Decomposing the Sense of Presence: Factor Analytic Insights

(Extended Abstract submitted to the 2nd International Workshop on Presence, 30.01.1999)

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Summary:

- The sense of presence is the defining experience for virtual reality (Steuer, 1992). Considering the possibility that presence is a multidimensional construct, the question now is: What are the defining experiences for the sense of presence?
- On the way to decompose presence, we focus on the distinction between a spatial-constructive and an attention component of presence (Witmer and Singer, 1998, see also the embodied presence model presented in Schubert, Friedmann, & Regenbrecht, in press).
- To our knowledge, this distinction has not been supported empirically so far. We present data from a survey on presence and immersion experiences, conducted with 246 participants and analysed in first and second order factor analyses.
- We found three different presence components. As predicted, a spatial-constructive component and an attention component were found. Additionally, a component involving reality judgements emerged. Separated from these are five immersion components. In the second order analysis, presence and immersion factors form different second order factors. These results support the distinction between presence and immersion, (e.g., Slater, Usoh & Steed, 1994; Slater and Wilbur, 1997).
- By decomposing presence into three components, these findings enable us to ask new types of research questions and provide material for a theory of presence in virtual environments.

Decomposing Presence

Steuer (1992, p. 73) defined "virtual reality as a particular type of experience" – one that involves the *sense of presence*, characterised as *the sense of being in a place*. Since then, this definition has been widely accepted. By now, many researchers also acknowledge that presence is a complex and probably multidimensional variable (Biocca & Delaney, 1995; Kalawsky, 1998; Sheridan, 1992; Sheridan, 1996; Welch, Blackmon, Liu, Mellers, & Stark, 1996). Our goal in the present research is to investigate the *various* particular types of experiences which form the sense of presence in virtual environments (VEs).

In a more general sense, this approach can be characterised as an attempt to draw distinctions. In principle, those distinctions can be drawn in two ways: One kind of distinction can be made between presence and other phenomena. We can call this kind an inter-conceptual distinction. The second kind of distinction differentiates inside the presence phenomenon and finds types or components. Those distinctions can be called intra-conceptual distinctions. Both distinctions have be drawn in the literature for the presence construct.

Inter-conceptual distinction. The main inter-conceptual distinction in the literature is the one between presence and immersion. It has most clearly been stated by Slater and colleagues (Slater & Wilbur, 1997). They define immersion as a quality of the technology used to immerse the participant. Presence, on the other hand, "is a state of consciousness, the (psychological) sense of being in the virtual environment" (Slater et al., 1997, pp. 604f). The distinction is first and foremost a theoretical and logical one. However, self report measures are available for both presence and immersion (Sheridan, 1996; Witmer & Singer, 1998). Thus, the difference between immersion and presence should be verifiable empirically. To our knowledge, this has not been done so far.

Intra-conceptual distinction. The main intra-conceptual distinction in the literature is the one between a spatial-constructive and an attention component of presence experiences. (We do not discuss the distinction between objective and subjective presence in this abstract, since this is mainly a methodological distinction and our research is based on subjective measures.) To our knowledge, the best treatment of this distinction has been presented by Witmer and Singer (1998). They call the spatial-constructive component *immersion* and the attention component *involvement*. Witmer and Singer clearly acknowledge that both are subjective experiences; we will thus call their first component *spatial presence* to avoid confusion.

The decomposition into a spatial-constructive and an attention component is consistent with a theoretical approach to presence that we have recently developed elsewhere (Schubert, Friedmann, & Regenbrecht, in press). This approach interprets presence as an *embodied cognition*: Presence develops from the mental representation *of bodily actions* as possible actions in the virtual world. When movements of the own body (or body parts) in the VE are represented mentally as possible actions, presence emerges. The construction of this mental representation requires the suppression of conflicting stimuli from the real world. Combining both aspects, our model predicts both a spatial-constructive and an attention component.

The empirical evidence that Witmer and Singer (1998) present is not a suitable test for the existence of the two components, since they aimed at measuring immersion instead of presence. Thus, just like the distinction between presence and immersion, the distinction between a spatial-constructive and an attention component remains to be tested empirically. These are the goals of the research we present here. For this purpose, we conducted a questionnaire study on immersion and presence experiences.

Factor Analytic Insights

Questions. In this survey, we combined questions from previously published questionnaires (Carlin, Hoffman, & Weghorst, 1997; Ellis, Dorighi, Menges, Adelstein, & Jacoby, 1997; Hendrix, 1994; Slater, Usoh, & Steed, 1994; Towell, 1997; Witmer & Singer, 1994), questions from our own past research (Regenbrecht, Schubert, & Friedmann, 1998) and newly

designed questions. The questions were translated into German and combined in one 75-item survey. Additional questions assessed technological and context variables. The participants were instructed to remember one of their last uses of a VE and to answer all questions only with reference to that single experience.

Participants. 246 people took part in the survey. Approximately 10 % of the participants were female, 90 % male. The mean age was 24.5 years (SD=5.3). The majority of our participants used desktop-based VEs with monitors and stereo sound. Users of head-mounted displays and CAVE environments were rare and used less audio equipment. 3D games were the main type of application. Interestingly, 60% of them were played in multi-user settings.

Sampling adequacy. We planned to use factor analytic methods for analysing the data. Factor analyses demand high numbers of participants and high inter-item correlations. Different criteria (Arrindel & Ende, 1985; Guadagnoli & Velicer, 1988; Guilford, 1956; Kline, 1994) indicated a high sampling adequacy and good preconditions for factor analyses.

Factorization and number of factors. The data were factorized using Principal Components Analysis and rotated using oblique Direct Oblimin rotation (Delta=0). Following the scree-plot and after additional checking for other solutions, we extracted 8 factors. This solution explains 50.27% of the total variance. The following table presents the components and their respective highest loading item.

Table 1. Components and highest loading items of the first order analysis.

Com-ponent	Name	Label	Eigen-value	Items	Highest loading item
1	spatial presence	SP	14.087	14	In the computer generated world I had a sense of "being there"...[a]
2	quality of immersion	QI	4.574	8	How much did the auditory aspects of the environment involve you?[b]
3	involvement	INV	3.824	10	I concentrated only on the virtual space.
4	drama	DRA	3.083	7	Did the virtual world seem to you like a film you were acting in?
5	interface awareness	IA	2.485	7	Overall, how much did you focus on using the display and control devices instead of the virtual experience and experimental tasks?[b]
6	exploration of VE	EXPL	2.262	6	How closely were you able to examine objects?[b]
7	predictability & interaction	PRED	1.967	6	Were you able to anticipate what would happen next in response to the actions that you performed?[b]
8	realness	REAL	1.901	5	How real did the virtual world seem to you?[c]

Note the sources of the items: [a] Slater, Usoh & Steed (1994), [b] Witmer & Singer (1994), [c] Carlin, Hoffman, & Weghorst (1997).

Second Order Factors. In order to further explore the relations between the factors, we computed a second order factor analysis of the scale sum scores (again Principal Components Analysis and oblique Direct Oblimin Rotation). Since we wanted to test how the factors group together, we forced solutions with 2 (explaining 53.82% of variance) and 3 factors (explaining 65.60% of variance), although the third factor had an Eigenvalue slightly below 1. The analysis shows that the three components *realness*, *spatial presence* and *involvement* together load on the first strong second order factor. When a two-factor solution is forced, they are joined by *drama* and *quality of immersion*. In the three-factor solution, these two variables together form the third factor. The second factor is in both solutions the same and consists of *interface awareness*, *predictability & interaction* and *exploration*.

Scale Formation. The scales defined by the factors, although preliminary, have reasonable reliabilities with Cronbach's Alphas ranging from α_{SP}=0.85 to α_{PRED}=0.71

Discussion

Now, what are the insights from our factor analyses? First of all, the analyses showed that reports on subjective experiences and reported evaluations of the technology form different factors. Consequently, we have supporting evidence for a distinction between *presence factors* and *immersion factors*.

Presence Factors. Next, the two factors *spatial presence* and *involvement* support the distinction postulated by Witmer and Singer (1998) and derived from our embodied presence model. In fact, the commonly used definition "sense of being there" is the highest loading item on SP. INV combines items describing the subjective experiences of awareness and attention processes. SP and INV do also together load on the first second-order factor, indicating that this may be a general presence factor. Surprisingly, a third factor loads on this general presence: *realness*. Items loading on it tap judgements of the VE concerning its realness or comparability to reality. The idea that attribution of reality or realness is a part of the sense of presence has been advocated earlier, but only tentatively so (Regenbrecht et al., 1998; Slater et al., 1994; Steuer, 1992). It seems that this factor puts the *reality* part of *virtual reality* back in the focus.

Immersion factors. All other factors tap evaluations of the immersing stimuli and the interactions with them. Our factor structure matches previous categorisations of immersion and interaction factors:

1. *Quality of immersion* (QI) relates to sensory factors (Witmer & Singer, 1998) and includes environmental richness (Sheridan 1992), multimodal presentation (Held & Durlach, 1992) and consistency of multimodal information (Held & Durlach, 1992).
2. *Interface awareness* supports the notion by "Held and Durlach (1992) ... that unnatural, clumsy, artifact-laden interface devices interfere with the direct and effortless interpretation of (and interaction with) a VE ..." (Witmer & Singer 1998, p. 230).
3. *Exploration* matches Witmer & Singer's (1998) *active search*: "An environment should enhance presence when it permits observers to control the relation of their sensors to the environment (Sheridan, 1992). To the extent that observers can modify their viewpoint ... they should experience more presence." (p. 230).
4. *Predictability & Interaction* resembles Witmer and Singer's (1998) *anticipation*, one of the control factors: "Anticipation: Individuals probably will experience a greater sense of presence in an environment if they are able to anticipate or predict what will happen next ... (an issue raised by Held & Durlach, 1992)" (p. 229).
5. The *drama* factor is related to the description of plot given by Slater and Wilbur (1997): "[Plot] is the extent to which the VE in a particular context presents a story-line that is self-contained, has its own dynamic, and presents an alternate unfolding sequence of events ..." (p. 605).

Asking new questions. Acknowledging that presence is a multidimensional construct enables us to ask new questions in the presence research. The prototypical hypothesis in today's presence research regresses a unitary presence measure on one or some immersion variables. Alternatively, we can now ask which immersion variables should determine which presence components – and which not. Another new hypothesis type is which immersion variable should influence which mediating cognitive process, which in turn could determine different presence components. These questions may be the venue to a theory of presence in virtual environments.

Reference List

Arrindel, W.A., & Ende, v.d.J. (1985). An empirical test of the utility of the observations-to-variables-ratio in factor and components analysis. Applied Psychological Measurement, (9), 165-178.

Biocca, F., & Delaney, B. (1995). Immersive Virtual Reality Technology. In F. Biocca & M. R. Levy (Eds.), Communication in the Age of Virtual Reality. (pp. 57-124). Hillsdale, NJ: Lawrence Erlbaum Associates.

Carlin, A.S., Hoffman, H.G., & Weghorst, S. (1997). Virtual reality and tactile augmentation in the treatment of spider phobia: a case report. Behaviour Research and Therapy, 35(2), 153-158.

Ellis, S.R., Dorighi, N.S., Menges, B.M., Adelstein, B.D., & Jacoby, R.H. (1997). In search of equivalence classes in subjective scales of reality. In M. J. Smith, G. Salvendy, & R. J. Koubek (Eds.), Design of Computing Systems: Social and Ergonomic Considerations. Proceedings of the Seventh International Conference on Human-Computer Interaction, (HCI International '97), San Francisco, California, USA August 24-29, 1997, Volume 2. (pp. 873-876). Amsterdam: Elsevier.

Guadagnoli, E., & Velicer, W.F. (1988). Relation of sample size to the stability of component patterns. Psychological Bulletin, (103), 265-275.

Guilford, J.P. (1956). Psychometric Methods. New York: McGraw-Hill.

Hendrix, C.M. (1994). Exploratory Studies on the Sense of Presence in Virtual Environments as a Function of Visual and Auditory Display Parameters. Master's Thesis. Human Interface Technology Laboratory of the Washington Technology Center at the University of Washington.

Kalawsky, R. (1998). A Tool for Evaluation of Contributory Factors Associated with Presence in Spatially Immersive Environments. Presented at the BT Presence Workshop, 10-11 June 1998. Document retrieved from the Internet, http://sgi-hursk.lut.ac.uk/~avrrc/presence/vrsart.htm.

Kline, P. (1994). An Easy Guide to Factor Analysis. London, New York: Routledge.

Regenbrecht, H., Schubert, T., & Friedmann, F. (1998). Measuring the Sense of Presence and its Relations to Fear of Heights in Virtual Environments. International Journal of Human-Computer Interaction, 10(3), 233-249.

Schubert, T., Friedmann, F., & Regenbrecht, H. (in press). Embodied Presence in Virtual Environments. In R. Paton & I. E. Neilson (Eds.), Visual Representations and Interpretations. Berlin: Springer-Verlag.

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

Sheridan, T.B. (1996). Further Musings on the Psychophysics of Presence. Presence: Teleoperators and Virtual Environments, 5(2), 241-246.

Slater, M., Usoh, M., & Steed, A. (1994). Depth of Presence in Virtual Environments. Presence: Teleoperators and Virtual Environments, 3(2), 130-144.

Slater, M., & 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(6), 603-616.

Steuer, J.S. (1992). Defining virtual reality: Dimensions determining telepresence. Journal of Communication, 42(4), 73-93.

Towell, J. (1997). Presence in Text-Based Networked Virtual Environments or "MUDS". Presence: Teleoperators and Virtual Environments, 6(5), 590-595.

Welch, R.B., Blackmon, T.T., Liu, A., Mellers, B.A., & Stark, L.W. (1996). The Effects of Pictorial Realism, Delay of Visual Feedback, and Observer Interactivity on the Subjective Sense of presence. Presence: Teleoperators and Virtual Environments, 5(3), 263-273.

Witmer, B.G., & Singer, M.J. Measuring Presence in Virtual Environments. (1994). ARI Technical Report. Alexandria, VA: U. S. Army Research Institute for the Behavioral and Social Sciences.

Witmer, B.G., & Singer, M.J. (1998). Measuring Presence in Virtual Environments: A Presence Questionnaire. Presence: Teleoperators and Virtual Environments, 7(3), 225-240.