environment as if they were really inside it.⁵ From a psychological point of view, the impression of “being there” has been defined as a “sense of presence.”^{6,7} When experienced in a VR setting, it is more precisely termed “mediated presence,” indicating a technology-induced illusion of being present in one (simulated) place when one is actually present in another (physical) place.⁸

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Even if many researches have focused their attention on the concept of mediated presence, we still lack a clear definition of the factors that contribute to generating it. In particular, there are two main theoretical approaches to the definition of presence. The first one defines it as a “perceptual illusion of non-mediation”⁹ produced by means of the disappearance of the medium from the conscious attention of the subject. In this vision, the “place illusion,” that is, the sensation of being in a real place, is considered the main component that contributes to the realistic response during a virtual experience. Place illusion is constrained by the sensorimotor contingencies afforded by the VR system and is strictly related to its level of immersion.²

The alternative approach in the definition of presence considers it as “inner presence,” a broad psychological phenomenon, not necessarily linked to the experience of a medium, whose goal is the control of the individual and social activity.^{7,10–23} This approach considers presence as the result of an evolved neuropsychological process,⁸ influenced by cognitive and emotional factors, which play a crucial role in the way we differentiate between the internal and the external, make our subjective judgments, react to the surrounding world, attribute a meaning to our experience, and learn things about it. Technical details, such as system resolution, immersion, speed and kind of interface, as well as the ability of the designer, contribute to the quality of the virtual representation, but the real author of the virtual experience is the user, who generates it driving its narrative flow through his/her own cognitive and emotional interpretation of the events.¹ When the user is emotionally and intellectually engaged in the experience and perceives a significant sense of control over the computer, his/her attention will focus on the interaction with the environment that generates an illusion of non-mediation, increasing his/her sense of presence.²⁴ A key element of this process that combines form and content is given by the introduction of narratives in the virtual contexts. Narratives are stories that users can inhabit from a first-person perspective. They create meaning for the individual’s experiences, influencing the way people will appraise them, and change the individual’s emotional states, modifying the way people evaluate the experience. According to Sherman and Craig,¹ narratives are responsible for mental immersion, through which users can be deeply engaged and involved in the experience, increasing their sense of mediated presence. In fact, when users identify themselves with the characters of the story, their suspension of disbelief makes the content of the virtual experience seem real. Because emotions have a very peculiar way of controlling minds and influencing people’s actions, motivating learning and exploration behaviors, narratives that attribute an emotional content to the virtual experience are supposed to contribute to a higher sense of presence and a better interaction with the environment than neutral ones.^{25,26}

Starting from these considerations, the aim of this study was to test experimentally how to optimize the virtual experience by manipulating its technological (level of immersion) and psychological factors (narratives). In particular, we tested whether an immersive technology and/or a meaningful narrative context influence the users’ sense of presence, providing a more compelling experience than a non-immersive and non-contextualized virtual space. In order to test our hypotheses, subjects were presented with a virtual

hospital and asked to find some blood containers in an immersive or non-immersive modality associated or not to an emotionally narrative context. In particular, we investigated if: (a) the immersive condition provides a higher sense of presence than the non-immersive condition; (b) the immersive condition provides a higher emotional response (in terms of physiological activation) than the non-immersive condition; (c) the narrative context increases the sense of presence compared with the non-narrative condition; (d) the narrative context increases the emotional response (in terms of physiological activation) experienced in the environment compared with the non-narrative condition.

Materials and Methods

Subjects

Eighty-four undergraduate students (42 males and 42 females) between 19 and 25 years old ($M = 21.45$ years; $SD = 2.91$) participated in the study. All of them were familiar with technology and habitually used a computer at least 5 days a week. They were randomly assigned to one of the following experimental groups (see Table 1). Group 1: a virtual hospital was presented to the subjects in an immersive condition associated to an emotionally related narrative (I–N group). Group 2: a virtual hospital was presented to the subjects in an immersive condition without the narrative (I–NN group). Group 3: a virtual hospital was presented to the subjects in a non-immersive condition associated to an emotionally related narrative (NI–N group). Group 4: a virtual hospital was presented to the subjects in a non-immersive condition and without the narrative (NI–NN group).

Students with a history of neurological disease, head injury, learning disability, psychological disorders, and those who used psychotropic medications were excluded from the study. All subjects were volunteers and did not receive any payment or credit for their participations. An informed consent was obtained before starting the experiment.

The virtual hospital

The virtual hospital, developed using the 3D Game Studio 6 software, was run on a portable computer (Sony Vaio Notebook PCG-GRT 996ZP, Pentium 4 3.20 GHz) equipped with a graphic card NVIDIA GeForce FX Go5600 with 3D performance and 64 MB of VRAM. The virtual environment represented a two-floor hospital connected by a lift (Figure 1). Many corridors and several rooms were located on each of the two floors. A big park and an ambulance parking surrounded the hospital. All subjects explored the same environment, but those included in the narrative conditions performed the task in the role of a doctor who had to find and bring a container with a rare type of blood back to the main hospital where a child was waiting for a life-saving transfusion. Moreover, subjects in the narrative conditions were told that a mad murderer was wandering around the hospital trying to kill them so that they could not reach the blood containers needed to save the child (see the Experimental procedure section). Subjects in the non-narrative conditions were just asked to find the blood containers exploring the virtual hospital, without any other specification that contextualized their task. In order to make the environment in the two conditions (narrative and non-narrative) as similar as

TABLE 1. PARTICIPANTS' DISTRIBUTION AMONG THE 4 EXPERIMENTAL CONDITIONS

	<i>Narrative</i>	<i>Non-Narrative</i>
Immersive	21 participants (IN)	21 participants (I-NN)
Non-Immersive	21 participants (NI-N)	21 participants (NI-NN)

possible, they also met the virtual character representing the mad murderer but without knowing anything about him.

The environment was presented on an external computer screen (Onyx-black LCD 16.1" UXGA) with a resolution of 1600×1200 in the non-immersive condition, and through a HMD (V-Real Viewer PC) with a resolution of 640×480 in the immersive condition. Participants navigated the environment using a joystick (non-immersive condition) or a joystick and the motion tracker integrated in the HMD (immersive condition).

Experimental design

The independent variables of the study were: narrative (exploration with a narrative context vs. exploration without a narrative context) and immersion (HMD: high degree of immersion vs. laptop screen: low degree of immersion). The measured dependent variables were: the sense of presence (in

terms of level of immersion) measured with the ITC-SOPI and the UCL self-reported questionnaires, and the physiological emotional response assessed by the heart rate (HR) recording.

Presence evaluation

The dependent variables were assessed using the following questionnaires:

- UCL Presence Questionnaire²⁷: a post-experience subjective measure of presence. Participants were required to provide ratings on a 1–7 Likert scale to the following questions: Q1 "... rate your sense of being in the virtual environment"; Q2 "To what extent were there times during the experience when the virtual environment was the reality for you?"; and Q3 "When you think back to the experience, do you think about the virtual environment more as images that you saw or as places that you visited?"
- Independent Television Company Sense of Presence Inventory (ITC-SOPI)²⁸: this post-exposure presence measure is divided in two parts. Part A consists of six items and refers to the participants' impressions/feelings that follow the virtual experience. Part B consists of 38 items and refers to the subjects' impressions/feelings during the virtual experience. A consistent scoring mechanism (1–5 point Likert scale ranging from "strongly disagree" to "strongly agree") is used for both parts. Factor analysis of this 44-item questionnaire



FIG. 1. The virtual hospital: (a) the hospital entrance; (b) the mad murderer wandering about the hospital; (c) the room with the blood-container refrigerator; (d) one of the hospital rooms.

showed that it measures the following dimensions of presence: (a) spatial presence—how physically present users feel in the virtual environment; (b) engagement—how involved users feel toward the content of the virtual environment; (c) ecological validity—the level of realism and naturalness of the environment.

As stated by Slater,² mediated presence is a qualia, and there is no way to measure it directly. However, indirect assessments based on questionnaires that compare responses with those that would have been expected in real experiences can be considered the most acceptable indirect measurement of it.

Psychophysiological evaluation

The Procomp Infiniti Biofeedback system was used to record the heart rate at the baseline and during the exploration of the virtual hospital.

Experimental procedure

Participants were asked to seat in a swivel armchair in front of a laptop screen. At the beginning of the session, they received one of the two sets of instructions according to the assigned group. Subjects in the non-narrative (NN) condition were simply told their goal was to find a blood container kept in the hospital refrigerator heedless of the other characters eventually present in the environment. Subjects in the narrative (N) condition had the same goal, but it was contextualized in the following narrative:

A child has been involved in a car accident in front of the hospital, and if she does not receive an urgent blood transfusion, she will die. You are a doctor and you have to find the blood containers as soon as possible in order to save the child's life. Be careful, because a very dangerous mad murderer is wandering around the hospital trying to kill you before you reach the blood containers needed to save the child. When you find him, run away to prevent him stopping you before you find the blood.

Due to its emotional significance, the encounter with the mad murderer was considered a significant moment of the virtual exploration, and was marked during the HR registration (HR-ENC).

The experiment was divided into two parts. The *baseline* phase, in which participants were requested to stay completely relaxed while the HR was recorded for 2 minutes.^{29,30} Immediately after that, participants read the experiment instructions and were instructed about the use of the HMD equipment (if included in the I-N or I-NN groups) and how to explore the virtual environment. The *navigation* phase, in which participants explored the virtual hospital until they found the blood containers while their heart-rate variations were recorded. At the end of the task, participants completed the UCL and the ITC-SOPI questionnaires in order to assess the sense of presence elicited by the navigation in the virtual environment. Finally, a debriefing phase concluded the session.

Results

We performed a multivariate analysis of variance (MANOVA) with immersion and narrative as independent factors, and the three UCL items, the three ITC-SOPI items, the HR

variation (HR mean during the exploration of the environment minus HR mean at baseline), and the HR values recorded when the subjects encountered the mad murderer (HR-ENC) as dependent variables. Results showed a significant effect of narrative, $F(8, 73) = 30.346, p < 0.001$, and level of immersion, $F(8, 73) = 10.913, p < 0.001$, and a significant interaction between narrative and immersion, $F(8,73) = 2.062, p = 0.051$. Analyses of each individual dependent variable are reported in Table 2. They show that the two narrative groups (N) and the two immersion (I) groups significantly differed in almost all the analyzed dependent variables except in the ITC-SOPI item "Ecological validity" (in the N groups) and in the HR when subjects encountered the mad murderer (in the I groups). The ITC-SOPI and the HR values were also significant in the interaction analysis (narrative×immersion).

Looking at the mean values calculated in the four experimental groups and reported in Table 3, we notice that in all the presence questionnaires, the means recorded in the I-N condition are the highest values, while the means in the NI-NN condition are the lowest, except in the ITC-SOPI Ecological validity item in which the I-N condition is not

TABLE 2. STATISTICAL COMPARISONS FOR EACH INDIVIDUAL DEPENDENT VARIABLE MEASURED IN THE STUDY

Condition	Dependent Variable	df	F	p	
Narrative	UCL Q1	1,80	14,222	.000*	
	UCL Q2	1,80	12,738	.001*	
	UCL Q3	1,80	21,878	.000*	
	ITC-SOPI	1,80	15,563	.000*	
	Spatial presence				
	ITC-SOPI	1,80	3,212	.077	
	Ecological validity				
	ITC-SOPI	1,80	17,464	.000*	
	Engagement				
	HR	1,80	20,341	.000*	
	(exploration - baseline)				
Immersion	HR-ENC	1,80	173,769	.000*	
	UCL Q1	1,80	14,349	.000*	
	UCL Q2	1,80	16,001	.000*	
	UCL Q3	1,80	9,885	.002*	
	ITC-SOPI	1,80	19,501	.000*	
	Spatial presence				
	ITC-SOPI	1,80	20,075	.000*	
	Engagement				
	ITC-SOPI Ecological validity	1,80	17,915	.000*	
	HR	1,80	4,187	.044*	
	(exploration - baseline)				
Narrative × immersion	HR-ENC	1,80	,040	.841	
	UCL Q1	1,80	,967	.328	
	UCL Q2	1,80	,347	.557	
	UCL Q3	1,80	2,612	.110	
	ITC-SOPI Spatial presence	1,80	1,199	.277	
	ITC-SOPI Engagement	1,80	,688	.409	
	ITC-SOPI Ecological validity	1,80	5,327	.024*	
	HR	1,80	,007	.933	
		(exploration - baseline)			
	HR-ENC	1,80	6,491	.013*	

*Indicates a statistical significance.

TABLE 3. MEAN VALUES CALCULATED FOR EACH INDEPENDENT VARIABLE IN THE FOUR EXPERIMENTAL GROUPS

Dependent variable	Group (I)	Group (J)	Mean	SD	Sig.
Presence evaluation					
UCL Q1	I-N	I-N	5.48	1.17	-
		I-NN	4.76	1.51	.043*
		NI-N	4.48	1.33	.045*
UCL Q2	I-N	NI-NN	3.38	1.28	.000*
		I-N	5.57	1.12	-
		I-NN	4.14	1.65	.022*
UCL Q3	I-N	NI-N	3.57	1.50	.009*
		I-N	5.81	1.44	-
		I-NN	4.19	1.46	.000*
ITC-SOPI Spatial presence	I-N	NI-N	2.95	1.32	.000*
		I-N	64.09	5.18	-
		I-NN	55.57	9.32	.003*
ITC-SOPI Ecological validity	I-N	NI-NN	52.52	11.60	.001*
		I-N	52.04	3.40	-
		I-NN	47.95	6.93	.256
ITC-SOPI Engagement	I-N	NI-N	47.23	7.00	.002*
		I-N	22.47	3.65	-
		I-NN	18.71	3.71	.000*
Psychophysiological evaluation	I-N	NI-NN	43.33	8.83	.000*
		I-N	17.76	4.78	.000*
		I-NN	15.42	4.69	.000*
HR (exploration - baseline)	I-N	I-N	13.18	10.66	-
		I-NN	2.95	6.23	.009*
		NI-N	9.19	8.62	.438
HR-ENC	I-N	NI-NN	2.08	2.66	.000*
		I-N	114.64	10.78	-
		I-NN	83.57	8.48	.000*
		NI-N	107.41	12.73	.352
		NI-NN	86.84	8.25	.000*

*Indicates a statistical significance.

significantly different from the I-NN group. Regarding the HR values, we also notice that the the I-N condition is not significantly different from the NI-N condition, but it is higher than the I-NN and NI-NN both in HR and HR-ENC.

Discussion

The main goal of the present study was to investigate which elements enhance the users' sense of mediated presence during a VR experience. To do this, we analyzed the contribution of technological (i.e., the physical immersion through the use of the HMD) and cognitive factors (i.e., the narrative) during the exploration of a virtual hospital.

The role of immersion

Consistent with our hypotheses, the results show a significant influence of physical immersion on all the presence self-reported questionnaires, suggesting its role in increasing one of the aspects of presence, defined by Slater² as place illusion. Compared to those who experienced the virtual environment in a non-immersive condition, participants who

used the HMD showed higher mean scores in all the UCL and ITC-SOPI items. In the immersive condition, characters and objects, as well as the environment itself, were perceived as more real, and the experience was judged more interesting and involving than in the non-immersive condition. Wearing the HMD, participants felt more present inside the environment and believed they could change the events interacting with characters and objects more than those in the non-immersive condition. Nevertheless, the level of immersion seems to be not sufficient to alter the subjects' physiological response, probably because it does not really contribute to the contextualization of the events, which is a key factor of any vivid emotional experience.

The role of the narrative

Providing a context to the virtual hospital navigation, the presence of the narrative had a significant effect both on the presence self-reported questionnaires, and on the heart-rate variations, increasing what has been defined by Waterworth as the users' sense of inner presence.⁸ In particular, compared to those in the non-narrative groups, and regardless the level of immersion, participants in the narrative conditions showed a higher HR variation between the baseline and the virtual exploration, and a higher heart-rate activation when they encountered the virtual character representing the mad murderer. These results are consistent with the Healey's theory on emotions,³¹ affirming that an increase in the heart-rate response is an important physiological indicator of arousal and valence activation. In fact, giving a specific role to the participants—being a doctor that must save a little child by finding the blood containers—and attributing negative characteristics to the character found inside the hospital—he was described as a dangerous mad murderer—significantly increased their emotional states. The narrative context led the two groups of participants (N vs. NN) to a different evaluation of the experience and modified their appraisal accordingly.³² In fact, even if all subjects were asked to perform exactly the same task (to find the blood containers), only those in the narrative conditions had a motivation to find them that gave more relevance to the experience. Similarly, even if all participants found a man inside the hospital, only those in the narrative condition knew that he was a murderer that could stop them reaching their goal. This information caused a significant alteration in their emotional response, according to Fridja's theory,³³ affirming that the emotion elicitation depends on the way people appraise situations.

The only measured variable for which we did not find a significant effect of the narrative was the ICT-SOPI Ecological validity item that measures the level of realism and naturalness of the environment. This result can be reasonably explained by the fact that the realism and naturalness of a virtual environment are physical characteristics more related to the way in which we perceive the environment than to the way in which we contextualize it.

Considering the factors immersion and narrative together and combining the four conditions (immersion, non-immersion, narrative, non-narrative), we found that the I-N condition is the one that generates the maximum level of mediated presence, both in terms of place illusion and inner presence. On the contrary, the condition that produces the minimum level of presence is the NI-NN. Given these results,

we argue that both immersion and narrative are important features that must be taken into account in order to create an effective VR experience because they contribute differently to the theoretical construct defined as “sense of presence.” Immersion increases the place illusion, that is, the strong illusion of being in a place in spite of the certain knowledge that one is not there, while a narrative that contextualizes the virtual experience generates an action based and controlled by the subject’s needs, motives, and goals that significantly contributes to generate an emotional response and to strengthen the sense of inner presence. Both the place illusion and the inner presence participate in the generation of the mediated presence, which requires adequate form to be directly perceived, conscious attention to that form, and content that will sustain such attention.

Previous studies have already investigated the impact of specific elements, such as the width of the field of view³⁴ or the emotional content provided by the virtual environment³⁵ on the users’ sense of presence, but this is the first attempt to address simultaneously the combination of technical and psychological aspects. Nevertheless, a possible weakness of this study that should be addressed in future researches is that we did not evaluate the presence, in our sample, of Blood-Injection-Injuries phobia, a subtype of specific phobias that includes, among the others, the fear of blood (hemophobia). Since participants were asked to look for blood containers, the possible presence of this kind of specific fear could be a confounding variable because high levels of fear are also known to increase the sense of presence during VR stimulation.^{36,37} Since this pathological condition is rare, we suppose that our results were not affected by it.

In conclusion, to obtain a high level of mediated presence, the virtual environment should be presented in an immersive condition and associated with a contextualized narrative, creating equilibrium between technological and cognitive elements. Nevertheless, our data suggest that, while immersion itself produces an increased presence as measured with the self-reported questionnaires but does not alter the physiological response, the narrative affects both the responses to the questionnaires and the subjects’ physiological activation. Other than increasing the proto (proprioceptive) presence and the core (perceptual) presence, the emotional content transmitted by the narrative also increases the extended (reflective) presence producing a significant sense of inner presence.⁸

Disclosure Statement

No competing financial interests exist.

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