

# The Relationship Between Presence and Performance in Virtual Environments: Results of a VERTS Study

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## 1. Introduction

Understanding the conditions under which Virtual Environment (VE) users experience a sense of presence may, in the long term, yield valuable insights into human cognition and psychology. More immediately, however, the general assumption is that a sense of presence impacts a user's ability to perform a task and, therefore, that insights into presence offer a potential payoff in terms of task performance. This paper describes a recent study that investigated the possible relationship between presence and task performance in VEs.

## 2. Experimental Task

In the study, the experimental task used a training exercise, supported by the prototype Virtual Emergency Response Training System (VERTS). This prototype was developed under the VERTS program, which was established in 1999 by DoD to investigate how VE technology could be used to support training Nuclear, Biological, and Chemical (NBC) special-response teams. The prototype provides training in basic mission procedures for Weapons of Mass Destruction Civil Support Team (WMD-CST) Survey Teams. These procedures include searching a designated area to locate and identify any dangerous materials, taking samples and placing alarms as appropriate, and reporting findings to an off-site team commander. The prototype has been used in several field studies and provides both a rear projection screen (immersive) and a desktop (nonimmersive) interface.

## 3. Performance and Presence Measures

Participants' knowledge of mission procedures was assessed in terms of the sum of performance scores for individual elements of the procedures. These individual

scores included the number identified and completeness of reporting for each of chemical hazards, suspicious objects, and casualties; the number of alarms correctly positioned; the completeness and timeliness of route following and marking; and the frequency of progress reports.

Since the measurement of presence is still an active area of research, two different measures were used: the Witmer-Singer Presence Questionnaire (PQ) (Witmer, 1998) and the Slater-Usoh-Steed (SUS) questionnaire (Slater, 1999). The PQ takes a predominantly technological approach, where most of the items query how the VE interface affects the participant's perception and ability to interact with the VE. The SUS questionnaire takes a more psychological approach by querying a participant's feelings on three aspects of presence: (1) the sense of being in the environment depicted by the virtual display, (2) the extent to which there were times when the virtual world seemed the presenting reality, and (3) the sense of having visited a place rather than having seen images.

## 4. Procedure

Participants were randomly allocated to one of the Immersive, Desktop, or Control groups. There were 12, 12, and 11 participants in each group, respectively. All participants were student intern employees. Participants were trained and tested individually. Participants in all groups started by studying a written mission procedures manual. Those in the Control group received no additional training.

Participants in the Immersive and Desktop groups each conducted two training missions using the VERTS prototype and their respective interface. The training scenarios were built using Institute for Defense Analyses (IDA) Virtual Cities databases that provide geospecific representations of real sites with accuracy

at the submeter level. The first was a warehouse on New York Pier 17, and the second was an office building, also in New York. Each site was populated with appropriate objects and suspicious elements, chemical hazards, and on-site casualties. Participants received verbal coaching on mission procedures during the first training scenario. No guidance was given during the second training scenario, but after-action reviews (AARs) provided performance feedback. VE participants completed the presence questionnaires at the conclusion of the second training session.

Knowledge of mission procedures was tested using a real-world training transfer test. This required conducting a survey mission in an area comprising two suites of room, positioned on opposite sides of a hallway. These rooms were undergoing renovations and contained a variety of repair and painting equipment and a few items of office furniture. Display mannequins were used to represent casualties. There were two separate hazards to identify, one suspicious object, and three casualties. Data were collected by using audio and video recordings and by conducting a post-inspection of the search area.

## 5. Results

### 5.1. Effect of Experimental Condition

Analysis of variance showed a significant effect of training condition on knowledge of mission procedures,  $F(2,35) = 7.56$  ( $p < 0.002$ ). Follow-on comparisons of means using the Tukey-Kramer HSD revealed a significant difference between performance of the Control group and each of the Immersive and Desktop groups, with participants in the VE training conditions achieving higher mission scores. This difference was expected. Participants in the VE conditions not only received the opportunity to practice mission procedures, but also coaching and after-action feedback. There was no performance difference between the VE training groups themselves. In other words, the addition of VE training did improve task performance over study of written mission procedures alone, but the extent of this improvement was not related to the immersiveness of the VE-based training.

Similarly, there was no significant difference between the VE groups with respect to the sense of presence they experienced during training.

### 5.2. Presence and Task Performance

The primary goal of this study was to see whether the sense of presence experienced during VE-based

training was related to the learning of mission procedures, as exhibited by performance on the training transfer test. A Pearson product-moment correlation test did reveal a correlation,  $r = 0.42$ ,  $p < 0.04$ , between SUS questionnaire scores and overall mission scores. No such significant relationship was found for the PQ total scores,  $r = 0.39$ ,  $p < 0.059$ .

Does the trend toward significance for PQ scores indicate that the failure to find a similar relationship using the PQ arose because this questionnaire is less sensitive? We do not have the data to answer this question. Looking at individual elements of mission performance, however, seems to suggest that the questionnaires may be measuring different constructs or at least different elements of the same construct. Specifically, SUS questionnaire scores were most correlated with the completeness of identifying and reporting hazards,  $r = 0.42$ ,  $p < 0.04$ , whereas the PQ total and Interface Quality subscale scores correlated best with the completeness of reporting free-standing objects,  $r = 0.43$ ,  $p < 0.04$ , and  $r = 0.54$ ,  $p < 0.007$ , respectively. The lack of a significant correlation between the PQ and SUS questionnaire scores may favor the second explanation.

It is important to stress that none of these correlations indicate whether presence acts as a causal influence on task performance.

## 6. Conclusions

This study provides support for the assumption of a relationship between presence and task performance. Especially for VERTS and the populations examined, we found a positive correlation between the learning of mission procedures and presence, as measured using the SUS presence questionnaire. Our next step will be to determine whether this relationship is a causal one. This will not be easy. It is difficult to identify factors likely to have a strong effect on presence but no direct impact on task performance.

## References

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