Measuring Temporal Variations in Presence

W.A. IJsselsteijn and H. de Ridder

IPO, Center for Research on User-System Interaction

P.O.Box 513, 5600 MB Eindhoven, The Netherlands

Phone: +31 (0)40 2475214

Fax: +31 (0)40 2431930

E-mail: ijssel@ipo.tue.nl

Summary

- In the current study we have applied the concept of presence to 3DTV research. More specifically, we took this concept to reflect the increased perceptual linkage between the observer and the mediated environment, supporting an illusion of non-mediation. We applied the continuous assessment methodology to reveal time-variant properties of presence, which were hitherto largely ignored, and to assess some of the contributing factors that have been suggested as determinants of presence.
- Our results indicate that subjective presence ratings are subject to considerable temporal variation depending on the stimulus material used. The continuous assessment methodology may be regarded as a useful measurement tool that is sensitive to this time-varying information in subjective presence judgements, provided that any conclusions are based on averaged results obtained from an adequate number of observers.
- We also found qualitative evidence suggesting that increasing the extent of sensory information provided to an observer, through the addition of stereoscopic and motion parallax cues (simulated via camera movement), may enhance the observer's sense of presence.

Presence: From Observer to Participant

The concept of presence, or the sense of being somewhere in space and time, has to date largely been applied to describe the user's experience when interacting with advanced media interfaces such as virtual environments. However, it has been argued that a theory of telepresence (i.e. any medium-induced sense of presence) should be applicable to all mediated environments, including more traditional media such as television (Kim & Biocca, 1997; Lombard & Ditton, 1997; Steuer, 1995).

With the advent and improvement of new display media, such as immersive displays or 3DTV, the 'discontinuity between the place of our current reality and the reality showing through the display', as Slater & Wilbur (1997) put it, is collapsing. This fusion of the observer space and the mediated or display space is brought about by making the display space part of the observer space (as is the case with 3DTV), making the observer space part of the display space (as with immersive displays such as HMDs) or combining these two approaches (e.g. CAVE). Reflecting this

continuity, presence can be conceptualized as the *perceptual illusion of non-mediation*, changing viewing into visiting, and the observer into a participant.

Determinants of Presence

Presence is a complex multidimensional construct (Barfield, Zeltzer, Sheridan and Slater, 1995), which, when applied to virtual environments, depends on a great many hardware, software, subject and task variables. Sheridan (1992) identifies three principal components of a sense of presence, from a participant-based viewpoint:

- *Extent of sensory information*: amount of useful and salient sensory information, in terms of cues to the appropriate sensors of the observer

- *Control of sensors*: the ability the observer has to control the relation of the sensors to the environment (e.g. modify viewpoint)

- *Ability to modify the environment*: the degree to which an observer is free to change objects in the environment and their relations to one another

Especially within the context of collaborative work in shared virtual environments, a fourth determinant may be identified, namely the *acknowledgement* of the self through the presence and reactions of others. This is what Heeter (1992) calls 'social presence' and is related, though not identical, to the concepts of *autonomy* (Zeltzer, 1992) and *plot* (Slater & Wilbur, 1997).

Stereoscopic displays are expected to contribute to a heightened sense of presence, since stereoscopic image presentation is likely to enhance the illusion of non-mediation through fusion with the observer space. In terms of Sheridan's (1992) determinants of presence, stereo information adds to the extent of salient sensory information available to the viewer.

Using stereoscopic video material, the current experiment was performed to assess whether presence ratings would show considerable temporal variation and how this variation, if and when it occurred, would be related to the image material, in terms of the sensory information available to the observer and its relation to the camera techniques used.

Measuring Temporal Variations in Presence

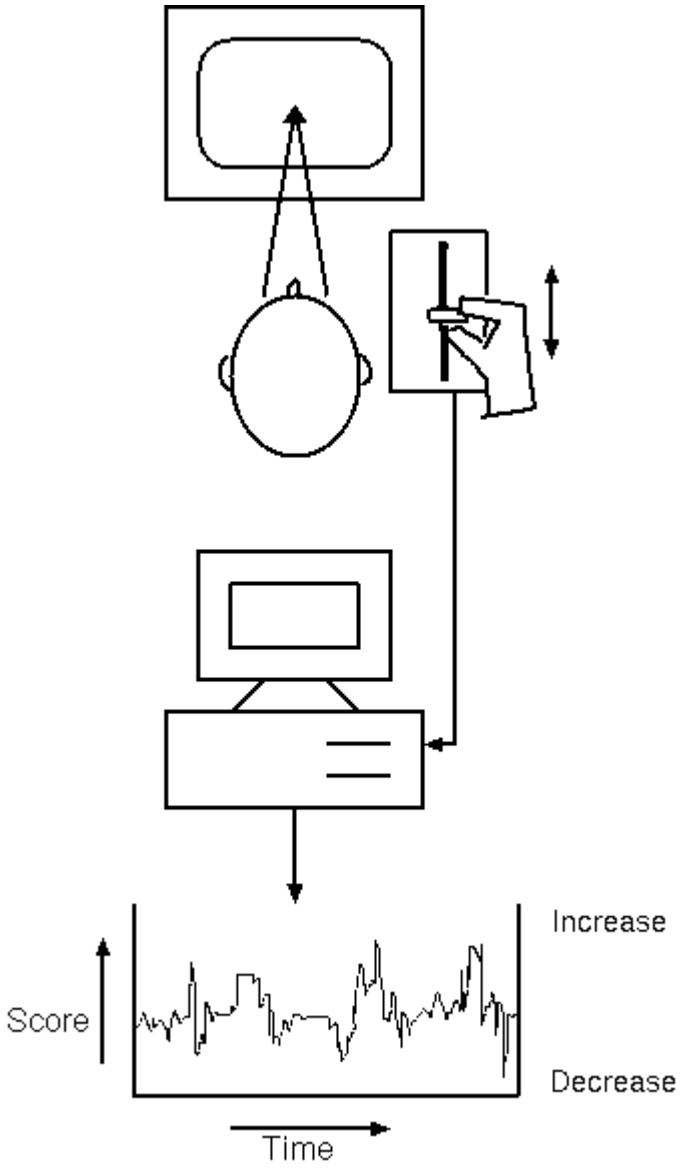
Temporal variations in the subjective sense of presence can be expected to occur either through stimulus variation (i.e. on-line modifications of any of the determinants of presence) or adaptation effects of prolonged immersion in a mediated environment

Current methodologies, either used or proposed, to measure the subjective sense of presence are limited in a number of ways (Freeman, IJsselsteijn, Avons, de Ridder & Franich, 1997; IJsselsteijn, de Ridder, Hamberg, Bouwhuis & Freeman, 1998). Post-immersion tests are potentially subject to inaccurate recall and anchoring effects. Futhermore, any discrete measure taken misses out on temporal variations in the subjective sense of presence during immersion.

In an attempt to overcome these limitations we have applied the continuous assessment methodology to measuring the subjective sense of presence (Freeman, Avons, Davidoff & Pearson, 1997b; IJsselsteijn, Freeman, Avons, Davidoff, de Ridder and Hamberg, 1997; IJsselsteijn et al., 1998). The method of continuous assessment was originally developed to evaluate perceived TV picture quality under the RACE MOSAIC project (ITU-R, BT 500-7; de Ridder & Hamberg, 1997; Hamberg & de Ridder, 1995). It requires subjects to continuously indicate the perceived strength of a specified attribute by adjusting the position of a slider along a graphical scale. A computer subsequently samples the position of the slider at a constant rate (see figure 1). This methodology is not subject to recall or anchoring effects and is sensitive to time-variant information. Furthermore, the potential disrupting effect

that on-line measurements may have on presence is kept limited with this method, since it requires very little in terms of effort or attention from the subject.

Figure1.



However, as with any other other subjective presence assessment methodology, continuous presence assessment is subject to sensitizing effects. The reason for this is that presence at this time is still a fairly unfamiliar concept to most naive observers, as has been demonstrated by Freeman, Avons, Pearson & IJsselsteijn (submitted). Proper instructions may help to clarify the concept, yet observers may still anchor their judgements onto the most salient feature of any mediated environment

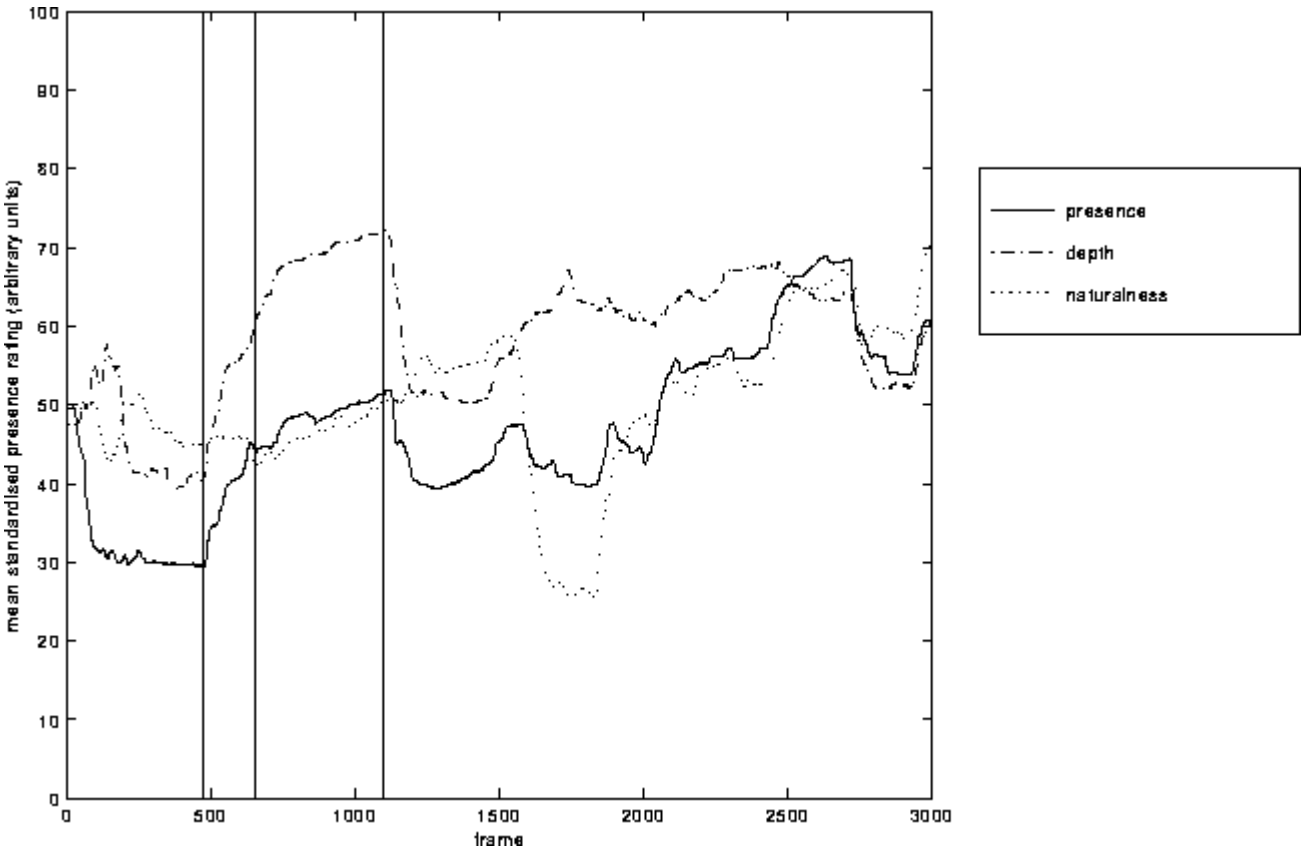
Experiment

Observers Twelve observers (either staff or students at IPO, 7 male, 5 female, average age 33 years) took part in the experiment on a voluntary basis. All had normal or corrected-to-normal vision. All observers had good stereoscopic acuity.

Equipment An 8-minute selection from a stereoscopic film, titled 'Eye to eye', was used as our image material. It was transcribed in detail to obtain a scene-by-scene description of image content, camera movement, visible depth cues and stereoscopic camera parameters. This image material varied in content and consisted of scenes that differed both in the amount and strength of the different depth cues present. In order to display the film, two digital studio video recorders (BTS DCR-100) were used as input for an AEA technology 20" stereo monitor which consisted of two BARCO CPM 2053 colour monitors (50 Hz PAL) with polarised filters in front of each. Observers were required to wear polarised spectacles to separate right and left eye-views. The slider with which observers indicated their response was connected to an ordinary PC that sampled the slider position 20 times per second and stored the collected data as files.

Procedure One experimental session consisted of showing the eight-minute selection of film three times (i.e. once for each attribute), resulting in a total session length of approximately 30 minutes. Observers were seated at a distance of 80 cm (approximately 2.5 picture heights) from the stereo monitor. For each presentation an observer was instructed to assess a different attribute (either depth, naturalness of depth or presence) by means of the slider, which he/ she held on his/ her lap and could operate with his/ her preferred hand. The observer was asked to move the slider upwards if he or she experienced an increase in the relevant attribute, and downwards when experiencing a decrease in the attribute. After the observers had a firm understanding of the task and the perceptual attribute they were asked to rate, lights were turned off. The film was presented without sound and in a completely darkened environment. The order in which the different attributes were assessed was varied to compensate for a possible effect of presentation order.

Results and discussion Figure 2 shows the mean standardized presence, depth, and naturalness ratings for the first 3000 frames (i.e. the first 2 minutes). A replication of this experiment was performed at the Department of Psychology at the University of Essex (UoE) using exactly the same methodology with 18 observers (Freeman et al., 1997a; IJsselsteijn et al., 1997). The results obtained at the two laboratories are very similar, indicating that observers are able to judge temporal variations in presence reliably.



Although a detailed scene-by-scene analysis of the responses of the subjects for the complete 8 minute sequence is beyond the scope of the present paper, we have marked a few interesting sections, from frame 0 to 1100. This analysis is in line with the analysis of the University of Essex results (Freeman, Avons & Davidoff, 1997). The film starts off monoscopically with a static shot of the presenter, with the left and right eyes being presented with the same images. From frame 475 (marked with a vertical line), the video is presented stereoscopically. At this point the mean ratings of perceived depth and presence both dramatically increase. Naturalness of depth also increases, indicating that the presented binocular disparity is well within optimal bounds. At frame 600 (marked) the camera starts to pan, mimicking observer motion and providing a motion parallax cue, and mean presence and depth ratings continue to increase. Interestingly, the mean ratings for perceived depth and presence suddenly drop when, at frame 1100 (marked), the scene changes to a screen-filled shot of a fish tank. One reason for this decrease in perceived depth may be the cessation of camera simulated observer motion, and thus the removal of the motion parallax cue. These results illustrate that an adding stereo and motion cues may enhance the feeling of presence, a result that provides qualitative support for one of Sheridan's (1992) theoretical determinants of presence, i.e. the extent of sensory information available to the observer. These basic findings have been confirmed in a more controlled experimental design by Freeman, Avons, Davidoff and Pearson (1997b).

A further analysis was performed using the first derivative of the continuous assessment graph, which reflects the rate and direction of changes in the subjective judgements of the observers, but ignores absolute values. When applying a threshold for only fairly rapid changes (where $|ds/dt| > 0.1$) 35 above-threshold changes in one or more of the dependent variables were observed. Each of these changes is preceded by a scene-cut, yet not every scene-cut results in a noticeable change. Therefore, a scene-cut seems to provide a necessary but not sufficient condition for a fast change in the subjective assessment data to occur. Furthermore, although above threshold changes are reliably preceded by scene-cuts, the scene-cuts do not determine the *direction* of the change. This seems to be dependent on the content of the scene, as has been illustrated above.

References

Barfield, W., Zeltzer, D., Sheridan, T.B. and Slater, M. (1995). Presence and performance within virtual environments. In: Barfield, W. and Furness III, T.A. (eds), *Virtual Environments and Advanced Interface Design*, pages 473-513. Oxford: Oxford University Press.

de Ridder, H. and Hamberg, R. (1997). Continuous assessment of image quality. *SMPTE Journal 106*, 123-128.

Freeman, J., Avons, S.E., and Davidoff, J. (1997). Effects of stereo and motion manipulations on measured presence in stereoscopic displays. Presented at Applied Vision Association AGM, 8th to 11th April 1997.

Freeman, J., IJsselsteijn, W.A., Avons, S.E., de Ridder, H. and Franich, R. (1997a). Assessment of the sense of presence in stereoscopic displays: its relation to display type and image content. ACTS TAPESTRIES WP 2.1 Technical Report, UoE/IPO.

Freeman, J., Avons, S.E., Davidoff, J. and Pearson, D.E. (1997b). Effects of stereo and motion manipulations on measured presence in stereoscopic displays. *Perception 26 (suppl)*, 42.

Freeman, J., Avons, S.E., Pearson, D.E., and IJsselsteijn, W.A. (submitted). Effects of sensory information and prior experience on direct subjective ratings of presence. *Presence: Teleoperators and Virtual Environments*.

Hamberg, R. and de Ridder, H. (1995). Continuous assessment of perceptual image quality. *Journal of the Optical Society of America A 12*, 2573–2577.

Heeter, C. (1992). Being there: The subjective experience of presence. *Presence: Teleoperators and Virtual Environments 1*, 262-271.

ITU-R Recommendation BT.500-7 (Revised). *Methodology for the subjective assessment of the quality of television pictures*, 1995.

Kim, T. and Biocca, F. (1997). Telepresence via television: Two dimensions of telepresence may have different connections to memory and persuasion. *Journal of Computer-Mediated Communication 3(2)* [On-line]. Available: http://www.ascusc.org/jcmc/vol3/issue2/kim.html.

Lombard, M. and Ditton, T. (1997). At the heart of it all: The concept of presence. *Journal of Computer-Mediated Communication 3(2)* [On-line]. Available: http://www.ascusc.org/jcmc/vol3/issue2/lombard.html.

Sheridan, T.B. (1992). Musings on telepresence and virtual presence. *Presence: Teleoperators and Virtual Environments 1*, 120-125.

Slater, M. and Wilbur, S. (1997). A framework for immersive virtual environments (FIVE): Speculations on the role of presence in virtual environments. *Presence: Teleoperators and Virtual Environments 6*, 603-616.

Steuer, J. (1995). Defining virtual reality: Dimensions determining telepresence. In: Biocca, F. and Levy, M.R. (eds), *Communication in the age of virtual reality*, pages 33-56. Hilldale, NJ: Lawrence Erlbaum Associates.

IJsselsteijn, W.A., Freeman, J., Avons, S.E., Davidoff, J., de Ridder, H. and Hamberg, R. (1997). Continuous assessment of presence in stereoscopic displays. *Perception 26 (suppl)*, 42-43.

IJsselsteijn, W.A., de Ridder, H., Hamberg, R., Bouwhuis, D. and Freeman, J. (1998). Perceived depth and the feeling of presence in 3DTV. *Displays* (in press).

Zeltzer, D. (1992). Autonomy, interaction and presence. *Presence: Teleoperators and Virtual Environments 1*, 127-132.