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Relationships Between Internal Factors, Social Factors and the Sense of Presence in Virtual Reality-Based Simulations

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KEYWORDS
virtual reality;
sense of presence;
disaster medicine;
education;
simulation

Abstract

Background: Virtual Reality (VR) has proven to be an interesting and expanding tool for healthcare education, especially with the impact of the Sense of Presence (SoP) on learning. The study was designed to investigate to what extent users' social and internal factors might influence the SoP and to further identify members of occupations' characteristics influencing immersive experiences.

Method: A cross-sectional study immersing 83 undergraduate students (ambulance attendants, students nurses, and medical students) in a mass casualty incident simulation was performed. Questionnaires were administred to assess personal, environmental, and experiential in pre and post-simulation.

Results: SoP was associated with gender, disaster medicine education, propensity for immersion, and members of occupations.. Immersion characteristics specific to occupational categories have been identified.

Conclusion: Personal differences were discovered between ambulance attendants, students nurses, and medical students. Consideration should be given on how best practices could promote the design of VR experiences that cater to professional groups' needs. Identifying in the future what level of experience is needed for a sufficient SoP also seems necessary.

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Introduction

Over the last few years, the use of Virtual Reality (VR) has moved from global entertainment (Dara et al., 2012) to various fields: gaming, military and aviation trainings, architectural design, psychosocial therapy and education. In healthcare, VR has been mainly adopted for therapeutical purposes, (e.g. managing phobia or anxiety through VR exposing therapy) (Freeman et al., 2017; Neri et al., 2017), and educational purposes (e.g. surgical procedures, teamwork) (Diegmann et al., 2015; Englund, Olofsson, & Price, 2017).

Key Points

- VR simulation has been proven to be an interesting training tool in critical care and disaster medicine
- To date, research was mainly conducted regarding impact of the media on the Sense of Presence
- Getting deeper into factors potentially influencing the Sense of Presence might help understanding why identical medium induce heterogenous scores

This versatility and multipurpose application are particularly relevant given the challenges and perspectives of medical and paramedical education (Chan & Zary, 2019). Indeed, these disciplines require clinical, and practical education while ensuring patient safety. VR growth in healthcare was therefore made possible by potential benefits including lower costs related to human and material resources (Pottle, 2019), greater opportunity to duplicate potentially hazardous environments (Bal, 2012), greater respect for ethical considerations (Logishetty et al., 2019) and better data collection and feedback (Grassini et al., 2020). The present study was designed to further investigate VR for educational purposes by analyzing factors that may influence the Sense of Presence (SoP).

Theoretical Framework

From the outset, research on VR have shown a particular interest in SoP (Slater et al., 1996). SoP is essential to make the environment feel "real" and the learning experience effective. Indeed, higher SoP during VR simulations appears to be linked to greater educational impact (Grassini et al., 2020).

These elements (educational impact) indicate the importance of being acknowledged by the factors potentially influencing the SoP. In a previous work (Servotte et al., 2020), authors aimed to explore the elements influencing the SoP using a Mass Casualty Incident-Immersive Simulation (MCI-IS) for nursing and medical students. Results from this study helped compile a framework identifying several parameters affecting the SoP and their interactions (Figure 1). This study pointed out the need to specifically identify which factors, especially social and internal, might influence the SoP. Getting deeper into that framework might help understanding why identical medium induce heterogenous SoP scores (Alsina-Jurnet & Gutiérrez-Maldonado, 2010). Therefore this study aims to further investigate these previous results from Servotte et al. (2020) by understanding to what extent social and internal factors of the users might influence the SoP and to further identify immersive characteristics specific to different members of occupations.

SoP is a subjective experience resulting from the feeling of being effectively present in the environment (Bowman & McMahan, 2007). This SoP is influenced by 2 major components, allowing real cognitive, physical, emotional and behavioural responses: the place illusion (feeling of being in the environment), and the plausibility (linked to the accuracy of the scenario) (Slater & Sanchez-Vives, 2016). Apart from these 2 features, SoP is also impacted by technological, and human factors. In their study, Servotte et al. (2020), synthetized the factors impacting SoP into 7 categories:

1. User's level of control
2. System factor
3. Stress
4. Internal factors
5. Social factors
6. Pictoral realism
7. VR sickness

"User's level of control" refers to the fact that being able to actively control the environment and allowing body movements lead to greater SoP (Persky et al., 2009). A high-quality head-mounted (HDM) display offering better pictoral realism to replicate a high fidelity environment can enhance the SoP (Diemer et al., 2015; Huber et al., 2018). These factors are included in "Pictoral realism" and "System factor" categories. "Internal factors" dimension refers to personal and cognitive characteristics that lead to a greater SoP. Empathy, imagination, high immersion propensity and high spatial intelligence have all been found to be internal factors that could influence the SoP (Wallach et al., 2010). Negative correlation between the SoP and cybersickness is represented by the dimension "VR sickness." Indeed, numerous studies have shown that higher cybersickness scores would decrease presence (Ling et al., 2013). Despite occasional mitigated results, strong emotions ("Stress" category) are generally associated with greater SoP (Diemer et al., 2015). Finally, some studies have analyzed the impact of social factors. For example, female participants are more likely to have higher SoP (Grassini et al., 2020).

To date, there is a large literature analyzing the impact of the media (User's level of control, System factor,

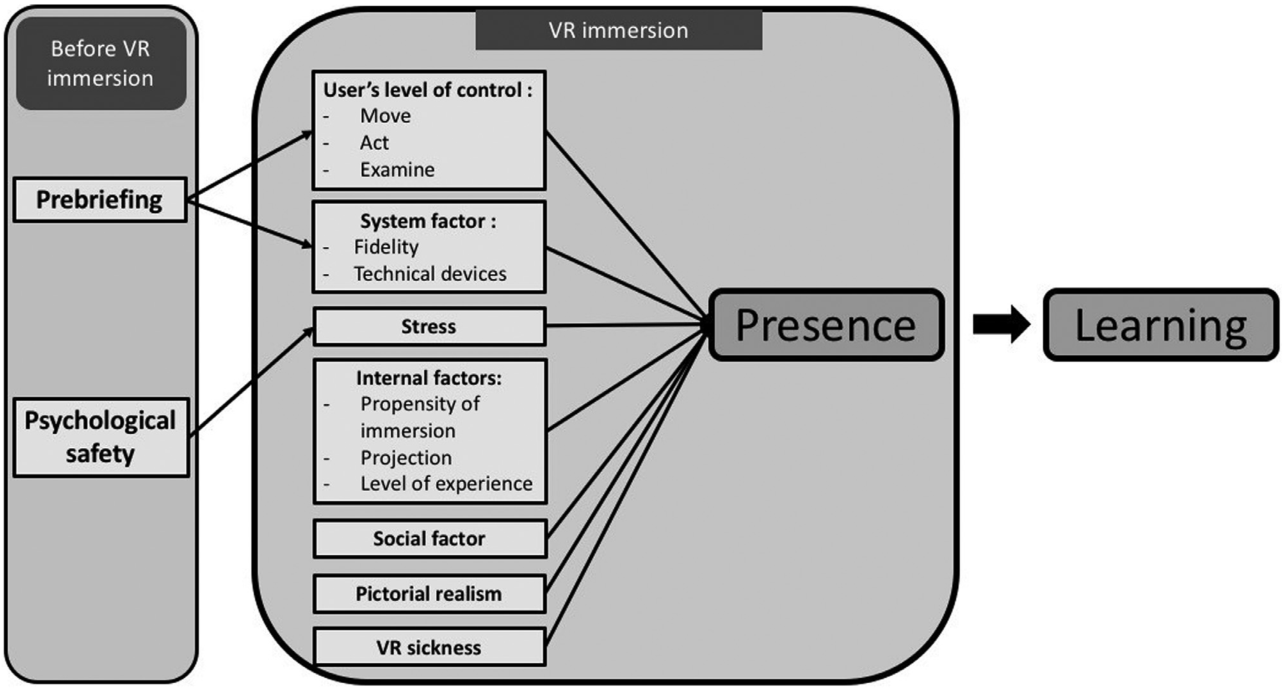

Figure 1 Servotte-Ghuysen framework depicting relationships between factors identified and sense of presence. Note.VR = virtual reality.

Pictoral Realism, VR sickness) on SoP (Alsina-Jurnet & Gutiérrez-Maldonado, 2010). However, few studies have addressed social factors (e.g. members of occupations) that are particulary relevant in healthcare education. Indeed, since healthcare is multidisciplinary, VR environments might be designed for different members of occupations. Moreover, psychological components, such as coping style, impact healthcare teams, and care management (Koziel et al., 2015). A better understanding of how these social and internal factors relate to the SoP may help in developing better VR educational pathways specific to each type of participant. Finally, this second study aimed at clarifying and expanding the original framework.

Methods

Design

A cross-sectional study was performed to address the following research questions:

1) What are the factors influencing the SoP in a MCI-SI?
2) How is the immersion process modulated among members of occupations?

Mass Casualty Incident-Immersive Simulation

Design

The design followed the Standards of Best Practice for Simulation[SM](Lioce et al., 2015). The ten criteria (Needs assessment; Measurable objectives; Format of simulation; Clinical scenario or case; Fidelity; Facilitator/Facilitative approach; Briefing; Debriefing and/or feedback; Evaluation; Participant preparation) have been analyzed and discussed by an interdisciplinary group composed of experts in simulation, expert in disaster medicine and psychologists. To meet the International Nursing Association for. Clinical Simulation and Learning (INACSL) standards of best practice, a particular attention was set on ensuring that the simulation aligns with learners' needs and that it meets relevant program objectives while maintaining psychological safety (Standards Committee, 2016b, 2016a).

The MCI-IS used was based on the Sierre coach crash, when a coach carrying 2 drivers, 4 teachers, and 46 pupils crashed into a wall in the tunnel of Sierre. The 2 drivers, the 4 teachers, and 22 children were killed. An emergency nurse who was present during the actual accident wrote the storyboard used in this MCI-IS. Three Mass-Casualty Incident (MCI) experts, 2 emergency physicians and 1 emergency nurse validated the adapted MCI-IS scenario. The programming has been realized by a VR company *Connexence®*.

Presimulation

The entire teaching activity was contained in a file including a full description of the activity, the content of the prebriefing, a description of the simulation, a user's guide, and debriefing suggestions. Two trained simulation instructors were present, at least one of whom is an expert in the field of emergency management. During the prebriefing the psychological safety was ensured by clarifying the objectives of the simulation and highlighting the possibility of making mistakes without consequences to themselves. Participants were informed of the paediatric nature of the victims and that they could stop the simulation at any time if they felt uncomfortable or sick. Similarly, contact numbers were provided for any post-simulation trauma or questions. Psychologists were also present on site in case their intervention became necessary. The equipment used during the activity was then presented (VR laptop, HTC vive® HDM having 2 OLED panels resolution 1,200 × 1,080 per eye ; field of view 110° ; refresh rate 90Hz) and explained. The different interactions : how to move, how to communicate, and what actions are possible during the simulation were also described. Then pre-simulation questionnaires in paper format were distributed. Participants completed the questionnaires and then performed the simulation one by one.

Immersion

Participants were first immersed in the Sierre tunnel to familiarize themselves with the environment and headset. When ready, the participant was then teleported to the entrance of the coach to triage the victims. The participants approached the victims and said aloud the colour of the tag that they wanted to attribute. A tag was then placed by the facilitator on the victim. During the simulation, participants were able to interact with the facilitators if they had any questions. The immersion time didn't exceed 7 minutes. After the immersion, in another room, the participants completed the post-simulation questionnaires in paper format.

Debriefing

Once the immersion session was completed by the participants, the instructors conducted a debriefing following the framework for Promoting Excellence, and Reflective Learning in Simulation (Eppich & Cheng, 2015). The preview-advocacy-inquiry-listen method was used to analyze participants'experience.

Recruitment

A nonprobability convenience sampling method was performed. The sample (n = 83) included students from 3 different healthcare professional groups: Medical students (n = 24), Ambulance attendants (n = 24), and Nursing students (n = 35). All students included were in their final year.

Participants were selected based on their availability and accessibility within the different schools: (a) Center for Medical Simulation at the University of Liège for the Medical students; (b) Namur Nursing students highschool; (c) Namur Ambulance attendants'training centre.

Before the simulation day, one researcher met with each group to provide details on the study, present the MCI-IC, and organize the agenda. An e-learning on Simple Triage And Rapid Treatment (START) triage validated by 2 experts in disaster medicine was also provided. This e-learning was designed to bring participants' triage knowledge up to the same level.

Data Collection

Design

The study took place at several school sites according to the groups studied from October 2019-March 2020. Data were collected through paper questionnaires (sociodemographics, immersion propensity, stress, cybersickness, coping, decision-making, SoP). The questionnaires were given at different times since some variables have to be collected before (e.g. stress) or after (e.g. cybersickness). No time-limit was set for the filling-in.

Assessment Instruments

A simulation and emergency medicine expert validated the relevance of the questionnaires below. Debriefing data were not collected but were used to feed discussion and perspectives.

Sense of Presence

The *Questionnaire sur l'Etat de Présence* (PQ-F) (Robillard et al., 2002) was used for this study. This later is the french-language validated adaptation of the Presence Questionnaire (Witmer & Singer, 1998) to measure the SoP. This scale includes 2 parts (before and after immersion) through 38 items. For each item, participants were asked a score between 1 (strongly disagree), and 5 (strongly agree). Total score can range from 38 to 190.

Immersion Propensity

The validated French adaptation of the Immersive Tendencies Questionnaire (Witmer & Singer, 1998), the *Questionnaire sur la Propension à l'Immersion* (ITQF) (Robillard et al., 2002) was used. This measurement is performed to assess the ability of individuals to immerse themselves in virtual reality. The questionnaire is divided into 4 sub-scales: involvement, emotion, focus, and play. For each of the 18 included items, students were expected to assign a score from 1-7 (1: not at all; 7: completely). The total score can range from 18-126.

Coping

Coping is defined as: "the set of cognitive and behavioral processes that an individual interposes between himself and an event perceived as threatening, to control, tolerate or diminish the impact of the latter on his physical and psychological well-being" (Lazarus & Cohen, 1977). For the present study, we used the french-language adaptation (Bruchon-Schweitzer et al., 1996) of the Ways of Coping Checklist (WCC) from Lazarus and

Folkman's (Folkman & Lazarus, 1980). This scale comprises 3 categories (problem-centered, emotion-centered and social support-centered) covering 27 items with 4 possible answers (no [1], rather no [2], rather yes [3] and yes [4]). Problem-focused coping includes all active individual behavior engaged to manage stressful situations and adjust a dysfunctional person-environment relationship in order to alleviate or eliminate the sources of stress. Emotion-focused coping strategies include all regulating efforts to decrease the emotional consequences of stressful events. Lastly, the social support-centered coping refers to "the individual's efforts to obtain the sympathy and help of others in order to obtain a listening ear, information, or material assistance". Final score corresponds to the category with the highest score.

Decision-making

The "*Inventaire rationnel-expérientiel*" (Stadelhofen et al., 2004) is the validated french-language adaptation of the Rational-Experiential Inventory (REI) (Pacini & Epstein, 1999). This questionnaire highlights one's preferential decision-making process based either on rationality or intuition and experience. The functioning of the rational system is described as intentional, analytical, essentially verbal, and independent of affects. Moreover, its operation can be accessible to consciousness. As for the experiential/intuition system, it is described as being preconscious, automatic, associationist, holistic, and deeply associated with affects. The scale consists of 40 items scored from 1-5 (1 = completely false to 5 = completely true).

Cybersickness

The french-language adaptation (Bouchard, Robillard, & Renaud, 2007) of the Simulator Sickness Questionnaire (Kennedy, Lane, Berbaum, & Lilienthal, 1993) was used to monitor students 'possible side effects that may occur during the simulation. The questionnaire contains 16 items for which participants have 4 different options: not at all (0), a little (a), moderately (b) and severely (c). The total score on this scale ranges from 0-48.

Stress Level

The stress level was assessed by a self-reported scale and The Mental Readiness Form (MRF) (Krane, 1994). The first is a Visual Analog Scale (VAS) for measuring participants' stress levels, from 0-10, before and after the simulation. The MRF is composed of 3 11-point scales addressing cognitive, affective, and physiological levels perception of stress.

Statistical Analysis

Rx64 Commander® (version 3.5.1) was used for all statistical analysis. Descriptive statistics were performed to describe the sample characteristics. Shapiro tests were conducted to examine the normality. Quantitative variables with a normal distribution were reported as means and standard deviations while skewed ones were reported as medians and interquartile ranges. Categorical variables were expressed as frequency and percentage. Univariate analyses were conducted using parametric tests for variables with normal distributions and non–parametric tests for skewed ones. Spearman correlations were also performed to measure the association between the SoP and quantitative variables. The alpha level was set at a standard level of 5% for all statistical interpretations

Ethical Considerations

This study was approved by the ethical committee of Liege University's Medicine Faculty (reference number 2019-212). All participants gave their written informed consent to participate in the study.

Results

Study Sample

The global study sample regrouped 83 undergraduate students, immersed in a MCI-IS. Among these, 24 medical students were included with an average age of 24 years (23-25.25). The ambulance attendants group was composed by 24 individuals with an average age of 28 years (24.75-40). Finally, 35 nursing students were included with an average age of 23 years (21.25-24). Table 1 summarizes the sociodemographic and immersion characteristics of the study sample.

In a second phase, immersion experiences were studied between the different members of occupations. The aim was to identify key trends based on members of occupations to better personalise the simulation session accordingly.

Sense of Presence

Table 2 and 3 summarize factors influencing the SoP. Results showed an association of SoP with gender, disaster medicine education, propensity for immersion, and members of occupations. The other variables were not correlated with the SoP. Regarding propensity for immersion, a positive relationship was found with SoP ($r = 0.33$). The greater the propensity for immersion, the greater the SoP. Regarding gender, females showed higher levels SoP compared than males. Students with prior disaster medicine education had higher SoP scores compared with less experienced students. Lastly, nursing students revealed greater SoP than other members of occupations in training.

Table 1 Sample Characteristics by Members of Occupation

Variables	Total(n = 82)	Medical Students(n = 24)	Ambulance Attendants (n = 24)	Students Nurse (n = 35)	*p*
Members of occupation no. (%)					
Ambulance attendants	24 (29%)				
Medical students	24 (29%)				
Students nurse	35 (42%)				
Gender no. (%)					
Males	30 (37%)	8 (33.3%)	20 (83.3%)	2 (5.9%)	<.001*
Females	52 (63%)	16 (66.7%)	4 (16.7%)	33 (94.1%)	
Age (in years) median [IQR]	24 (22-26.75)	24 (23-25.25)	28 (24.75-40)	23 (21.25-24)	<.001*
Disaster medicine education no. (%)					
Yes	53 (65%)	3 (12.5%)	17 (70.8%)	33 (97.1%)	<.001*
No	29 (35%)	21 (87.5%)	7 (29.2%)	1 (2.9%)	
VR experience no. (%)					
Yes	22 (27%)	7 (29.2%)	6 (25%)	9 (26.5%)	.95
No	60 (73%)	17 (70.8%)	18 (75%)	25 (73.5%)	
Triage score (/10) median [IQR]	10 (8-10)	10 (8-10)	10 (8-10)	10 (10-10)	0,44
Stress (/40) mean ± SD					
Pre-immersion	15.74±7.34	18.77+-7.72	10.63+-4.83	17.5+-6.75	<.001*
Post-immersion	11 (7-19)	20 (14-22)	8 (6-12)	9.5 (7-15.75)	<.001*
Sense of Presence (/190) mean ± SD	145.32±19.87	138.5 (128.75-152.25)	145 (132-159)	151.5 (138-166.5)	.04*
Immersion propensity (/126) mean ± SD	69.79±13.87	69.83+-13.46	66.16+-13.13	72.32+-14.46	.25
Cybersickness (/48) median [IQR]	19 (17-22.75)	21.5 (18-29)	17 (16-19)	19 (18-22.25)	<.001*
Coping no. (%)					
Emotional	4 (5%)	2 (8.3%)	0 (0%)	2 (6.2%)	.55
Problem	76 (95%)	22 (91.7%)	24 (100%)	30 (93.8%)	
Decision making no. (%)					
Intuitive	28 (35%)	6 (26.1%)	6 (25%)	16 (48.5%)	.11
Rational	52 (65%)	17 (73.9%)	18 (75%)	17 (51.5%)	

IQR = Interquartile range; VR = Virtual reality

Table 2 Correlations Between Internal, Social Factors, and the Sense of Presence

Variables	Coefficient R	R^2	*p*-value
Age (in years)	-0.08	0.006	.48
Work experience (in months)	-0.13	0.02	.27
Immersion propensity	0.33	0.11	.003*
Stress before simulation (/40)	-0.12	0.01	.31
Stress after simulation (/40)	- 0.03	0.0008	.81
Cybersickness	0.0005	0.0000003	.1

Immersive Characteristics of Members of Occupations

Regarding members of occupations, results showed significant associations. Between groups differences appeared in terms of gender and age. Regarding education in disaster medicine, medical students had less training experience than nursing and ambulance students. Medical students also showed higher levels of pre- and post-simulation stress than nursing and ambulance students.

Regarding SoP, nursing students reached higher scores than medical, and ambulance students. Furthermore, the level of cybersickness was higher in the medical students group compared with the 2 other groups.

The medical students group seemed to be mostly composed of women with a more rational decision making (73.9%) and problem-centered coping (91.7%). Regarding the immersion experience, this group had high scores of stress before and after immersion, good immersion propensity but lower SoP, and increased cybersickness.

Ambulance attendants were predominantly men with the strongest rational decision making (75%) and problem-centered coping (100%). Their immersion experience was characterized by a lower stress before and after the simulation, lower cybersickness and immersion propensity but high SoP.

Table 3 Univariate analyses between internal, social factors and the Sense of Presence

Variables	Modalities	Mean +- SDMedian (P25-P75)	p-value
Gender	Male (n = 29)	139.13 +- 18.69	0.039*
	Female (n = 51)	148.70 +- 20.03	
Disaster medicine education	No (n = 29)	134 (128-152)	0.005*
	Yes (n =51)	150 (140-163)	
Disaster medicine simulation	No (n = 59)	145 (131-160)	0.82
	Yes (n= 20)	147.5 (134.75-159)	
VR experience	No (n = 59)	146 (132-159)	0.7
	Yes (n = 21)	145 (134-165)	
Coping	Emotion (n = 4)	135.5 (129-141)	0.2
	Problem (n=75)	146 (132-160)/	
	Social support (n=0)		
Decision making	Intuition (n=28)	151.5 (140.75-159.5)	0.13
	Rationality (n =51)	144 (129-160)	
Members of occupation	Ambulance attendants (n = 23)	145 (132-159)	0.04*
		138.5 (128.75-152.25)	
	Medical students (n = 24)	151.5 (138-166.5)	
	Students nurse (n = 34)		
Triage score	Ambulance attendants (n = 23)	10 (8-10)	0.44
		10 (8-10)	
	Medical students (n = 24)	10 (10-10)	
	Students nurse (n = 34)		

Note. Triage experience = effective triage on field; VR = Virtual reality

The nursing students group was defined by participants almost exclusively female. These participants mainly used problem-centered coping (93.8%) but mixed decision making processes: half of participants showed intuitive decision making (48.5%) and the other half rational decision making (51.5%). In terms of immersion experience, this group tended to decrease its stress after immersion, had the greatest SoP and immersion propensity and fair cybersickness score.

Discussion

The aim of this study was to explore internal and social factors influencing the SoP and the impact of members of occupations on the process. Compared to prior work, results from this study allow to identify new social factors impacting the SoP: members of occupations, gender, and previous disaster medicine experience. Figure 2 details the previously developed framework. Moreover, the SoP do not seem to be mitigated by several internal factors such as coping, and decision making. These results help to highlight specific immersion characteristics based on members of occupations.

Sense of Presence Scores

Regarding SoP, scores were higher than previous studies and previous work (Servotte et al., 2020). This could be explained by an improved pre-briefing and briefing of the simulation compared to prior work. Indeed, a parallel with the accident of Sierre was realized and may have allowed a better context and certain emotional experience that could have enhanced the SoP (Bouchard et al., 2008; Gorini et al., 2011). Higher SoP scores could also be explained by the limited actions and interactions asked for in this simulation (less care were asked compared to prior study). Indeed, complex tasks and navigation in a VR environment require better spatial intelligence, and therefore may be less accessible for some users with lower spatial intelligence (Alsina-Jurnet & Gutiérrez-Maldonado, 2010). Without any clear reason, cybersickness appeared much greater this time compared to prior study whereas settings were identical (Servotte et al., 2020). Medical students experienced more cybersickness than their colleagues. This could thus explain their lower SoP scores, as previously stated in many studies (Ling et al., 2013).

Sense of Presence and Social Factors

Higher SoP is proven to lead to better training performance (Grassini et al., 2020). Therefore, particular attention should be given to optimize participants'SoP in the development of an immersive simulation training. We noticed that SoP differed according to members of occupations, with nursing students having higher scores. It might therefore be considered that the development of a single VR training using the same modalities among different

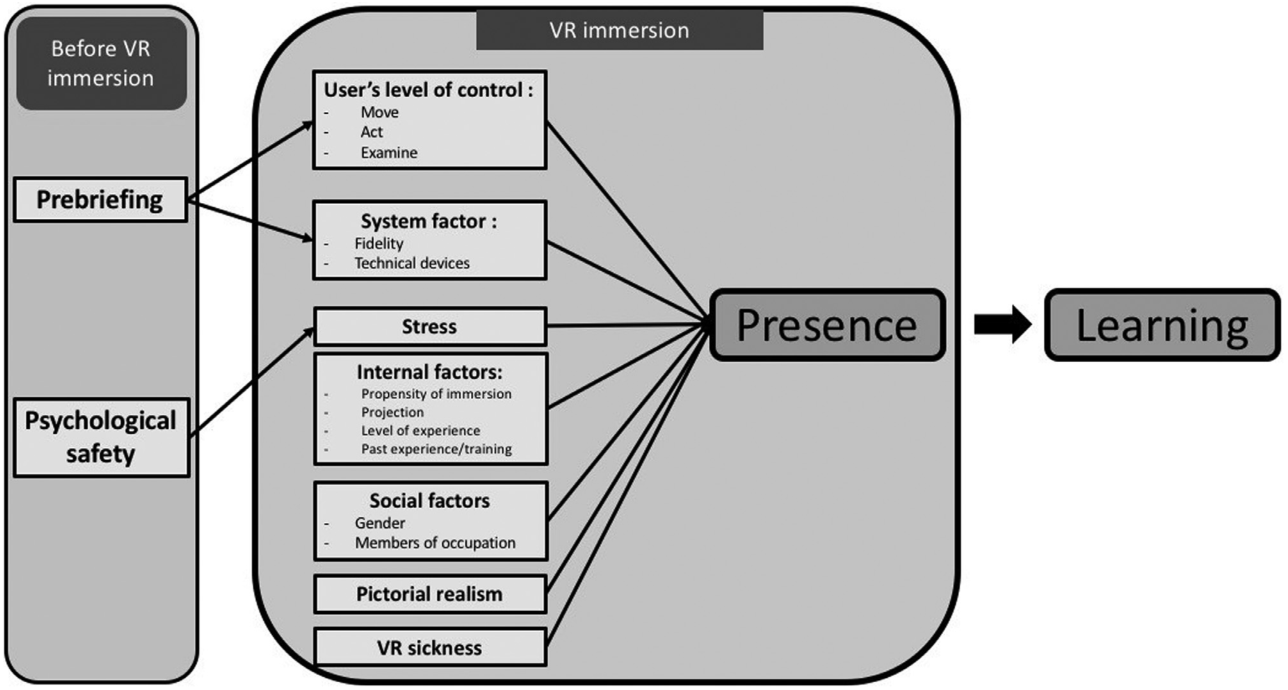

Figure 2 Adapted framework of Servotte-Ghuysen framework depicting relationships between factors identified and sense of presence. Note.VR = virtual reality.

members of occupations could have differential impact on the participants according to their categories. Indeed, this strategy could lead to major disparities in the SoP scores, and therefore inequities in training efficacy. Therefore, it would be worth considering the latter points when developing a VR environment by adapting the teaching program depending on participants' background to ensure an optimal learning impact.

Regarding experience, participants who had previous disaster training had a statistically higher SoP than those with no prior training. However, as stated by other authors (Alsina-Jurnet & Gutiérrez-Maldonado, 2010; Schuemie et al., 2001) having VR experience would have no impact on SoP scores. One hypothesis could be that the training experiences may have given our candidates a better emotional and cognitive response. Past research showed that familiarity, prior experience and a rich cognitive schema can increase the level of SoP (Heeter, 2003). Wirth (2007) further explored the link between SoP and prior experience. Indeed, past experiences would constitute a "library" of spatial experiments enabling the reconstruction of the most accurate scenario (filling "empty slots") once in the VR environment. Therefore, participants with past training experience could more easily fill the missing space-related information from their memory. This would lead to an increase in the richness and consistancy of the environment and therefore greater SoP (Dean & Morris, 2003). This link between past experience and SoP brings interesting insights as VR simulation is often used to prevent performing certain acts the first time on patients or to reduce cost. However, insufficient past anchoring could reduce expected learning and therefore be no longer profitable (Dean & Morris, 2003). It could therefore be interesting to identify participants' experience before the VR session. The INACSL have already stated the importance of learners' experiences and knowledge brought to the simulation activity for a greater presence in their standards of best practice (Standards Committee, 2016b). These later recommendations should therefore be applied to VR simulations. Similarly, standards of best practices dedicated to VR could be developed to promote efficiency.

Sense of Presence and Stress

Regarding emotional response, before immersion, the 3 groups showed different levels of stress with ambulance attendants appearing less stressed. This difference in stress could be explained by the fact that ambulance attendants had more training and simulation in disaster medicine than the other 2 groups. After immersion, medical students kept higher stress scores than the nurse, and ambulance students. These higher stress scores seemed to be correlated with the lack of training in the medical group (Shearer, 2016). Given this, the awareness of a lack of training in this group might have influenced the increase of stress score after immersion. Conversely, stress scores were significantly lower among nurses only. Similarly to prior study (Servotte et al., 2020), nurses who felt less able to triage victims may have discovered their ability to do so. During our tests, we also found that nurses asked more questions and verbalized their stress more easily. These characteristics may have contributed to this decrease in stress. As the lack of past training may lead to higher level of stress, this data should be collected, and taken into account during the pre-briefing to make adaptations.

SoP may also be influenced by individual differences. Regarding gender, females of the sample seemed to have higher SoP scores. While many studies do not show any gender difference, some have showed higher SoP in female participants (Grassini et al., 2020). This gender difference in SoP could explain better performances and learning in female groups (Yang et al., 2016). Previous research have considered this lack of a clear pattern regarding gender and SoP, raising the more global issue of the relevance of our current measurement methods to capture de complete spectrum of the SoP (Smith, 2019).

Sense of Presence and Internal Factors

No clear association was found between coping style or decision-making and the SoP. Yet participants from the 3 groups had the same tendencies for these 2 variables. Therefore, further investigation of personality or intelligence types may be more interesting. Indeed, spatial intelligence, and introversion have proven to increase user's SoP (Alsina-Jurnet & Gutiérrez-Maldonado, 2010). However, these studies were performed in a context of using VR environment for therapies and not for educational purposes. Moreover, as individual factors, and SoP differ among users of the same medium (Sacau et al., 2008), it would be valuable to analyze these variables on the same sample while using various media.

Limitations

Selection bias may occur as schools were chosen from different regions but students of the same occupational category were all from the same school. This limits the participants' variability. A social desirability bias could also occur since the simulations were organized within the school. In order to limit this bias, students participated on a voluntary basis. Although, even if validated, French version of the instruments used often had fewer items than the originals (English version). The number of questionnaires may also have caused fatigue and may have impacted the answers. Another limitation was that the trainings given among the groups didn't take place under the same conditions (dates and locations). The information given may also varied depending on the instructor. However, to lessen this limit harmonized simulation sessions, and standardized tools were used (pre-briefing). Moreover, both instructors were experienced simulation instructors. Another limitation relates to sample size. We expected 30 participants and 4 groups. Due to the Coronavirus pandemic, data collection had to be prematurely closed. As a result, recruitment of the fourth group, which was the master's students in public health, and completion of the group of medical students to reach the 30 participants were not possible. Given this small sample size, it is therefore necessary to remain cautious about generalizing the results of this study. Lastly, there might be some gap in the framework revised as VR experience might ultimately rely more on immersion and less specifically on aspects of learning (such as educational preparation, experience, decision-making).

Conclusions

The present study aimed at better understanding the SoP process and its modulation among different members of occupations in healthcare. Results revealed significant difference in SoP among the groups. Such differences between members of occupations should be considered when developing virtual reality training to enhance pedagogical experience. This study also emphasizes that best practices should promote the design of VR experiences that cater to professional groups' needs. Regarding SoP, the persistence of some knowledge gap, and the need for a more comprehensive definition of the SoP is still missing in the literature. In that sense, cognitive processes related to prior experience, and memory should also be further investigated. Indeed, identifying what level of experience is needed for a sufficient SoP seems necessary to optimally benefit optimally from the immersive experience.

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Declaration of Interest

The authors declare no conflict of interest

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