

A User-Centered Methodology for Investigating Presence and Task Performance

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Introduction

Many people would argue that Virtual Environments technology is the answer to a question that has not been defined yet. While the advances of technology are quite inspiring[2], what is still lacking is a conceptual and analytical framework[1] as well as a set of 'evaluation' metrics which could assess specific interfaces and designs. The study described in this paper was conducted in order to investigate if the notion of presence in a specific virtual environment (VE) application correlates with task performance. Three different groups of 18 subjects took part in an experiment which investigated people's knowledge acquisition, environmental perception and sense of presence while experiencing a seminar in three different conditions: In the 'real' world in person, attending the seminar as a 3D experience with audio and also, listening to the seminar, being provided by only audio information. The authors' primary goal was to use a knowledge acquisition application, enriched with a set of varied factors in order to answer the following questions:

- Is the notion of presence going to correlate, positively or negatively (if any), with task performance?
- By using the data taken from the seminar as conducted in reality, are we going to get any valuable information about the effectiveness of our methods of research?
- Could we perceive this 'real' dataset as a 'threshold' that should be approached -or overcome- when designing an educational or simulation/training application, thus serving as an additional means of evaluating different designs?

Design of the experiments

This study investigated the relation of presence and task performance while three different groups of 18 subjects 'experienced' the same task in three different conditions: In the real world, using a 3D application with audio and only listening to an audio file without any visual stimuli. In particular, the first group of subjects attended a lecture which took place in a specific seminar room in the University of Bristol. The duration was 15 minutes. The lecturer used 12 slides and an overhead projector. The seminar was digitally video-recorded and the audio was extracted in order to be used in the remaining two conditions. The seminar room was modeled accurately and the audio extracted from the 'real' experience was incorporated

in the 3D application which also included a slide show synchronised with the audio. The application was displayed on an 21' inch monitor and subjects were able to explore the room from a steady viewpoint having the ability to move on a full circle with a specified radius. A static billboard with a texture displaying the lecturer was included in the application. The application was implemented using VRML and Java and it was hardware accelerated having an average frame rate of 40fps. No additional hardware was used at this point. The second group of 18 subjects was asked to use the application for the specified time of the lecture and their navigation tendencies were monitored. Finally, a third group of 18 subjects was asked to listen to the audio previously extracted from the video recording of the 'real' seminar.

All three groups were asked to fill in approximately the same questionnaire after completing the task. This questionnaire included two sub-questionnaires. The first was designed to test the subjects' knowledge acquisition and environmental perception. There were 22 multiple-choice questions, 16 related to the actual factual information communicated in the seminar (the same set used in all three conditions) and 6 questions relevant to the environment (used for the 'real' and 3D condition). 50% of the answers of the first 16 questions were included in the slides and also were mentioned by the lecturer and the remaining 50% were only mentioned and not included on the actual slide show. The second sub-questionnaire was designed to measure presence on a Likert 7-point scale. The questions used in the Slater et al.[6] study were adopted in order to assess the level of presence of the subjects who took part in the experimental process. This set of questions were designed to investigate various aspects of the experience and the concept of presence itself and was not associated with the technology or the interface employed. For example, issues investigated were the dominance of the real world over the virtual one, the sense of visiting a 'place' versus viewing a scene or listening to a sound, or the kind of memory the user had compared with normal everyday memories, since this research method is applied after the actual experience. The authors could only apply such a set of questions, without significantly changing them, to all three conditions.



Figure 1: The seminar room.



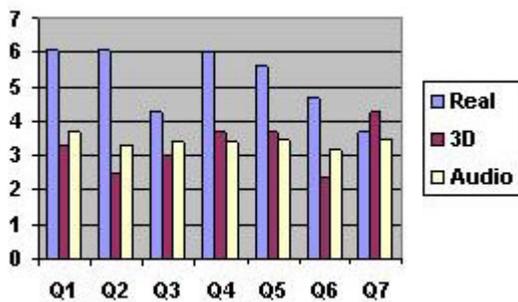
Figure 2: The final 3D application.

This study followed an initial pilot study based on the same idea[4] which initiated a few significant differences on the design of the main set of experiments: More questions were added relevant to the task as well as relevant to the environment. In particular, the task performance questionnaire was enhanced by adding a confidence measure and a memory type choice for each question (Remember, Know, Familiar, Guess). While using the 3D application, navigation was restricted towards simulation of head movements and a billboard was added to indicate the existence of the lecturer. Moreover, the presence questionnaire

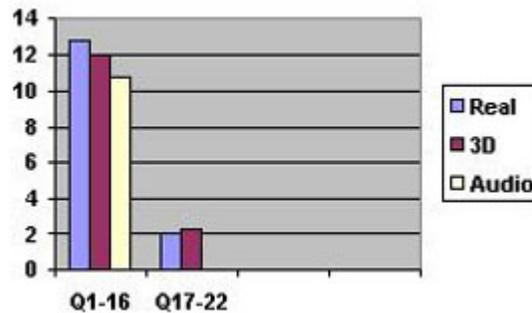
was constructed and subsequently given to subjects for completion at the same time as the task questionnaire.

Results

The results from the three different set of data were preliminary analysed using a comparison of means and standard deviations as well as applying the ANOVA statistical method to identify where significant statistical differences lie. Presence was much higher and significantly different for the 'real' seminar compared with both the 3D and the audio condition, which proves the validity of the measuring method(Graph 1). However, there was no statistically significant difference in presence, between the audio and the 3D/visual condition. In terms of the task, performance was higher and significantly different between the 'real' seminar and the audio one. The former was also higher, looking at the respective means of the data, than the scores from the 3D condition but the ANOVA showed no statistical difference(Graph 2). The same applies for the 3D vs audio conditions. However, the scores were higher and statistically different for those questions that had their answers written on the slides and were also mentioned by the lecturer, showing that visual stimuli made a difference in user task performance between the real/3D condition compared to the audio only condition. User confidence scores were significantly higher for the real seminar and statistically different between the real and the audio condition.



Graph1: Presence scores(Means).



Graph2: Task scores(Means).

In general, we conclude that presence did not correlate positively with task performance in all cases. However, the set of data for presence and the task taken from the real seminar, could serve as an 'evaluation threshold' for consideration towards design of simulated mediated applications. Although there was no statistical difference for presence between the 3D condition and the audio one, subjects reported a much higher sense of 'enjoyment' while using the 3D application(question 7). This fact, differentiates 'presence' from the sense of 'amusement' that the subjects felt. It was more 'fun' using the 3D application, however, the two different sets of subjects for the 3D and audio condition, felt an almost 'equal' sense of 'being' there. This is in a sense verified by comparing the means of the presence data taken from question seven of the presence questionnaire which indicated that users had a higher degree of their 'sense of losing track of time' while using the 3D application. In a different study, which could be more educationally oriented, it would be interesting to investigate if this fact affected in any way, the amount of knowledge that the subjects retained in time.

In this study, the design of the application and of the '3D space' in particular, as well as the level of VE technology used, was kept as simple as possible. The authors were interested in getting a basic set of data for presence and task performance out of an application which included a minimum amount of interactivity and basic technology. They were also interested in confirming the validity of the questionnaires used, as this research method always evokes a lot of doubts. More interactivity and realism elements as well as more 'immersive' virtual environment technology should be used in the future, employed for a more extensive study.

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