

Social Presence and Interpersonal Trust in Avatar-Based, Collaborative Net-Communications

Gary Bente, Sabine Rüggenberg, Nicole, C. Krämer
University of Cologne

{bente@uni-koeln.de, sabine.rueggenberg@uni-koeln.de, nicole.kraemer@uni-koeln.de}

Abstract

The paper deals with social presence effects of embodiment in collaborative net-communications. Social presence was measured by an extended questionnaire including an item set on emotional closeness of the partners. Principal component analysis revealed a consistent structure with the five dimensions: co-presence, closeness, comprehension, contagion and coordination. In addition a measure for interpersonal trust was applied which differentiates between cognitively and affectively based trust. Correlation analysis showed significant relations between closeness and affectively based trust. Results of a media comparison including face-to-face interactions, phone, chat and avatar-based net-communications point to distinct response patterns for the different social presence factors and interpersonal trust. Only with respect to co-presence the avatar-based interactions led to higher scores than phone or chat interactions. Data are discussed with respect to multi-dimensional conceptualisation and multi-level measurement of social presence.

Keywords--- **embodiment, avatars, virtual environments, social presence, collaborative work**

1. Avatars in net-based collaboration: research objectives

As early as in the 1980ies Jaron Larnier, founder of the legendary VPL Inc. introduced a virtual environment, the so called RB2 system (Reality Built for Two), which should serve as a telecommunication medium, allowing two people to meet in a shared virtual world and to interact with the virtual objects and with virtual representations of each other. Later he commented on the

use of avatars within virtual environments: „*One intriguing implication of virtual reality is that participants must be able to see representations of one another, often known as avatars. Although the computer power of the day limited our early avatars to extremely simple, cartoonish computer graphics that only roughly approximated the faces of users, they nonetheless transmitted the motions of their hosts faithfully and thereby conveyed a sense of presence, emotion and locus of interest*” [1]. Based on the technological developments of the last decade, recently various avatar communication systems have been introduced [2, 3, 4, 5, 6] which overcome many restrictions of the early days. As each of these developments focused on different technical issues as well as on distinct applications, the resulting systems differ remarkably in some of their basic characteristics, as there are the bandwidth of conveyed behavioral dimensions, the immersiveness of the display technology, the immediacy of transmission of behavioral cues, etc. While early stage research was more concerned with the technical components which create immersion and presence recent studies focus on the applicability of avatar-platforms in different contexts. Evidently, the possibility to detect, store, transmit and thus influence nonverbal behaviour like gaze, movement, gestures and postures in real time made a strong argument for the usage of avatar platforms in communication and perception research [4, 7].

A more recent impetus for the application and systematic evaluation of avatars came from the areas of computer supported cooperative work (CSCW) and computer supported collaborative learning (CSCL). Based on theoretical concepts like *common ground* [8, 9, 10, 11] and *group awareness* [12, 13, 14] researchers in these fields expect significant improvement of collaborative learning and problem solving by including nonverbal channels into the net-based communication

process. Embodiment by means of avatars appeals to these scholars as a possibility to facilitate the net-based communication process, to improve social relationships, to positively influence group processes and cohesiveness and to create higher levels of interpersonal trust. Interestingly, a closer look at the concepts of “common ground” and “group awareness” reveals a wide conceptual overlap with the concept of social presence. So besides the challenge to integrate user friendly and efficient avatar systems into collaborative environments there is a theoretical challenge to model and empirically verify the specific communicative functions and socio-emotional effects of embodiment. As previous work has shown [15] questionnaire data are not sufficient to catch the subtle and transient low level effects inherent in nonverbal communication, like e.g. the use of specific gestures, the timing of mutual gaze, the coordination of verbal and nonverbal activities etc. With respect to the conceptual integration mentioned above it will thus be necessary to provide behavioral measures of social presence, common ground, group awareness and interpersonal trust in addition to subjective verbal reports to figure out to which degree the variables depend on each other or whether they have a common behavioral base. Last but not least it has to be shown that the use of avatars causes desirable effects beyond the experience of social presence and group awareness in the sense of task performance, outcome and efficiency of collaborative work. These various aspects describe the objectives of our current research project which is funded by the DFG (German Research Foundation) within the special interest program “Net-based Knowledge Communication in Groups”. In the following, we will present a pilot study conducted within this project aiming at the validation of questionnaire instruments on social presence and interpersonal trust in a media comparison paradigm.

2. Social presence and interpersonal trust in avatar environments: a pilot study

Major objectives of the pilot study were (1) the development and evaluation of a questionnaire for measuring social presence (SP) and interpersonal trust (IT) in avatar-based collaborative net-communications and (2) a first tentative media comparison focusing on the differential effects of the ABC desk as compared to face-to-face-communication (ftf) as well as audio-based and text-based net-communication. Following the suggestions of Biocca et al. [16] the development of the SP questionnaire was based on an integrated approach. They define social presence as “the moment-by-moment awareness of the co-presence of another sentient being accompanied by a sense of engagement with the other” (p. 2). The degree varies from the peripheral sense of

spatial co-presence of the other to progressively higher levels of social presence. Those are characterized by a deeper sense of psychological involvement, access, and connection to the intentional, cognitive, and affective states of the other. Higher levels include a sense of behavioral engagement leading to actions that are perceived as linked, reactive, and interdependent. As mentioned above, we also aim at identifying criteria for social presence in terms of correlates that are said to be crucial with regard to the outcome of mediated collaborations. One of the aspects mentioned to be important in net-based interactions is trust [17, 18, 19]. The well-known assumption that „trust needs touch“ [20, 21] offers the question by which aspects the trust-building process can be facilitated even in net-based communication settings where getting in “touch” is at least in a literal sense impossible. In this context the possible relation between the perceived social presence of the communication partner offered by the characteristics of a communication medium and the perceived interpersonal trust [22] between participants has been discussed. However, no integrative analyses of these two aspects can be found in the relevant literature. Thus, we aim at investigating the relation of social presence and interpersonal trust – both on the level of subjective experience.

2.1. Method

2.1.1. The ABC-desk: An avatar-based collaborative desktop environment ABC desk (avatar-based collaborative desktop environment) developed at the University of Cologne is conceptualized as a low immersive open desktop system (no HMD, or shutter-display) focusing on the real time transmission of a broad range of nonverbal behavior during net-based communication and collaboration [2, 3]. The setting very much resembles a video conference situation, where the interaction partner is just visible on a screen or in a screen window. In contrast to the video conference situation the avatar-system allows for masking the identity of participants, for the recording and the experimental control of the behavioral data. Moreover, interlocutors in an avatar-based virtual environment can refer to a shared virtual object world, which means that they can contingently handle the same objects e.g. in a collaborative task. In particular, the ABC desk was constructed to allow for (1) the real time interaction of up to three interlocutors including nonverbal signals like head movements, body movements, gestures and eye movement, (2) the experimental variation of the visual appearance of the interlocutors, (3) the online filtering of behavioral cues, (4) the recording of verbal and nonverbal behavior, (5) the interactive and/or algorithmic modification of

behavior protocols, and (6) the offline rendering and replay of stored movement data. Non-verbal behaviour is detected by means of Cybergloves, Polhemus trackers and a high resolution eye-tracking system, which we developed for this purpose. Data are transmitted via Intranet (TCP-IP). Animation is performed on the target computer by means of an AVI-CODEC developed for this purpose. The CODEC transforms angular data into 3D-animations and renders the movement of a low-times a second there is no speed problem at all. For this study the ABC desk was used as a *Virtual Video Conference (VVC)*: The interaction partner's avatar is presented on a separate monitor in full-screen mode (see figure 1). The virtual representatives were high resolution avatars (see figure 2) which are rendered by a commercial 3D animation tool (Kaydara Filmbox©) accessing a continuous data stream which is also provided by AVI codec. Besides the *VVC* two further mediated communication settings were used in this study: a) text-based communication supported by a chat tool and b) audio communication.



Figure 1: Base version of the avatar-based collaborative desktop environment (screen shot during calibration phase showing to the inter-locutors their own avatar)

2.1.2. Measurement of social presence and interpersonal trust For the measurement of social presence an initial set of 58 five-point Likert scale items was created by translating those used by Biocca et al. [17] into German. These were extended by further newly created items, pertaining to the perceived closeness of the participants during the interaction as discussed for example by Kumar and Benbasat [23] or Tu [24]. Examples of the items are given in table 1.

Referring to the literature a 20 item questionnaire was created for the measurement of interpersonal trust, which should particularly be able to differentiate between the two components (1) *cognitively-based trust* (competence of the other participant) and (2) *affectively-based trust* (trustworthiness of the other participant) as described by Kanawattanachi und Yoo [18].



Figure 2: High resolution avatars

2.1.3. Participants and Design 48 (24 male and 24 female) student participants took part in the pilot study. Matching for sex the participants were randomly assigned to four different communication settings: chat (text), phone (audio), avatar (audio-video), and face-to-face (full bandwidth). The interaction partner was always a confederate of the experimenter. The participants were involved in a collaborative problem solving task, where they had to select a potential employee for a certain job. The interactions were time limited and lasted between 5 to 10 minutes. After ending the communication the participants had to answer the questionnaires on social presence and inter-personal trust.

2.2. Results

2.2.1. Dimensions of social presence Principal component analysis of the social presence items (VARIMAX rotation) resulted in a five component solution explaining 63% of the variance (see table 1 for a list of factors and item examples). Four of these factors are in accordance with the social presence dimensions conceptualised by Biocca et al. [16]. The factors were named *co-presence*, *comprehension*, *connectedness* and *contingency*. One additional factor emerged which exclusively contained the added items on perceived acquaintance and intimacy of the interaction partners. The component was named *closeness*. The labels of the principal components are listed in table 1 together with the labels suggested by Biocca et al. [16] and the psychological dimensions they refer to, as there are: spatial, social, cognitive, emotional and behavioural relatedness. Internal consistency values were good to excellent for all scales (see table 1 for Cronbach's alpha). Also, the scales showed consistent reciprocity, i.e. the item pairs asking for one's own and the partner's experience always loaded in the same direction on the same factor.

2.2.2. Dimensions of interpersonal trust Principal component analysis of the 20 item questionnaire on interpersonal trust (VARIMAX rotation) issued a two factor solution, explaining 65 % of the variance. As expected, the factors clearly reflect the conceptual differentiation between cognitively and affectively based trust. Table 2 shows item examples and the results of internal consistency tests which were excellent for both factors.

Table 1: Factor structure and internal consistencies of social presence scales

Scale	Item amount and example	Cronbach's Alpha
Co-presence <i>spatial relatedness</i> (perceived shared space)	6 items (I often felt as if we were in different places rather than together in the same room.)	.940
Closeness <i>social relatedness</i> (acquaintance/intimacy)	11 items (My partner was still a stranger to me.)	.936
Comprehension <i>cognitive relatedness</i> (perceived attentional engagement)	8 items (My thoughts were clear to my partner.)	.855
Contagion <i>emotional relatedness</i> (perceived emotional contagion)	6 items (I was sometimes influenced by my partner's moods.)	.814
coordination <i>behavioural relatedness</i> (perceived behavioral interdependence)	5 items (My actions were often dependent on my partner's actions.)	.727

2.2.3. Correlations between social presence and interpersonal trust Two significant correlations could be found between the trust scales and two of the social presence scales. The factor *cognitively-based trust* showed a significant correlation ($r = -.664$; $p = .000$) with the social presence factor *comprehension* (attentional engagement). The *affective-based trust* aspect on the other hand correlated significantly ($r = .513$; $p = .000$) with the social presence factor *closeness* (intimacy). Although the correlated scales are evidently touching the same psychological qualities it is hard to say at this point whether there is a conceptual overlap, respectively a redundancy in measurement, or whether there are causal

relations, in the sense that only the experience of specific qualities of social presence lead to distinct patterns of interpersonal trust.

Table 2: Factor structure and internal consistencies of interpersonal trust scales

Scale	Item amount and example	Cronbach's Alpha
cognitively based trust	10 items (I think, that I could also rely on his/her competences when facing challenging tasks.)	.918
affectively based trust	8 items (I would confide even private information to my partner.)	.901

2.2.4. Differential media effects on social presence and interpersonal trust The assumption that the consideration of social presence as a multi-dimensional construct could be useful for further investigations was confirmed by cross media comparisons. Table 3 shows the results of ANOVAs and pair-wise comparisons (ex-post Scheffé tests). The different communication groups (text, audio, avatar, and ftf) varied with regard to the level of perceived social presence showing a different pattern of presence aspects for each setting. The findings did not confirm a general superiority of the avatar-based communication setting in facilitating the social presence experience of the participants. Certainly, there is no linear relation between bandwidth and social presence as could be expected e.g. on the base of media richness theories or cues filtered out models of computer mediated communication [25, 26]. Figure 4 visualizes the direction of the significant results. Only for the aspect of *co-presence* the results met the assumption that the usage of an avatar will stimulate the presence experience in a better way than text- or audio-based technologies (see figure 4a). However, this result has to be interpreted very carefully as the avatar-effect is close to zero. What can be said is that in contrast to ftf, audio and text have negative effects and the avatar is neutral. While *co-presence* can be considered an individual non-evaluative judgement *closeness* is constituted by an interpersonal and emotional experience. Here, embodiment might have positive as well as negative effects depending on the nonverbal behavior of the vis-à-vis (one might see somebody as a stranger because he/she is unknown or we may judge the behavior we observe as strange). It is thus quite plausible

Table 3: Media differences in social presence and interpersonal trust (ANOVA of average factor score)

	1 FtF	2 Avatar	3 Phone	4 Chat	F	p	Pairwise comparison (Scheffé Test)
co-presence	1.37	-.014	-.601	-.749	36.07	.000	1>2, 1>3, 1>4 (p = .000) 2>4 (p = .023)
closeness	.145	-.119	.589	-.615	3.54	.022	3>4 (p = .027)
comprehension (inverted scale)	-.184	1.04	-.667	-.190	10.12	.000	2>1, 2>4 (p = .006) 2>3 (p = .000)
contagion	.342	-.059	-.190	-.093	.654	.590	-
contingency	.014	.206	-.209	-.011	.33	.803	-
cognitively based trust	.509	-.912	.667	-.264	10.19	.000	2<1 (p = .001) 2<3 (p = .000)
affectively based trust	.206	-.162	.286	-.330	1.04	.384	-

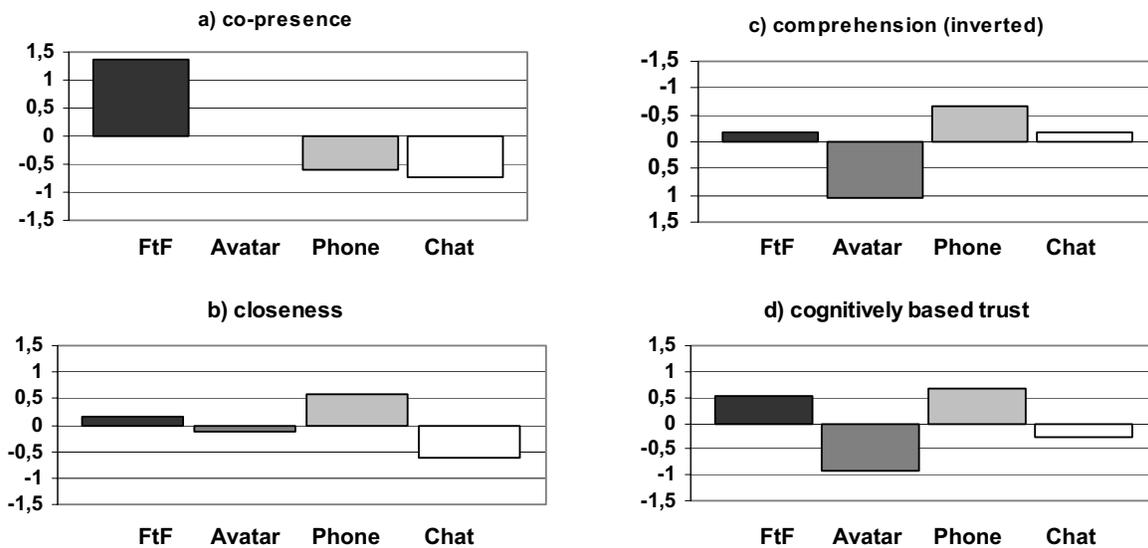


Figure 4: Significant media effects in the factors (a) co-presence, (b) closeness, (c) comprehension and (d) cognitively based trust

that both modalities which include the visual channel (ftf and avatar) show mean values close to zero (averaging positive and negative effects). As expected, however, phone did much better than chat in creating the feeling of acquaintance and intimacy (see figure 4b).

Comprehension indicates an evaluative judgement with respect to cognitive rather than emotional relatedness. Again audio does best in creating the experience of attentional engagement (see figure 4c).

Direct comparisons however show that there is only one significantly deviant condition, the avatar condition, which produces negative responses in mutual understanding (positive values). The reasons for this can only be speculated about. Certainly, the avatar representations are something new and uncommon to the participants and might focus attention more on the visual channel than usual, thus creating additional mental workload and distraction from the content of the dialogue. Especially technical deficiencies might be seen as a possible cause for such a misled attention. The results on *cognitively based trust* confirm this result as they are mostly consistent with the comprehension data (see figure 4d). Again the audio condition shows the best scores while the avatar condition generated the lowest levels of cognitively based trust. Again irritating aspects of the new communication technology might be responsible for these negative effects.

3. Discussion and conclusion

The questionnaire instruments introduced for the measurement of social presence and interpersonal trust instruments could prove their internal factorial validity as well as the external validity in distinguishing effects of different communication media and ftf communications. The extended item set as compared to Biocca et al. [16] constituted a new factor with highest variance explanation which was called closeness. The factor represents feelings of interpersonal immediacy and emotional closeness to the vis-a-vis. Only the traditional co-presence factor however revealed media effects as expected, showing significantly stronger co-presence

effects for the avatar condition relative to phone and chat. As the co-presence values for the avatar-based encounters however were close to zero the data can hardly be interpreted as a positive effect in itself. Moreover, one could also assume that the nonverbal information did not receive the persistent attention and did not become salient in the expected way. This result strongly indicates the necessity of additional behavioral measures for social presence. For example measures of gaze direction on one hand and measures of nonverbal activity could be analysed to point out specific structural differences or similarities between ftf and avatar-based communication. Figure 5 exemplarily shows such an integrated analysis for two interlocutors in a three-minute sequence of an avatar-mediated collaborative interaction. As a global measure of nonverbal activity the upper curves in the two graphs show the movement complexity (number of body parts in action) of each partner. The bar-charts underneath show the gaze pattern, where the black areas indicate a gaze towards the avatar window in the desktop workbench (see figure 3a). The first minute (up to dotted line) was spent in chatting and the last two minutes in collaborative problem solving.

The graph clearly indicates a strong correlation between nonverbal activity and visual attention which is similar to ftf situations. This kind of correlations could serve as benchmark values when testing social presence effects of emergent communication technologies. The inclusion of behavioral measures in general thus seems to be of high relevance for a further conceptual clarification of social presence leading to more objective definitions of the various dimensions and also to a differentiation with respect to related concepts like common ground, group awareness or interpersonal trust. In any case it has to be prevented that the concept of social presence is expanded to a degree that all known aspects of interpersonal communication and group dynamics are included. Such a meta-concept would have no discriminative value at all and would immediately lose its potential to relate subjective media experiences to technical parameters.

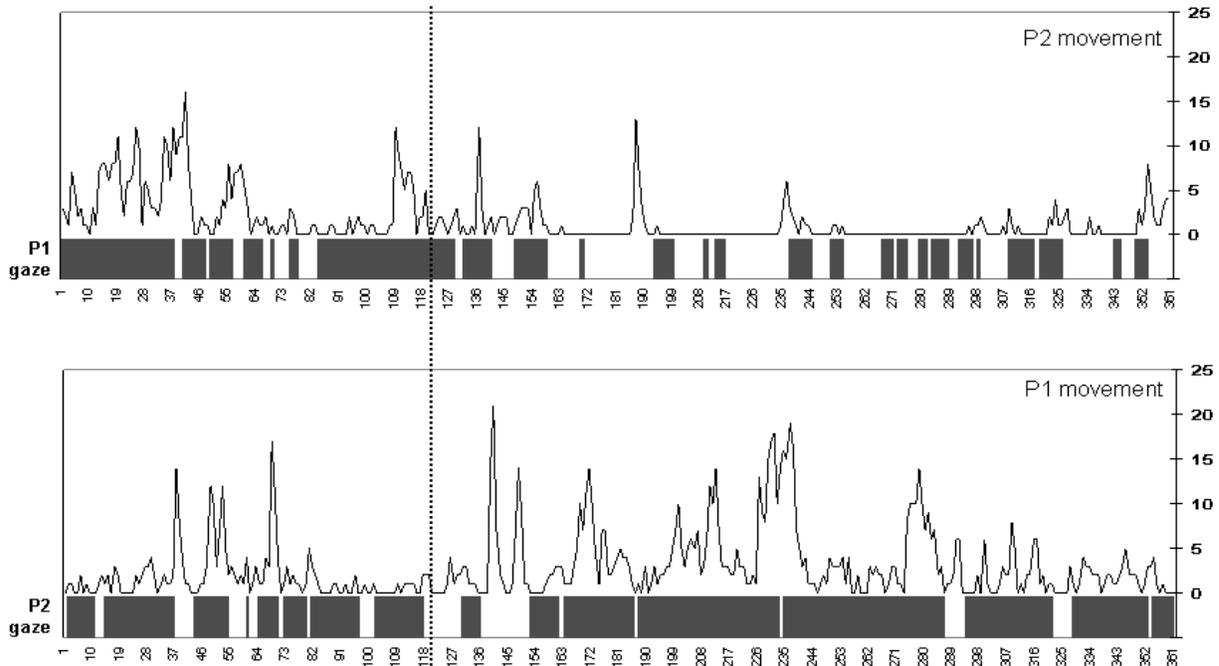


Figure 5: Example of an integrated analysis of mutual gaze and nonverbal activity in an avatar-based collaborative dyadic interaction (explanation see text)

Acknowledgements

This research was supported by grant BE 1745/4-1 within the Special Priority Program “Net-based knowledge communication in groups” from the Deutsche Forschungsgemeinschaft (DFG, German Research Association).

References

- [1] J. Larnier. Three-dimensional tele-immersion may eventually bring the world to your desk. Online document. Available: http://oeuf.epfl.ch/Members/berger/News_Item.2004-04-27.2114285855 [6.5.2004]. 2001.
- [2] Bente, G. & Krämer, N. (in press). Virtual gestures. Embodiment and nonverbal behavior in computer-mediated communication. In A. Kappas (Ed.), *Emotion in the internet*. Cambridge: Cambridge University Press.
- [3] A. Petersen, G. Bente, & N. C. Krämer. Virtuelle Stellvertreter: Analyse avatar-vermittelter Kommunikationsprozesse. In G. Bente, N. C. Krämer & A. Petersen (Eds.), *Virtuelle Realitäten* (pp. 227-253). Göttingen: Hogrefe. 2002.
- [4] J. Blascovich, J. Loomis, A. Beall, K. R. Swinth, C. L. Hoyt, & J. N. Bailenson. Immersive Virtual Environment Technology as a Methodological Tool for Social Psychology. *Psychological Inquiry*, 13, 146-149. 2001.
- [5] M. Slater & A. Steed. Meeting people virtually: experiments in shared virtual environments. In R. Schroeder (Ed.), *The Social Life of Avatars. Presence and Interaction in Shared Virtual Environments* (pp. 146-171). London: Springer. 2002.
- [6] K. Müller, H. Troitzsch, & A. Renkl. Der Einfluss nonverbaler Signale auf den Kommunikationsprozess in einer kollaborativen virtuellen Umgebung. *Zeitschrift für Medienpsychologie*, 15 (1), 24-33. 2003.
- [7] G. Bente, N. C. Krämer, A. Petersen, & J. P. de Ruitter. Computer Animated Movement and Person Perception. *Methodological Advances in Nonverbal Behavior Research. Journal of Nonverbal Behavior*, 25 (3), 151-166. 2001.
- [8] H. H. Clark. *Using Language*. Cambridge: Cambridge University Press. 1996.
- [9] H. H. Clark & S. Brennan. Grounding in communication. In L. B. Resnick, J. M. Levine & S. D. Teasley (Eds.), *Perspectives on socially shared cognition* (pp. 127-149). Washington, D.C.: American Psychological Association. 1993.
- [10] R. E. Kraut, D. Gergle, & S. R. Fussell. The use of visual information in shared visual spaces: informing the development of virtual co-presence. *Proceedings of the 2002 ACM Conference on Computer Supported Cooperative Work*, New Orleans, Louisiana, USA, 31-40. 2002.

PRESENCE 2004

- [11] B. Steinheider & E. Burger. Kooperation in interdisziplinären Teams. In Gesellschaft für Arbeitswissenschaft e.V. (Ed.), *Komplexe Arbeitssysteme - Herausforderungen für Analyse und Gestaltung* (pp. 553-557). Dortmund: GfA-Press. 2000.
- [12] P. Dourish & V. Bellotti. Awareness and coordination in shared workspaces. *Proceedings of CSCW'92*, 107-114. 1992.
- [13] C. Gutwin. Workspace awareness in real-time distributed groupware. PhD Thesis, Department of Computer Science, University of Calgary, Canada. 1997.
- [14] C. Gutwin, S. Greenberg, & M. Roseman. Workspace awareness in real-time distributed groupware: framework, widgets, and evaluation“. *Proceedings of HCI'96 Conference on People and Computers XI, Computer-Supported Cooperative Work*, 281-298. 1996.
- [15] M. P. Huang & N. E. Alessi. Presence as an Emotional Experience. In J. D. Westwood, H. M. Hoffman, R. A. Robb, & D. Stredney. (Eds.), *Medicine Meets Virtual Reality: The Convergence of Physical and Informational Technologies Options for a New Era in Healthcare* (pp. 148-153). Amsterdam: IOS Press, 1999.
- [16] F. Biocca, J. Burgoon, C. Harms, & M. Stoner. Criteria and scope conditions for a theory and measure of social presence. Paper presented at „Presence 2001“, 4th annual international workshop, May 2001, Philadelphia. Available:<http://nimbus.ocis.temple.edu/~mlombard/P2001/Biocca1.pdf> [26.5.03]. 2001.
- [17] J. Riegelsberger. The Effect of Facial Cues on Trust in E-Commerce Systems. In *Proceedings of HCI 2002, Volume II*, London, UK. 2002.
- [18] P. Kanawattanachai & Y. Yoo. The dynamic nature of trust in virtual teams. *Journal of Strategic Information Systems*, 11(3), 187-213. 2002.
- [19] T. Bickmore & J. Cassell. Relational Agents: A Model and Implementation of Building User Trust. *ACM CHI2001 Conference Proceedings*. Seattle, Washington, pp 369-403. 2001.
- [20] S.L. Jarvenpaa & D.E. Leidner. Communication and Trust in Global Virtual Teams. *Journal of computer-mediated communication* 3(4). 1998.
- [21] C. Handy. Trust and the virtual organization. *Havard Buisness Review*, 73 (3), 40-50. 1995
- [22] D. Spencer. Computer-mediated communications : state of the art. Group facilitation, collaboration and asynchronous learning networks. Available:web.njit.edu/~hiltz/CMC_SOTA_David.doc. [25.4.04]. 2000.
- [23] N. Kumar & I. Benbasat. Para-social presence: a re-conceptualization of „social presence“ to capture the relationship between a web site and her visitors. *Proceedings of the 35th Annual Hawaii International Conference on System Sciences (HICSS-35.02)*, IEEE Computer Society. Available: <http://csdl.computer.org/comp/proceedings/hicss/2002/1435/01/14350013b.pdf> [24.7.03]. 2002.
- [24] C.-H. Tu. The impacts of text-based CMC on online social presence. *The Journal of Interactive Online Learning*, 1(2), 1-24. 2002.
- [25] L. Sproull & S. Kiesler. Reducing social context cues: Electronic mail in organizational communication. *Management Science*, 32, 1492-1512. 1986.
- [26] J. Short, E. Williams, & B. Christie, B. *The social psychology of telecommunications*. London: John Wiley. 1976.