How Putting Yourself into the Other Person's Virtual Shoes Enhances Collaboration

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Abstract

Working together in collaborative virtual environments (CVEs) with different systems is often problematic; different capabilities can lead – among other things – to an unequal distribution of tasks and to misunderstandings. This paper reports on an experiment in which participants worked together on a task and switched halfway through from an immersive system to a desktop one (and vice versa) – and exchanged ideas about this with their partners afterwards. It was found that there are several advantages in collaborating in connection with experiencing different and unequal systems: partners learn not only about the strengths and limitations of the different systems, but also about collaborating with others and about the implications of using different technologies. The paper concludes with the implications of this 'good inequality' for the design and use of CVEs.

Keywords---virtual environments, collaboration, copresence, learning, immersive projection technology, desktop systems.

1. Background and Aim

Online collaboration is becoming increasingly common, and collaborative virtual environments (CVEs) are an important part of this development [1]. When people work together at a distance via computers or in CVEs, they often use systems with different capabilities, typically without being aware of the type of system their partner(s) are using.

The consequences of this asymmetry can be positive or they can go unnoticed: partners may 'divide the labour' between themselves, taking on different tasks without being aware of this. Or the consequences may be problematical insofar as the inequality between systems may lead to differences in leadership in carrying out a task or in status – again, without being aware that this inequality has been introduced or shaped by the technology.

One of the reasons for these effects is the absence of social cues in computer-mediated communication and other media. This effect has been studied at least since the research of Short, Williams and Christie [2], who made comparisons between different communication technologies and face-to-face communication in terms of 'social presence'. CVEs are potentially a 'richer' medium in terms of social presence since they support a sense of 'being there together' in an environment other than the one in which you are physically present (the commonly used definitions of presence, copresense, and social presence; see [3], [4], [5]).

In this paper we investigate collaboration in VEs, and in particular whether having the experience of different systems can enhance – rather than being a problem for – collaboration. The question was investigated by means of an experiment in which participants switched system halfway through the task. Their comments afterwards – both about their individual experience and about their experience with others – show that 'putting yourself in the other person's virtual shoes' can be a valuable learning experience in CVEs, and perhaps in online collaboration generally. Since asymmetrical setups will continue to be commonplace in the everyday usage of CVEs, it is important to study how this inequality can be managed in supporting online collaboration. The aim of this study is thus to investigate how people experience to solve a task together using both immersive and non-immersive systems, and how changing systems influences their experience of the two systems and their sense of the collaboration.

1.1. Previous Research

Previous research about collaboration in VEs with different systems has shown a variety of effects. A study by Slater and colleagues [6] of small group collaboration showed that the person using an immersive system (in this case a head-mounted display) was considered to be the leader in a group working together with two persons on desktop systems where they did not know what type of system the others were using. There were similar findings in studies by Schroeder and colleagues [7] for pairs working together with one person in a Cave-type or immersive projection technology (IPT) system working with a partner using a desktop system. Again, the person using the IPT was considered the leader and as contributing the greater share to the task, even though there was no such leadership or unequal contribution when doing the same task face-to-face, desktop-to-desktop, or IPT system networked with another IPT system. An additional finding was that the participants 'naturally' divided the task or the labour between themselves, with the immersed person taking a more active role in the spatial aspects of the task and in manipulating objects, whereas the desktop person took a more 'supervisory' role – again, without being aware of the differences in the system that their partner was using and without being aware that they were 'dividing the labour' between them [8]. Finally, Axelsson [9] has analysed the findings of studies from both immersive and desktop systems and pointed out the problems when people in shared virtual environments are not aware of the status differences introduced by asymmetrical technologies.

A further study that is relevant here are the findings of Hindmarsh et al. [10] about problems of working together on networked desktop systems on a spatial task because of the restricted field of view and also because partners are not aware of what their collaborators can and cannot see. Heldal et al. [11] by contrast found that this problem on the whole does not apply with collaboration in networked IPT systems.

In contrast to these studies with their between subject design, the following study used a within subject design, giving users a first hand experience of both types of technologies. This is important to investigate since, in practice, people will often be confronted with asymmetrical setups

2. Method

The experiment used a within subject design. 18 subjects arranged into nine pairs participated in the experiment. Each pair met in a virtual environment to solve a Rubiks-cube type puzzle (see figure 1) using an immersive and a non-immersive system. The trial was limited to twenty minutes and subjects changed systems half way through the trial. The subjects were 17 postgraduate students who were taking a pedagogical course and one teacher (the quotations below are translated or taken from subjects whose English was not their first language – hence some quotes have awkward phrasing). There were 4 females and 14 males from various disciplines at a technical university. The subjects had all seen each other during the course, but they had no previous experience of working together.

2.1. Technology and Task

The immersive system used was an IPT system, a 3x3x3 meter TAN VR-CUBE with stereo projection on five walls (no ceiling). The application was run on a Silicon Graphics Onyx2 Infinity Reality with 14 250MHz R10000 MIPS processors, 2GB RAM and 3 Infinite Reality2 graphics pipes. The participant wore CrystalEyes shutter glasses and used a 3-D wand for navigation. A Polhemus magnetic tracking device tracked the head via the glasses and the hand via the wand.

The non-immersive desktop system consisted of a Silicon Graphics O2 with one MIPS R10000 processor and 256MB RAM and a 19-inch screen display.

The dVise 6.0 software was used.

With the IPT systems, the subjects could move the blocks or cubes by putting their virtual hand into the virtual cube and pressing the button of the 3-D wand. On the desktop system, participants could navigate by moving the middle mouse button and could select the cubes by clicking on them with the left mouse button. To move the cubes, they had to keep the right mouse button pressed and move the mouse in the desired direction. They could also rotate the cube by pressing the right mouse button combined with the shift key. The movements of the avatar in the desktop system that was transmitted through the technology showed only the position of the avatar (no pointing) in relation to the virtual objects, visualized with a static avatar, whereas the avatar in the immersive system was dynamic and represented the user's tracked movements.

Both the IPT and desktop systems allowed the participants to 'mark' the cubes by selecting them, which made their outlines appear as dotted lines (which was also visible to their partner).

Audio communication was via headsets with microphones and earphones.

The task was to solve a puzzle involving 8 blocks with different colours on different sides and to rearrange the blocks such that each side of the finished cube would display a single colour. The colours on the sides of the 8 blocks were red, blue, green, orange, yellow, white, and black.

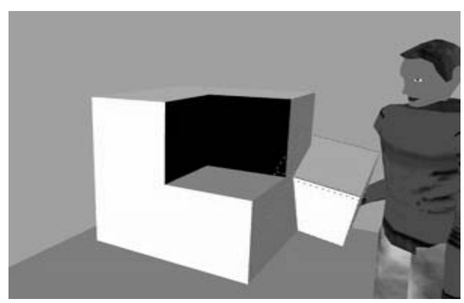

Figure 1 The Rubiks Cube Puzzle

2.2. Procedure and Experimental Design

Before the trial session started, all subjects were given verbal instructions about the experiment. They had 5 minutes to familiarize themselves with the system, but were not allowed to start communicating with the partner. The total time for doing the task was 20 minutes and they changed system half-way through. Post-trial inverviews with individual users took between 5 and 15 minutes and small focus group discussion of between 4-6 participants too between 45-60 minutes.

2.3. Data Collection and Analysis

Apart from the interviews and discussions, observations were also made during the trial. Post-trial interviews and discussions were audiotaped and the trial sessions were audio- and videotaped.

The analysis presented here is based on the transcribed post-trial interviews. We were particularly interested in the subjects' experience of changing systems and how that influenced their experience of the technology and their perceived sense of collaboration. We used content analysis as presented by Altheide [12] to interpret the interviews. As we were particularly interested in how subjects had experienced using the systems and working with their partner, we asked them about this. This allowed us to lift this theme out of the transcribed text, and to divide this theme, in turn, into technical and social aspects. These themes were subdivided further according to the following schema:

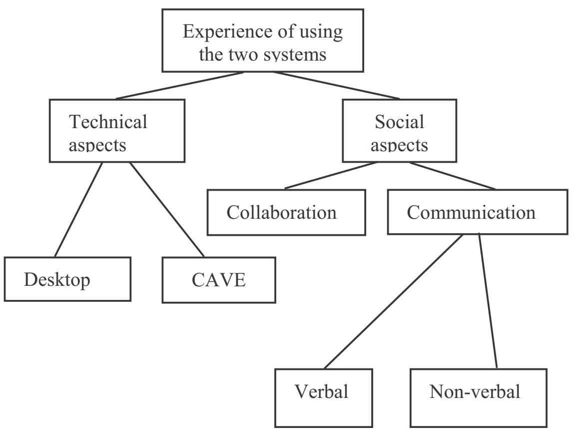

Figure 2 Schema of interpretation

3. Method

In the following section we present, first, the material related to technology, followed by social aspects. Quotes from subjects are coded as follows: I1 represents a quote from the first subject starting the trial in the IPT system, and D1 from the first subject starting the desktop system etc.

3.1. Experience of Using Different Systems: Technical Aspects

One question concerned how the subjects experienced to use the two different systems during the trial. Typically the subjects remarked on the different technical functionalities. In general they experienced the IPT system as intuitive to use and manipulation of the cubes as easy. The desktop system was experienced as difficult to use because of the need for button pressing for manipulating objects. Typically subjects commented on similarities and differences:

> "I started at the workstation [referring to the desktop system]…When I came down here [room with the IPT system] it was more intuitive in a way what I should do. I saw where I was and I had only one type of control apart from my own movements. The only thing I needed to do was to grasp and release. There I could twist and do the turns. At the workstation I had to do it with control –alt-shift or control-shift and a mouse click so it was harder for me to do the task there. I thought I noticed that for Sharon as well. When she came up there [to use the desktop system] she didn't really know how to move either" (D1)

> "One was more handicapped there [on the desktop system]. One can not do everything. The function one could have is to stand aside and look since one do not have the same functionalities. Here [IPT system] one is much smoother." (D7)

> "I think you get a better view from here, from the computer [desktop system], but you can not handle the things from here very well. I don't know if there is a problem with a cable or with the special joystick. But I think when you are there on the stage [IPT system] it is easier to move and manipulate object." (I11)

Regardless of which system they started with, subjects shared the same view. However, departing from majority opinion, one subject said:

> "I think that the computer [desktop system] was easier, but one is used to computers. At the same time, here [IPT system], some things were easier to do here such as walking around faster and see the colors. That one could do faster down here, but the mere use of it, the computer was easier, but that is surely a habit issue, one is used to control [with the keyboard]. Here it was more of trying to see the hand and, well, click on the right spot. I experienced that as harder."(D6)

Most subjects could intuitively and easily use the IPT system even though they had no previous experience with the technology. A few subjects expressed minor difficulties in grasping objects with their virtual hand using the wand, but the general experience was that it was easy to manipulate the virtual objects in the IPT system in comparison with using the desktop system.

Another experience linked to the technology was the difference in immersion. Even though the majority of subjects said that the IPT was more intuitive to use in comparison with the desktop for actions such twisting and turning the virtual objects, some subjects experienced the IPT as too immersive:

> "My feeling is that you can manage better the system trough the computer [desktop system]. That cube [IPT system] is…it…cause a lot of

> difficulties. You feel surrounded by cubes. And you sort of…you can grab one of them. But for me from this monitor I can see everything and probably I can manage my tools. I think so." (I13)

Another subject said in the same vein:

> **"**There they are all around you [talking about the virtual cubes] so it is hard to get a real overview."(I16).

Even subjects that did not mention the feeling of being "surrounded by cubes" said that the desktop provided a better overview of the cube puzzle. The following two quotes illustrate the general view of the subjects about the advantage of using the desktop in comparison with the IPT system:

> "I think it was easier in front of the desktop using the mouse and keyboard to have an overview and perhaps help out a bit and check it out and think a bit"(D9).

> "I think you get a better view from here from the computer but you can not handle the things from here [the desktop system] very well"(I11).

It was not the case that subjects were in total favor of one system compared to the other. The subjects appreciated the two different systems in different ways. The different technical functionalities of the IPT and desktop systems were useful for different purposes in solving the puzzle together. The IPT system was experienced as useful for manipulating objects and the desktop system for getting a clearer overview of the puzzle. At the same time, the different technical functionalities also caused different types of difficulties: the desktop was associated with manipulation difficulties with problems moving objects because of the need for button pressing; in the IPT system, on the other hand, it was difficult to get an overview of the puzzle. This yields the following picture:

	IPT	**Desktop**
Manipulation	Easy	Difficult
Overview	Difficult	Easy

3.2. Experience of Using Different Systems: Social Aspects

The subjects were also asked a number of questions concerning their experience of using the two systems in relation to social aspects. We will present, first, their views of collaboration and then their views about communication.

Most of the subjects experienced the trial as a highly collaborative situation and expressed themselves in a positive way about working together. Regardless of whether they solved the puzzle or not, working with a partner was a good thing. But although 11 of 18 subjects commented in a positive way about collaboration, three felt that they could have solved the task without a partner. Only two reported that their collaboration was not working.

Most thought that their collaboration improved after having changed systems, and thought that they used this knowledge about how the different systems worked to improve the collaboration:

> "I thought it [the collaboration] worked well. I thought it worked very well when one knew, when one had tried out each other's tools. In the first instance one did not know what kind of capabilities the other had. I noticed that he could move around much easier but I did not know if that was because of him being better to manage the terminal or what it was. I didn't know that he was down here [IPT system], that he had a tool like this. It became much easier after, when one knew, then we could divide the work better between us."(D7)

> "I think the collaboration with my partner was really fruitful and especially because we had two different views. From the computer I can see above better, and he can handle better the cubes, so I think the collaboration is necessary to solve the task faster." (I11)

> "You know, we started with no strategy at all. That was actually bad because we didn't see what next. But during this final stage we understood better each other and that was a relief."(I13)

Even subjects who thought they did not really make active use of their knowledge about the different technologies believed that it would have improved their collaboration.

> "I think it is better than working with my self because obviously there some task that is more difficult to do from computer but its easier for me to move around and he can turn around more easier different side of the block. So I think that it is good to compensate but all we need is to have a better plan if we know the task earlier or in the middle. We should have some time in the beginning to just [talk about] - how we should do the task?...It's easier to control when you sit here in front of your computer [desktop system] of course. So maybe it is good to have a strategy and then do some work from the computer first and then do down stairs [IPT system] to make the detail." (I10)

In relation to the experience of collaboration, most subjects thought that collaboration was useful and it was improved by the fact that they changed systems. The change of system led to an increased understanding of each other's perspectives and capabilities. This understanding enabled them to divide the labor based on the capabilities of the technology - such that the IPT person manipulated the objects and took a more active role in moving the objects, and the desktop person had an overview and took a more 'supervisory' role.

As for communication, subjects regarded verbal communication via the audio channel as crucial, but they also considered it to be as important to see their partner's avatar movements and actions. Typically they commented about the way their partner moved around in the environment. In particular, those who started off using the desktop system found it remarkable that their partner moved around so easily or smoothly in comparison with themselves:

> "In some way I realized that he had a different tool. One understands that at once when one see how smoothly he can move. One understood that quite quickly. Then it took a while before we talked about what kind of tool the other one had, but that became obvious when we changed."(D7)

This quote also illustrates how some subjects attributed the differences in movements to the technology without knowledge about the differences between the systems. Some subjects, however, associated this to a difference in their partners' skills:

> "I thought it was a superman I had met that could do exactly as he pleased with his keyboard."(D3)

The ability to refer to objects by pointing to or moving them facilitated communication about which object was being handled at the moment. However, the ability to refer to objects was different in the two systems, as one subject noticed:

> "He was there in a way. It was really hard to express when one was upstairs [desktop system]. Then one had to grab a cube and say – "I am over here". But for him [in the IPT] he could say "where I am", or, "where I am going". In some way he was there but I was not."(D8)

This example indicates the subtle mix of verbal and non-verbal communication in a CVE with an asymmetrical setup. Referring to objects depended on the system: in the desktop systems it was necessary to grab a cube and also mark it visually to indicate to the partner what object one is talking about. In the IPT, subjects could point in referring to a cube. Movement could be conveyed by means of the dynamic avatar, which was not possible on the desktop system. Not only was action more intuitive in the IPT system, but language use was more intuitive in the sense that "here" and "there" could be conveyed through the interface as in the physical world. Subjects realized that knowledge of the different system also improved the way they communicated:

> [Changing systems halfway through] "was fun. One could see these different possibilities. But that also made, given that one had tried both systems, one could more easily communicate with the systems and [also] communicate better with each other." (D6)

Changing systems was thus important for a better understanding of each other's possibilities and constraints, which helped subjects to agree about who should do what.

Finally, the experience of collaboration and communication is also reflected in subjects' comments related to 'being there together' or copresence:

> "Without voice communication it would have been difficult, so it was crucial."(D8)

However, this same subject also felt that he sometimes forgot his partner when he was in the IPT when working with the objects:

> "But also, since I did not see him, or rather he was over there so to speak, he was not close to the cubes. Then it was very easy to forget [him] …not until I was working alone I thought: oops, now I'm doing too much!"(D8)

This quote also illustrates that it is the position of avatars that subjects responded to, and in this case, when the subject was preoccupied with the cubes, he felt that he lost awareness of his partner.

4. Discussion

Previous studies have highlighted the disadvantages of asymmetrical setups, but as we have shown, if users can become aware of the differences entailed by different systems, this can also provide users with a better understanding of the possibilities and constraints of different technologies and thereby enhance collaboration. The view of our subjects was clearly that changing systems was positive; they thought that they could collaborate and communicate better after the change. They also realized that they made use of the different capabilities of the technology and could improve their strategy for solving the task by making use of these different capabilities. They recognized that the IPT gave them better possibilities for object manipulation and the desktop system gave them a better overview.

Interestingly, subjects recognized the benefits as well as the drawbacks of each system. Their better understanding thus not only made them aware of each other's possibilities and constraints, but also enhanced their interpersonal interaction. These were insights that in some cases they were able to implement during the second sessions after switching systems for the first time, and in other cases this occurred to them only after both sessions and they would have been able to implement what they had learned in future collaboration. (One idea suggested by this study is that this type of collaborative exercise with unequal systems could be a good pedagogical tool for learning about the difference that different technological capabilities can make.)

Before we discuss the implications of these findings further, it will be useful to recall some of the disadvantages of unequal systems. One of the main disadvantages is that partners may not be aware of the different capabilities that they and their partners have. This can lead to misunderstandings in communication, to adopting a poor strategy for collaborating on the task, and it raises the issue of fairness – at least in the case where two people *should* be collaborating on an equal basis and yet they are unaware of their different capabilities.

Another point to make here is that overcoming these disadvantages by 'trading places' will often not be possible. The point of distributed work is that partners can work together at a distance, but even if many people will be familiar with (or have access to) desktop systems in which they can collaborate in a 3D environment and where they can manipulate objects with a mouse, the same cannot be said for immersive systems. And although immersive systems may become more accessible in the future, they may also become more powerful and remain costly. Further, the general point – that different capabilities may be more invisible in CVEs than in the case of other technologies - will still apply to asymmetrical systems (since this asymmetry or inequality will not be conveyed through the interface) regardless of how accessible they become (and there are likely to be some asymmetries in most systems). Finally, it is worth mentioning that although for many tasks, symmetrical or same system setups will be an advantage for collaboration, for other tasks, there may be advantages for two or more participants to have different technologies and play different roles (for example, when people need to perform different complementary tasks).

One result of using of unequal systems is that, as mentioned earlier, when collaborators are unaware of the type of system that their partner is using, they may divide the labour between themselves – again, being unaware that they are doing this. In this study, when the participants *did* know the reason for their unequal participation, they said that they could make use of this knowledge to figure out a better strategy to do the task. In other words, creating a 'common ground' in a situation of missing social cues allowed them to collaborate better [13]. When they did *not* know about the technical reason for the different behaviors that was conveyed through the interface, on the other hand, they interpreted the difference as either personal (working with a more skilled person) or technical (working with different type of system). It can therefore be seen that technology is not only a tool *for* social interaction, but also an important feature *in* social interaction [14].

Conclusions

The finding that collaboration can be enhanced by awareness of different technological capabilities will have obvious relevance for the design of systems and their uses: how can systems provide knowledge about different capabilities? Can it be built into systems, or should task sessions be structured so as to allow for 'wearing the other person's virtual shoes'? This study will also have ramifications for research on presence and copresence: could the sense of copresence be enhanced – or possibly diminished - with the awareness that one's collaborator may have a different affordance for copresence? (One reason for mentioning the latter possibility is that it has been shown that a person's 'copresence' may not only be related to one's own system, but also to one's partner's sense of 'presence' and 'copresence' in *their* system, [7]).

One obvious suggestion that one might be tempted to make in response to this study is that the differences between the capabilities of the technology should *always* be made obvious to users, and that this can easily be done with CVE technology. For example, avatars could have labels that specify what type of system and input/output devices they are using. Note, however, that this solution would also have drawbacks: apart from possible creating a cognitive overload on the users' part (how much such information could the user 'take in'?), it may also be that in focusing on figuring out what capacities they and their partners have, collaborators may lose the advantage of 'naturally' dividing the labour between them and thus add to rather than improving the time they take for the task.

A limitation of our trial was that it was short and subjects had only one chance to solve the task together. It may be that collaborators are able to adapt to the different capabilities, or to the absence of social cues which make them aware of these differences, over the course of time [16]. It would be interesting in future research both to test whether such adaptation takes place, and whether longer sessions with different systems could mitigate the need for 'trading places' or if this could be even more valuable with longer sessions. It would also be interesting to find out whether simply communicating the different capabilities verbally or by the partner's demonstrating them to each other remotely could be just as effective as experiencing the different systems.

To sum up: putting yourself into the other person's virtual shoes can enhance the interaction and the strategy in a collaborative task, as well as providing people with valuable insights into the use of CVE systems. In other words, 'the good inequality' can enhance collaboration. As the discussion has shown, however, such a setup for 'trading places' may not always be possible or desirable to implement. Future research will show under what circumstances the experience of different technological capabilities can be useful – for users, for research about CVE systems and their design, and when VEs are used for practical collaborative work beyond the trial setting of this study.

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References

[1] E. Churchill, D. Snowdon, and A. Munro (eds.) Collaborative Virtual Environments: Digital Spaces and Places for Interaction. Springer. 2001.

[2] J. Short, E. Williams, B. Chrisite. The Social Psychology of Telecommunications. John Wiley & Sons. 1976.

[3] M.J. Scheumie, P. van der Straaten, M. Krijn, C. van der Mast. Research on Presence in Virtual Reality: A Survey, Cyberpsychology and Behaviour, **4(**2), 183-201. 2001.

[4] R. Schroeder. Social Interaction in Virtual Environments: Key Issues, Common Themes, and a Framework for Research. in R.Schroeder (ed.) The Social Life of Avatars: Presence and Interaction in Shared Virtual Environments. Springer. 1-18. 2001.

[5] F. Biocca, C. Harms, J.K. Burgoon. Towards a More Robust Theory and Measure of Social Presence: Review and Suggested Criteria. Presence: Journal of Teleoperators and Virtual Environments. **12**(5), 456-480. 2003.

[6] M. Slater. A. Sadagic. M. Usoh, R. Schroeder. Small Group Behaviour in a Virtual and Real Environment: A Comparative Study. Presence: Journal of Teleoperators and Virtual Environments. **9**(1), 37-51. 2000.

[7] R. Schroeder, A.Steed, A-S.Axelsson, I.Heldal, Å.Abelin, J.Wideström, A. Nilsson, M. Slateer. Collaborating in networked immersive spaces: as good as being there together? Computers & Graphics. **25** (5), 781-88. 2001.

[8] J. Wideström, A-S-Axelsson, R.Schroeder, A. Nilsson, I. Heldal, Å. Abelin. The Collaborative Cube Puzzle: A Comparison of Virtual and Real Environments. in *Proceedings of ACM Conference of the Third International Conference on Collaborative Virtual Environments*, 165-171. 2000.

[9] A-S. Axelsson. The Digital Divide: Status Differences in Virtual Environments. in R. Schroeder (ed.) The Social Life of Avatars: Presence and Interaction in Shared Virtual Environments. Springer, 188-204. 2002.

[10] J. Hindmarsh, M. Fraser, C. Heath, S. Benford, C. Greenhalg. Fragmented Interaction: Establishing mutual orientation in virtual environments. in *Computer Supported Collaborative Work (CSCW'98)*, 217-226. 1998.

[11] I. Heldal, A. Steed, M.Spante, R.Schroeder, S. Bengtsson, M. Partanen. Successes and Failures in Co-Present Situations, forthcoming in Presence: Journal of Teleoperators and Virtual Environments. 2004.

[12] D. Altheide. Qualitative Media Analysis. Sage Publications. 1996.

[13] A-S. Axelsson, Å. Abelin, R.Schroeder. Communication in Virtual Environments: Establishing Common Ground for a Spatial Collaborative Task, In *Presence 2003: 6th Annual International Workshop on Presence* 2003 URL: http://www.presence-research.org.

[14] M. Spante. Shared Virtual Environments: Technology, Social Interaction, Adaptation and Time. Licentiate Thesis, Chalmers University of Technology. 2004.

[15] J.B. Walther. Time Effects in Computer-Mediated groups: Past, Present, and Future, in P. Hinds, S. Kiesler. Distributed Work. MIT Press, 235-257.2002.