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An Experimental Study of the Effect of Presence in Collaborative Virtual Environments

Gerhard M*, Moore DJ*, Hobbs DJ†

*Leeds Metropolitan University, †University of Bradford

Abstract

This paper explores one aspect of interaction in virtual environments, namely the degree of 'presence' experienced by participants in relation to the avatar style used to represent them. A prototype virtual art gallery was created as a vehicle for conducting a series of on-line experiments designed to measure and compare the effects of different forms of avatar on presence. The choice of experimental procedure, together with analysis and interpretation of the results are presented.

Introduction and rationale

The user-computer interface has undergone many changes, from the textual interfaces of the 70's to graphical interfaces in the 80's, from incorporation of multimedia elements in the 90's to current work in portraying sophisticated virtual environments. At the same time, systems have evolved from being single-user oriented to sophisticated collaborative multi-user systems. As a result, traditional HCI (Human Computer Interaction) guidelines are limited in their applicability for the design of such systems and are consequently unlikely to address the full range of aspects now inherent in these virtual environments.

Further, there are currently no evaluation methods specific to CVEs, and differences between virtual environments and conventional interfaces are not fully understood (Kaur *et al* 1998). Consequently, defining an evaluation methodology is complex but it can at least be argued that the specific diet of evaluation techniques needed depends on the characteristics of the system to be evaluated as well as on the purpose of the evaluation itself (Tromp and Benford 1996). Whilst the experimental design and the evaluation of the experiment described in this paper are founded on general HCI usability principles, it is argued that the approach adopted nevertheless forms a unique approach to CVE usability evaluation.

The factor that allegedly distinguishes CVE technology is the sense of immediacy and control created by presence: the feeling of 'being there' (Psotka 1995). It is this factor, therefore, which will be addressed via the evaluation approach just discussed. The term *presence* as used in this context is understood as the possible result of the process of cognitive immersion, and is not to be confused with *virtual presence*, which is simply the deployment of avatars within CVEs. P*resence* may be felt in varying degrees (including no feeling of presence) and may or may not be caused by the use of avatars.

An avatar is '*the representation of a user's identity within a multi-user computer environment*' (Gerhard and Moore 1998). In other words, an avatar is a proxy for the purposes of simplifying

and facilitating the process of inter-human communication in a virtual world. The use of avatars potentially entails several useful properties within a virtual environment, in particular identity, presence, subordination, authority, and social facilitation. Avatars may provide a way for other users to better understand the actual or assumed persona of the underlying user. They may help establish a feeling of presence within a multi-user virtual environment. They may imply subordination, being under the direct control of the user, without significant control over their own actions and internal state. Avatars may also facilitate social encounters in the virtual world and may imply to others that they are acting with the authority of the underlying user.

Based on a review of existing CVE applications and literature, a theoretical framework for understanding the relevance of user embodiments within a CVE for education was expounded by Gerhard and Moore (1998). They argue that presence is an important and desirable characteristic for virtual environments, particularly virtual learning environments, and propose that the nature of the avatars involved could be a contributory factor in the degree of presence engendered. In order to explore this hypothesis the series of experiments described below was conducted using a variety of avatar styles.

Presence Measures

The usability of an interface is defined as a measure of the ease with which a system can be learned or used, its effectiveness and efficiency, and the attitude of its users towards it (Preece et al 1994). The main difficulty with CVE usability evaluation is the fact that CVEs are founded on very recent technology and so far only prototypes of truly collaborative, 3-dimensional virtual learning environments currently exist.

Based on the degree of involvement that has already been observed within full-immersion Virtual Reality systems, Bricken and Byrne (1993) propose that an obvious benefit of presence in educational CVEs will be that it leads to a greater degree of engagement and excitement on the part of the learners. Considering presence as a result of cognitive and social immersion to be the prima facie ‘key added value’, researchers have, however, only just begun to analyse the nature of presence, what cognitive variables are connected to presence, how presence is generated in multi-user VEs, and what its benefits for education and training might be. Further, as presence characterises the response of participants to the system, it is seen as an obvious choice for the key variable in the usability evaluation process of CVEs. Indeed, presence has been used before as the basis for predicting performance in, and potential benefits of, new learning systems in Sheridan (1992), and Held and Durlach (1992).

Measuring presence is not a trivial task, however. Asking questions that measure only the subject’s perception of the technology that contributes to immersion can easily be confused with actually measuring a subject’s feeling of ‘being there’, or their behavioural responses to events in the VE. The vast majority of evaluation studies measure presence through questionnaires in an attempt to elicit subjective feelings of presence (Slater and Usoh 1994).

There have been some suggestions for more objective measurement of presence. For example, Sheridan (1992) was concerned with whether subjects duck, blink or carry out other involuntary movements in response to a sudden event. However, there are problems in attempting to infer the effects of the deployment of avatars in web-based, multi-user virtual environments through such a simplistic mechanism. For example, an involuntary response might also be caused by a sudden loud noise without implying or correlating with a feeling of presence by the user at that time.

The most suitable approach to the measurement of presence is heavily debated among researchers (Slater 1999; Witmer and Singer 1999). Within the current experiment the approach to measuring presence largely followed the methodology of Witmer and Singer (1998) who argue that

involvement and *immersion* are both necessary for experiencing presence. Whereas *involvement* is defined as a psychological state experienced as a consequence of focusing one's attention on a coherent set of stimuli, *immersion* is a psychological state characterised by perceiving oneself to be in an environment of continuous stimuli and experiences.

However, as these presence measures apply only to single-user virtual environments, extended presence measures, namely *awareness* and *communication,* are needed to cover issues specific to multi-user collaborative virtual environments. All four measures (involvement, immersion, awareness and communication) were therefore used in the current research. Furthermore, it has been argued that measuring presence makes sense only when speaking about the degree of presence in one virtual environment setting relative to another (Slater *et al* 1996), since presence cannot be measured in absolute quantities. The current research acknowledges this and therefore populates the same world model with different types of user embodiments, thus enabling comparative measurement of presence and hence a meaningful evaluation.

Hypotheses and experimental design

The experimental study aimed to find out whether the appearance of avatars influences the level of presence. To assess this, three types of user representation were constructed: basic shapes, animated cartoon-style avatars, and animated realistic avatars. The basic shape avatars (Figure 1) were created in VRML, the animated cartoon-style avatars (Figure 2) were created by Avatara (www.avatara.com), and the animated realistic avatars (Figure 3) were created by Cybertown (www.cybertown.com)

The implementation of the experiment was fully Web-based. Pre- and post-questionnaires relating to the experience within the virtual art gallery were implemented as CGI/Perl online forms to be submitted by subjects electronically. The virtual gallery model was implemented in VRML and comprised only basic shapes for defining the geometry of the room and the picture frames. The *Blaxxun Community* virtual world server (see www.blaxxun.com) was used to make the virtual gallery accessible on a Web server and enable avatar and chat interaction. The *Blaxxun Contact* VRML browser was used on the client side. Terminals to access the system were provided at locations within Leeds Metropolitan University and Axis premises.

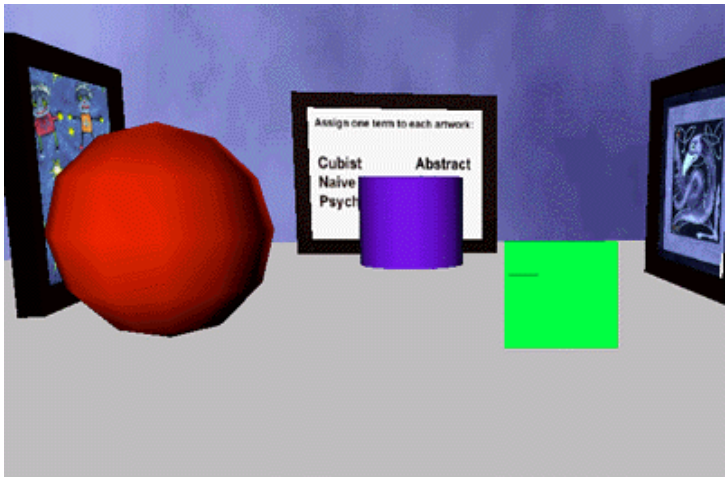

Figure 1: Avatar style – Shape

Figure 2: Avatar style – Cartoon

Figure 3: Avatar style – Realistic

A collaborative task was given to subjects, designed to stimulate interaction and communication. The task involved identifying the art style of a number of contemporary artworks. To simplify the task and to aid subjects without expert knowledge in the visual arts, participants were provided with a list of six different styles to select from - Cubist, Abstract, Naïve, Celtic, Psychedelic, Surreal. Their task was unanimously and collaboratively, as a group, to assign the most appropriate style to each of four artworks with which they were presented (see Figure 4 for a typical example). Since the group had to agree on one joint decision, the task was collaborative in nature.

Twenty seven subjects took part; their scores of the pre-experiment questionnaires being used to divide them into three matched groups of three subjects each that were then randomly assigned the three avatar styles. The various variables involved in the experiment are shown in Figure 5. The two variables that need to be controlled are previous *experience* and individual *immersive tendencies*. To reduce the effects of *maturation* (rehearsal effect), another potential source of internal invalidity, a between-group design was applied to guarantee subjects participate only once in the experiment.

Image	Style	Title	Artist Name
	Naive	Silver Haired Children	Mandy Wrightson
	Celtic	Lyre Bird	Christina Scurr
	Surreal	Fantastic Mr Fox	Tomas Lewis
	Psychedelic	Blue Moon Over Marrakesh	Johnny McGuinness

Figure 4: Example Exhibited Artworks from the Axis Database

The post-questionnaire employed attitude statements with Likert-scales as well as open-ended questions to reveal attitudes, beliefs and experiences of subjects (Silverman 1993). These questions aimed to measure the degree to which aspects of the virtual environment engendered a sense of presence. The questionnaire collected data regarding the dependent variables of immersion, communication, involvement and awareness, and also covered the moderator variables relating to the nature of the environment itself together with its user interface.

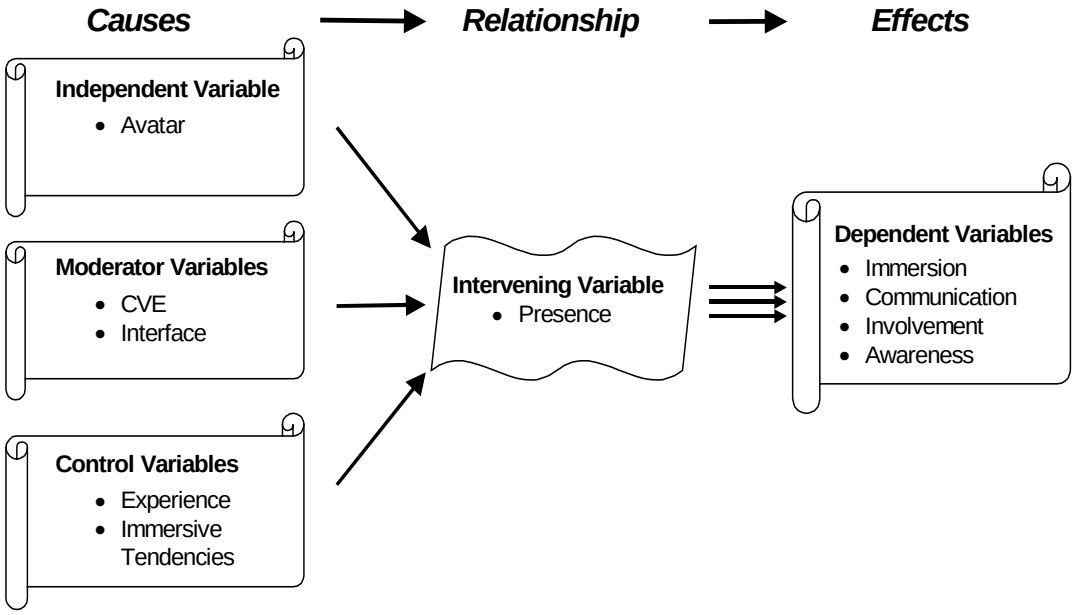

Figure 5: Combined Variables

Results and Analysis

Figures 6, 7, and 8 summarise the data from the experimental study. Results showed that the effects of avatars on presence differed significantly overall ($F_{2,24}=26.155$, $p<0.0005$) between the three groups. Further analysis indicated that the degree of presence was significantly higher when deploying cartoon-style avatars as opposed to basic shape avatars ($p < 0.0005$). Similarly, the degree of presence was found to be significantly higher when deploying realistic avatars as opposed to basic shape avatars ($p < 0.0005$). In contrast, the degree of presence was not significantly different between the use of realistic avatars as opposed to cartoon-style avatars.

These findings were supported by the data collected from subjects by the questionnaire, particularly the open questions. Subjects with cartoon-style and realistic avatars displayed a more positive general attitude towards the experiment and answered in much more detail than those with basic avatars. Furthermore, when directly questioned about avatars their answers were more positive and described the avatars as *amusing*, *realistic*, *funny*, *adding to the experience*, *interesting*, or *excellent*. On the other hand, basic avatars were in some cases not recognised as virtual bodies at all and in other cases were referred to as *very poor*, *could be better*, *extremely simple*, or *could be improved*.

Overall, the results of this study show that different avatar styles do influence presence to different degrees, in particular that animated cartoon-style or realistic avatars promote more presence than basic shape avatars. Further, the former gave rise to sufficiently high scores on the presence scale to strongly suggest that the deployment of such animated avatars does indeed engender a feeling of presence. Additional evidence for this was provided by qualitative data obtained during the experiment and suggested a consequential benefit to the perceived experience within the virtual environment. Thus the experiment succeeded in finding empirical evidence for the benefits of some styles of avatars through measuring the cognitive variable of presence. This evaluation technique will therefore be used again in evaluating the concept of a hybrid avatar/agent model for user representation in educational CVEs, which is the focus of forthcoming experimental work by the authors.

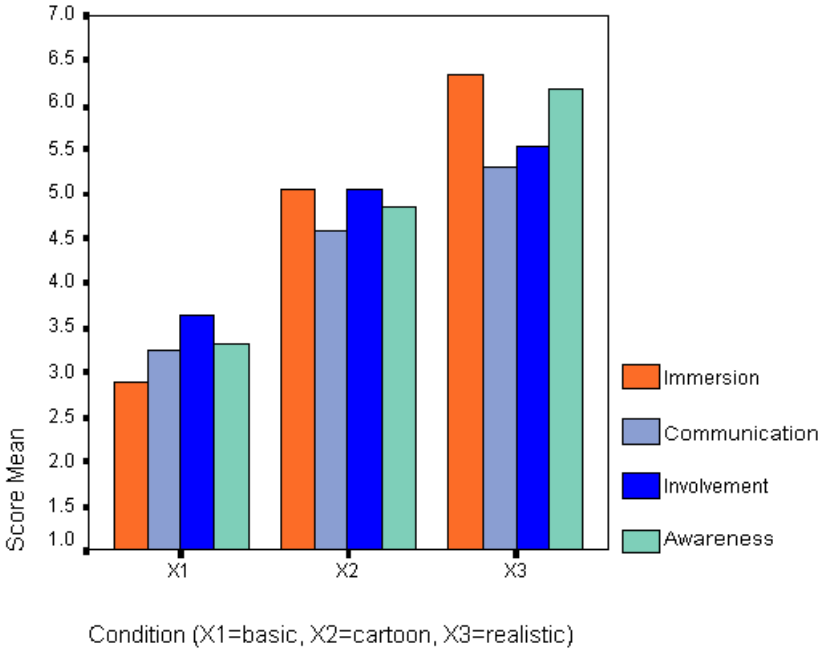

Figure 6: Subscale Scores

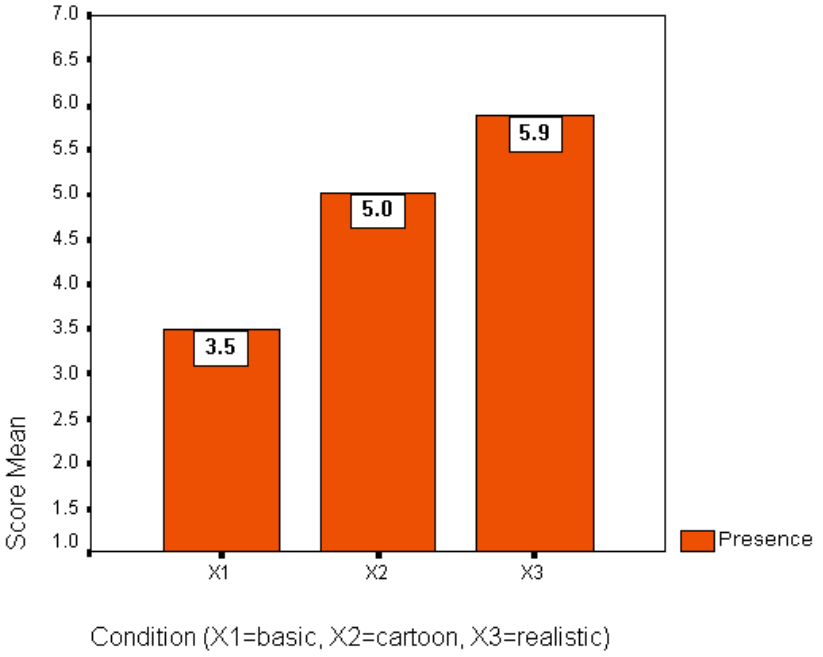

Figure 7: Presence Scores

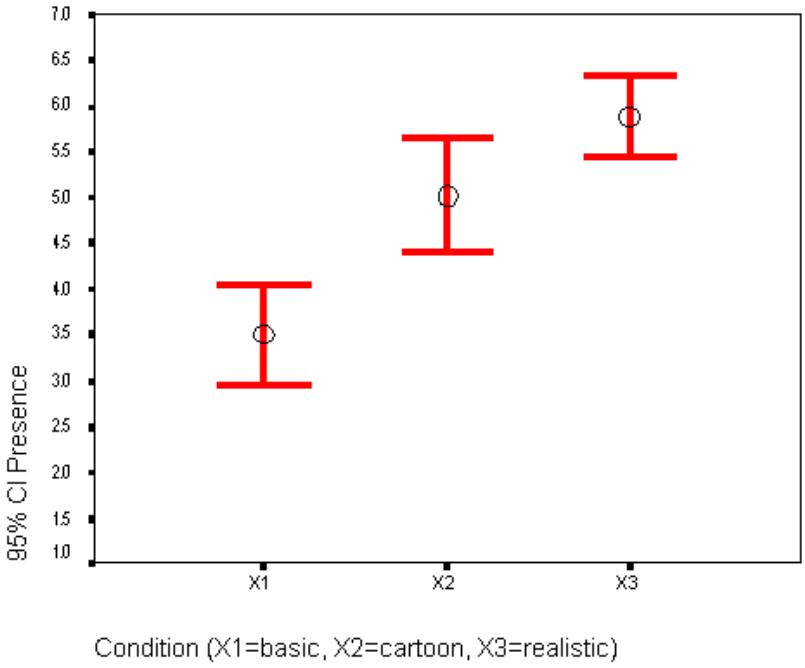

Figure 8: 95% Confidence Interval for Presence Means

Discussion

Overall, the statistical results of this study strongly suggest that the deployment of animated avatars improves the CVE experience of subjects with respect to presence; that is, animated cartoon-style or realistic avatars cause more presence than basic shape avatars. It is reassuring that these statistical findings were supported by the qualitative data from the questionnaires.

In sum, this experiment has succeeded in not only evaluating the use of avatars in CVEs, but also in finding empirical evidence for the benefits of animated avatars by measuring a cognitive variable called presence. Evidence was found for the hypothesis that the deployment of animated, cartoon-style or realistic avatars improves the virtual experience of participants as compared to those represented by basic avatars. Thus, the results of this study strongly recommend employing animated avatars in the design of future educational CVEs.

Further, it can be argued that in a situation of time-independent collaborative learning a continuous presence of all participants is desirable. When members of a group are not co-present, there is a lack of community feeling (Huxor 1998). A continuous presence of all participants may be achieved using agent technology to control the avatar when the underlying user is not present (Gerhard and Moore 1998). Thus, the success of the current experimental design and evaluation approach is seen as a stepping stone towards evaluating the notion of a continuous presence achievable by a hybrid avatar/agent model, the goal of a forthcoming experiment involving intelligent agents for delivering ‘presence-in-absence’.

References

Bricken, M., Byrne, C. (1993), Summer Students in VR: A Pilot Study on Educational Applications in VR Technology, in *VR Application and Explorations*, Wexelblatt, Alan (Ed.) Academic Press, Toronto, Canada

Gerhard, M., Moore, D. (1998), User Embodiments in Educational CVEs: Towards Continuous Presence, in *Proceedings of the International Conference on Network Entities, (NETIES '98)*, Leeds, UK

Gerhard, M., Hobbs, D., Moore, D., Fabri, M., (1999), Cognitive Immersion in CVEs: A Hybrid Avatar/Agent Model for User Representation in Virtual Learning Environments, in *Proceeding of the Eurographics UK Conference*, Cambridge, UK

Held, R., Durlach, N., (1992), Telepresence, in *Presence: Tele-operators and Virtual Environments*, Vol. 1, MIT Press, Boston, USA

Huxor, A., (1998), The Role of 3D Shared Worlds in Support of Chance Encounters in CSCW, in *Proceedings of International Conference on Digital Convergence: The Future of the Internet & WWW*, Bradford, UK

Kaur, K., Tromp, J., Hand, C., Istance, H., Steed, A. (1998), Usability Evaluation for Virtual Environments, in *Proceedings of the UEVE '98 Workshop*, Leicester, UK

Preece, J. (1994), *Human Computer Interaction*, Addison Wesley

Psotka, J. (1995), Immersive Tutoring Systems: Virtual Reality and Education and Training, in *Instructional Science*, Vol. 23, USA

Sheridan, T. B. (1992), Musings on Telepresence and Virtual Presence, in *Presence: Tele-operators and Virtual Environments*, Vol. 1, MIT Press, USA

Silverman, D. (1993), *Interpreting Qualitative Data - Methods for Analysing Talk, Text and Interaction*, Sage Publications Ltd, London, UK

Slater, M., (1999), Measuring Presence: A Response to the Witmer and Singer Questionnaire, in *Presence: Tele-operators and Virtual Environments*, Vol. 8, No. 5, pp 560-565, MIT Press, USA

Slater, M., Usoh, M. (1993), Presence in Immersive Virtual Environments, in *Proceedings of the IEEE Conference – Virtual Reality Annual Symposium*, Seattle, USA

Slater, M., Usoh, M. (1994), Body Centred Interaction in Immersive Virtual Environments, in *Artificial Life and Virtual Reality*, Thalmann, D., Thalmann, N.M., (Eds.), John Wiley & Sons, USA

Slater, M., Steed, A., McCarthy, J., Maringelli, F. (1996), *The Influence of Body Movement on Presence in Virtual Environment*s, UK

Tromp, J., Benford, S., 1996, Presence, Telepresence and Immersion: Interaction and Embodiment in Collaborative Virtual Environments, in *Proceedings of FIVE '95 Framework for Immersive Virtual Environment*, London, UK

Tuckman, B. W. (1972), *Conducting Educational Research*, Harcourt Brace Jovanovich, Inc., New York, USA

Witmer, B., Singer, M., (1998), Measuring Presence: A Presence Questionnaire, in *Presence: Tele-operators and Virtual Environments*, Vol. 7 (3), MIT Press, USA

Witmer, B., Singer, M., 1999, On Selecting the Right Yardstick, in *Presence: Tele-operators and Virtual Environments*, Vol. 8, No. 5, pp 566-573, MIT Press, USA