PRESENCE IN VIRTUAL CAVE

Investigating presence in VR-CAVE environment for historical sites.

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Abstract. Using Virtual Reality (VR) to visualize sites and places from the past, present and future is widely acknowledged. This study is making use of a recently installed U-Cave VR Theatre at Birzeit University (BZU) in Palestine. This study test hypotheses connected to presence in VR environments, using the case of historical sites. Historical sites in general are important for reasons of cultural identification and environmental integrity. In many historical sites, it is difficult for a layperson to read and understand the meaning of the site, since the remaining ruins don't provide enough information. This study contributes to improving the public understanding for historical sites by unfolding the role of VR to overcome the harsh reality of many damaged historical sites. Presence in VR environments is usually defined as "being there", with high consideration for the physical ether of the virtual environment, it confines attention to the awareness of place. The study argues that VR technology doesn't only provide a stereoscopic experience to subjects, it also adds a fourth dimension "time" by conveying the unconsciousness of man from the meanwhile moment to a different timeframe. This is made possible by innovative design of the VR environment and the nature of the content. It is concluded that; perceived presence is higher in a VR-CAVE environment in comparison to a 2-D traditional presentation. The results indicated that VR visualizations have a positive impact on raising the awareness of the identity of historical sites. The analysis

also revealed evidence of the power of VR technology to function as a 'time machine' that is capable to allow users live experiences in a different time-frame.

1. Definition of Presence in Virtual Reality Environments

One of the most common definitions of presence is the "subjective experience of being in one place or environment, even when one is physically situated in another" by Witmer & Singer (1998, p.225). Lombard and Ditton (1997) defined presence as the perceptual illusion of nonmediation (Lombard & Ditton, 1997), this says that the subject experiences presence, when he/she fails to recognize the mediated technology that delivers the virtual environment.

Slater and Wilbur (1997) defines immersion as an objective description of aspects of the system such as field of view and display resolution while presence as a subjective phenomenon such as the sensation of being in a virtual environment (Slater & Wilbur, 1997). On the other hand, Welch (1999, p.547) stated, "there is a pervasive belief that presence is causally related to performance … despite the popularity of this notion, however, there is no solid evidence to support it" (Welch, 1999). This argument puts emphasis on presence as a subjective sensation, thus, it has been argued that subjective report is the essential basic measurement (Sheridan, 1992).

A cognitive presence theory that attempts to explain human sensory perception of presence throughout an experience is expected to give rise to the design of innovative systems that offer "richer" experiences. Ijsselsteijin and Riva (2003) stated in their book *Being There* that "as a user experience, the feeling of 'being there', or presence, is not intrinsically bound to any specific type of technology- it is a product of the mind" (Ijsselsteijn & Riva, 2003, p.5).

2. Measuring Presence in VR Environments

Presence is measured by subjective and objective measures. Subjective measures of presence are measures where the participant is asked for a conscious judgment, either online or post-test, of his/her psychological state/response in relation to the mediated environment (IJsselsteijn, Ridder, Freeman, Avons, & Bouwhuis, 2001). Questionnaires are commonly used as subjective measures of presence; they are more used than objective measures; because objective measures are concerned with the actual performance of the technology to deliver the sensation of the virtual experience. The VR experience, on the other hand, differs across different VR environments according to the nature of display technologies used to

mediate the experience. Hence objective measures do not describe the experience of the user in the virtual environment and so they should always be investigated in conjunction with subjective measures. Subjective measures are based on the theory proposed to define the factors that affect presence. Vince (2004), states in his book *Introduction to Virtual Reality* that "the objective of VR is not to replicate our experience of the real world, but to make things as realistic and useful as possible, then solutions are within our grasp" (Vince, 2004, p.67). The assumption held in most studies about presence in virtual environment is that, human beings sense the highest level of presence in the real world (Flach & Holden, 1998; Witmer & Singer, 1998; Zahoric & Jenison, 1998; Schuemie & Van Der Mast; 1999; Slater, 2009).

3. Methods

Upon arrival at the VR-CAVE theatre, participants received instructions that they were required to watch a presentation. Short presentations of two old towns were projected to participants. One group of participants was exposed to a 2-D presentation, while the other group was exposed to the same presentation in 3-D stereoscopic. When the show was over, participants were asked to pick up the questionnaires under their seats to complete them. The scores of the questionnaires were entered in SPSS statistical software for analysis.

3.1 MEASUREMENT TOOL: BZU PRESENCE QUESTIONNAIRE

Based on an investigation made on presence measurement tools, the researchers decided to use the newly developed BZU-Presence Questionnaire (BZU-PQ). BZU-PQ revealed consistent results when tested in comparison with the ITC-SOPI questionnaire (Lessiter, et al, 2000). BZU-PQ is based on the Theory of Negative Effects. The theory indicates that the impact of negative effects in a technology mediated environment is a very important measure in investigating subjective presence, it is measured by examining two factors: Negative Effects felt by Human's Sensory Recipients, and Negative Effects caused by System's Components. The human's sensory recipients are referred to as "VS THEM" (Vision, Smell, Touch, Hearing, Emotions, and Mind). While interface design, display screen, sound system, and haptic devices are components of the system that may possibly erupt negative effects to be felt by the human's sensory recipients. (BZU-PQ) is used to measure perceived presence across technology mediated environments; the questionnaire is a 7-point Likert scale, it is based on the following five factors: (1) Control and Interaction,

(2) Naturalness of Interface Design, (3) Technical Capabilities, (4) Negative Effects Felt by Human's Sensory Recipients 'VS THEM', and (5) Negative Effects Caused by System's Components. The questionnaire consists of three main parts. Part A of the questionnaire is tailored to serve the purpose of this study, it posses questions to measure the awareness of participants to identify the historical site presented. It collects data to reveal the relationship between previous exposure and the awareness to identify the historical sites presented. It also poses questions to investigate the time-transmission capability of VR technology. Part B is based on the conceptual framework of the aforementioned five factors, it consists of 28 questions that attempts to measure subjective presence, and Part C attempts to collect feedback from participants about their overall technology mediated experience, it consists of two questions, the first is (If one's level of involvement in the real world is identified to be equal to 100%, rate your level of involvement in BZU VR experience in terms of percentage) and the second is an open-ended question to freely write notes.

3.2. STIMULI

Two 3-D models were used for the experiment; one representing a local historical model that was familiar to subjects (Birzeit Old Town in Palestine), and the other from Portugal (Guarda Town) which was unfamiliar to them. The models were presented as a walkthrough simulation for about 8 minutes at VR-CAVE. The models were presented in two ways: the first as 2-D traditional projection method by presenting the simulation on a wall-screen using a projector; the second as 3-D VR presentation by projecting the simulation using the full capabilities of the VR-CAVE (three U-walls shape theatre including stereoscopic projection with glasses. The two models were selected because they included large amounts of historical heritage located in two different continents; the stimulus is therefore capable of evoking lateral emotions toward familiar and unfamiliar virtual historical sites; such emotions are thought to influence the subjects' awareness of the identity of historical sites.

3.3. PARTICIPANTS

A hundred and thirty students and employees at BZU (66 female, 64 male, with average age range 16-52 years) voluntarily participated in the experiment. 36 of these participants currently live at Birzeit town/Palestine.

4. Results

The results of the experiment are reported in three sections. In the first section, we report on subjects' perceived presence of the two presentations represented across different technology mediated environments. In the second, we report the analysis of the ratings of perceived presence in relationship to the subjects' awareness of the identity of historical sites; in addition, we discuss the analysis of the data collected in regards to previous real-life exposure. In the third section; the subjects' perceived sense of time-transmission during the experience is reported.

4.1. SUBJECTIVE PRESENCE RATINGS ACROSS DIFFERENT IMMERSIVE ENVIRONMENTS

The researchers conducted experimental sessions in the VR-Cave environment and in the 2-D traditional presentation. Subjects in the VR-Cave environment experienced higher level of presence compared to that sensed by subjects of the 2-D presentation. Table-1 shows the average ratings of the five-factors of perceived presence across VR U-Cave and 2-D presentations.

TABLE 1. Mean & standard deviation of presence ratings in 2-D vs. VR U-Cave Environment.[Factor 1: Control and Interaction, 2: Naturalness of Interface Design, 3: Technical Capabilities, 4: Negative Effects Felt by Human's Sensory Recipients 'VS THEM' , and 5: Negative Effects Caused by System's Components]

	Fact. 1	Fact. 2	Fact. 3	**Avg**	Fact. 4	Fact. 5	**Avg**
2-D Presentation							
Mean	3.307	3.222	4.111	**3.456**	4.761	3.723	**4.242**
Dev.	.881	.562	.721		.745	.745	
3-D VR U-Cave							
Mean	4.179	4.611	4.833	**4.541**	4.36	3.66	**4.01**
Dev.	1.276	1.167	1.157		1.124	1.110	

It is interesting to notice that, the averages of the three factors (Control, Interface Design, and Technical Capabilities) are higher when the rating of negative effects is lower; it is also worth noticing that in a 2-D presentation, subjects scored higher ratings of negative effects felt by their sensory recipients (VS THEM) than subjects in VR environment, the same applies to negative effects caused by system's components of the environment.

4.2. PERCEIVED PRESENCE, THE AWARENESS OF THE IDENTITY OF HISTORICAL SITES, AND PREVIOS EXPOSURE

This research is conducted using reconstructed cases for historical sites from two different cultural backgrounds, (78%) of the subjects in the 2-D presentation identified the old town of Birzeit, while (84%) of subjects in the VR U-Cave environment identified it. On the other hand, all subjects of BZU identified the continent where the old town of Birzeit exists. (35%) of BZU subjects who identified the old town of Birzeit currently live at Birzeit town. In regards to the Guarda town model in Portugal, on the level of identifying the continent where the European town exists, (55.5%) of the subjects in the 2-D presentation recognized it, and (75%) of the subjects identified the continent in the VR U-Cave environment.

4.3. PRESENCE AND THE TIME CAPABILITY OF VR TECHNOLOGY

Using a 7-point Likert scale, the questionnaire posed two questions to measure the ability of VR technology to convey a sense of time-transmission to a different instance of time; the questions are: (To what extent you felt that the environment has a specific time plot in the present, past or future? And, to what extent did you feel that the events of the environment made you live in a different timeframe?). The average rating of the first question is (4.21) while for the second is (4.23), the average of both questions is equivalent to (61.57%). On the other hand, subjects in the 2-D presentation, conveyed (50.7%) of perceived sense of time transmission which is lower than that of VR experience. The analysis also revealed a highly significant correlation between average presence of (Factors 1, 2, and 3) and the time-transmission effect of VR technology. A highly significant correlation is also depicted between the average of negative effects (factors 4 and 5) and the time-transmission effect of VR technology.

5. Discussion

VR changes our relationship to information; it is the first intellectual technology that permits the active use of the body in the search for knowledge. However, the learning process always involves external factors related to previous knowledge acquired from different sources like magazines, media broadcasting and the internet, in addition to previous real-life exposure; for this reason, the researchers think that, regardless of the place of living, all participants identified the continent of the Portugal old town correctly (Europe), however over 80% identified the location of the Guarda town to be in Italy and not Portugal. It is interesting to notice that,

for the question: (If one's level of involvement in the real world is identified to be equal to 100%, rate you level of involvement in BZU VR experience in terms of percentage), the average score is found to be (63.27%) which is very close to that of calculated presence score of all factors excluding negative effects (64.5%). Thereby, this finding supports the approach taken averaging up the first three factors of presence separately from the negative effects factors. Review of the literature reveals different definitions and descriptions of presence. The issue of sense of presence is an issue of the relationship between sense and presence, and the issue of presence is an issue of "being there" (Reeves, 1991). In the questionnaire, participants were asked to select one of 3 provided options that best describes his/her experience, participants responded as follows: Stereoscopic 3-D graphics (40 hits), Being in a different world (59 hits), and Manipulate the mind to stimulate illusionist feeling (28 hits). VR technology makes the transportation in historical spaces as realistic, immersive and interactive as possible, thus a sense of time transition is made possible by its rich capabilities. The results revealed a moderate feeling of time transition for participants in the U-Cave theatre (average of 60%).

6. Conclusion

This research study confirmed significant correlations between the awareness to identify historical sites and the five factors that thought to influence presence: [Interaction, Naturalness of Interface Design, Technical Capabilities, Negative Effects felt by Human's Sensory Recipients 'VS THEM', and Negative Effects Erupted from the System's Components]. It is also believed that VR technology would have a promising perpetual impact in the field of rehabilitation of historical sites because of its ability to convey a state of time-transmission.

The results of the research emphasize on the capability of VR technology to provide richer visual, auditoria, and sensual effects in comparison to traditional 2-D presentations, the analysis reported a higher sense of awareness to identify historical sites of different backgrounds in VR environment than in 2-D traditional environment. The research also emphasizes on VR time transmission effect; the statistical analysis points to a significant relationship between the aforementioned five factors and perceived sense of time transmission in VR environment.

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