Copresence and Interaction in Virtual Environments: An Overview of the Range of Issues

Ralph Schroeder

Department of Technology and

Society

Chalmers University

Gothenburg, Sweden

+46-31-772-3888

ralsch@mot.chalmers.se

Summary

Studies of shared virtual environments (SVEs) have used widely different approaches to how copresence and interaction should be analyzed. In this paper, I argue that - if we take our starting point from what people actually *do* in shared VE's, and findings about what they do *together* - then we can focus much more narrowly on the few essential features of interaction in SVEs. To do this, I review the different disciplinary approaches to SVEs and the range of findings in this field, and conclude by suggesting how the field can advance.

1. Introduction

'Entities are not to be multiplied beyond necessity', Occam's razor, attributed to William of Ockham

This paper attempts to identify which features of interacting with others in shared virtual environments (SVEs) really matter, so that researchers in the field can more systematically tackle this area of investigation. My overall argument is that – given that theory and evidence must always be closely

linked – there is a much narrower range of phenomena in this area than is often supposed. Specifying this range more precisely will enable researchers to focus and build up knowledge in this field in a cumulative way.

After reviewing previous studies, I will consider what SVE experiences generally consist of, and how different disciplines have approached the study of these experiences. Then I will review the available evidence. As I cannot review in detail *all* the evidence or data resulting from shared VE trials and uses in this limited space, what I will do instead is to provide illustrations of the *range* of data that is relevant, and I will do this with reference to three sets of data:

1. A set of experimental trials which has covered the *range* of available technologies – immersive CAVE-type, desktop, head-mounted display (HMD), and an equivalent real setting – in which pairs collaborated on a Rubik's cube-type puzzle-solving task.

2. A review of the *range* of participant observation and other studies of internet-based SVEs.

3. A survey of the *range* of the most relevant results of studies of SVEs not covered in points 1 and 2 that are documented to date.

By means of this review, we will find that only a very limited range of theoretical perspectives is relevant to the study of SVEs. This will also allow me to argue that, although 'presence' is central to the study of single-user VEs, when it comes to 'copresence', which should be equally central to shared VEs, it is necessary to specify closely what is meant by this term, since the meaning of copresence is more diffuse. My overall argument is that a comprehensive review of the theory-data links in the field makes it possible to get a better sense of the most useful directions for the future study of SVEs.

Before we embark, a brief note on terminology: in this essay, I will use SVE instead of collaborative VEs (or CVEs) since SVEs is less restrictive - it includes not just collaboration, but all uses of SVEs. Nevertheless, a strict definition of virtual reality (VR) and VEs will be used here, whereby VR is a 'computer-generated display that allows or compels the user (or users) to have a feeling of being present in an environment other than the one they are actually in and to interact with that environment'[Schroeder, 1996; see also Ellis, 1991] This is not as wide-ranging as the definition of CVEs of Snowdon, Churchill and Munro [2001] which includes 2D and text-based environments, and

which is therefore too wide for our purposes (for example, copresence and interaction in text-only environments would put a very wide variety of phenomena within our purview, phenomena that have little to do with the sensory experience of a shared space together). I will also exclude 'agents', a topic often associated with SVEs, from the discussion - except if they provide a real user with the experience of encountering another person.

A final preliminary note: why do we need a strict definition of VR and SVEs? The reason is that for knowledge to make progress, we need a focused and systematic assault on specific phenomena that are delimited by clear concepts. Without these, we cannot communicate about - or build on each other's - findings.

2. Previous Studies

If 'presence' is the 'sense of being there', then 'copresence' is the sense of 'being there together'. So far, we only have a survey of presence [Scheumie, van der Straaten, Krijn and van der Mast, 2001; see also the bibliographic essay Isselstein, Lombard and Freeman 2001]. The survey mentions only three studies [Slater, Sagadic, Usoh and Schroeder, 2000; Axelsson et al. 2002; and Thie and van Wijk 1998] under the heading of 'copresence'. Two recent essay collections present a range of studies [Churchill, Snowdon and Munro, 2001; Schroeder, 2002], but for copresence, there is no survey or synthetic overview of research. Zhao [2001] provides a 'taxonomy of copresence', but the category of SVEs as defined in this taxonomy also includes videoconferences, telephone conversations, instant messaging - and thus includes phenomena far beyond those that involve 'being there together'.

Another term that is sometimes used in this context and for which there have been reviews is 'social presence'[Sallnäs, 2002]. But this refers either to the *individual's* experience of being with another person (in other words, it takes an individualistic perspective), or to the extent to which the *medium* affords this experience: in other words, it is a measure of the individual's psychological state in relation to the medium – without the context of what individuals actually *do* in the VE, or what they do *together*.

3. The Limits of Shared VE Experiences

As soon as we categorize existing SVEs, we find that these are in fact quite limited. We can start by excluding situations in which users are not doing things together or where they are not aware of each other, since these are not *shared* VEs. SVE experiences can then be subdivided into sensory experience and experience with others.

3.1 Sensory Experience of Interaction with the VE

Of the five senses, we can leave out smell and taste, since input/output devices here are not yet widespread, and, even if they are feasible, they are unlikely to be implemented. We need only to bear in mind that the *absence* of these two senses contributes to the lack of 'media richness' or absence of 'social cues' in interpersonal interaction.

For similar reasons, we can also leave out haptics/touch, though here we have a limited number of studies [Durlach and Slater, 2000; Sallnäs, 2002] of how haptics affect copresence and task performance. Nevertheless, haptic systems will, for the foreseeable future, be used for specialized collaborative situations and will therefore only feed into our knowledge of interaction in SVEs to a limited extent. Unlike interaction in the physical world, most SVE experiences consist of a kind of 'pseudo-touch', which works by means of visual collision detection or visual manipulation of objects.

It follows from the definition above that text communication is not VR, though we will include graphical VEs with text-only communication below inasmuch as they meet the – visual - copresence requirement. 'Ambient' sounds may or not be powerful shapers of the experience – as far as I am aware, this has not been examined. What we are left with is that people can communicate via voice, and they can see each other and interact with others and with the environment visually. In short, we are left with a visual and auditory joint experience and setting for the interaction.

3.2 Experience with Others

Apart from sensory experience, when we turn to social experiences, we find that here, too, people do a remarkably small range of things together in SVEs: they perform simple tasks and socialize. Putting it the other way around, if we were to compare this with our experiences in the real world, our range of experiences in SVEs would be a very small subset of our real world experiences.

Findings about these joint experiences in VEs, as we shall see in more detail later, relate to a restricted range of phenomena:

1. how small groups experience doing a limited short-term task with each other
2. how larger groups of people establish relations to each other in internet-based desktop 'social' VEs, VEs that are mainly used for socializing and entertainment

Again, this is a limited range of activities. It entails a limited range of experiences that participants are focusing on together, or that they are aware of in relation to each other and doing together. This should not be misinterpreted to imply that this cannot be a 'rich' form of interaction. Walther [1996] argues, for example, by means of his concept of 'hyperpersonal' relations, that people may have highly expressive relations vis-a-vis each other despite – or perhaps because of – the absence of the many channels which may distract from our joint focus of attention on interpersonal relations. And there are many other examples of very complex interactions with others in internet-based desktop 'social' VEs. But even if these relationships or forms of interaction are 'rich' and complex, they are not as multi-facetted as face-to-face relations. And this more narrow focus - a common auditory and visual experience and the experience of doing a limited range of things together - is all that needs to be analyzed.

4. Different Disciplinary Approaches to SVEs

Against this background, we can now examine how different disciplines have approached these experiences.

4.1 Theoretical versus Applications-oriented Research

Knowledge about SVEs can be put into two categories: abstract - how do they work? and practical - how can we improve how they work?

Studies related to practice, to improving the technology (human factors/usability), tend to be either lists of aspects that should be taken into consideration, or suggestions for improvements that are specific to particular applications [see Stanney, Mourant and Kennedy, 1998; and on the limitations of practical research in the similar context of videoconferencing, see Daly-Jones et al, 1998]. Research on SVEs is often driven by a mixture of applications or technology development and more theoretically oriented questions, and while we will encounter lessons from both types of research, the focus here will be on the theoretical lessons from SVEs.

4.2 Sociology

For how people socially interact in the *real* world, there is a well-established body of social scientific knowledge. As we shall see, this body of knowledge has been applied in various ways to understanding social interaction in VEs. Perhaps the central question for SVEs has been: to what extent are the mechanisms of real world interaction imported into SVEs, and to what extent do they operate differently *within* SVEs.

Problems arise when we need something more than the mechanics of interaction *within* the SVE; that is, the larger social and technological context in which this interaction takes place: how can we get a grip on how the *real* setting affects the interaction in SVEs? For the relation between real world interaction and interaction in SVE's, we have very little data as yet, except for some short trials which allow real-virtual comparisons in experimental conditions [Slater, Sadagic, Usoh and Schroeder, 2000; Schroeder et al., 2001], and limited research about how, for example, online games playing fits in with other uses of media [Axelsson and Regan, 2001]. But apart from these experimental trials and studies of internet-based SVEs - again, a very limited range of settings - there are no findings to date.

Perhaps the best we can do in this area for the moment is to 'nest' this issue in the wider area of computer networks in their social context – in other words, to treat VEs as a special case of computer-mediated communication (CMC), and how CMC generally - as opposed to SVEs in particular - relates to its social context [for a recent review of the internet, see DiMaggio et al, 2001]. But to compare SVE technology with other similar ones will remain problematic, since there are few technologies which provide users with comparable experiences to SVEs [Schroeder, 1999]; socializing in text-based MUD's, passive 'presence' in highly immersive media like IMAX movie theaters, and the like do not afford the same type of copresence and interaction with others. Nevertheless, the lack of real settings is both an advantage - we can build up knowledge effectively in the isolation of laboratory settings - and a disadvantage - laboratory findings will be affected in unanticipated ways by real world settings which may limit their validity.

4.3 Communication and Media Studies

Apart from sociology, we can also draw on theories of communication or media studies, but here studies have pointed in different directions. A major line of research has been to evaluate the impact of the absence of social cues and media richness, with the general finding that the absence of social cues and less media richness leads to poorer communication. Walther [1996], on the other hand, as mentioned earlier, has argued that people establish 'hyperpersonal' relations in new media precisely because of this absence of social cues or the lack of media richness.

Experimentally-based communication theories have the limitation that they deal with interaction only for short periods. Especially for studies of collaboration in CMC, this has been a limitation so far [Scott, 1999]. Again, the most useful way to approach SVEs in this regard may be to embed or 'nest' how we conceive of SVEs within what we know about other longer-term uses of media and other forms of CMC [Schroeder, 1999].

4.4 Social Psychology

Social psychological or psychological theories address behavioural and cognitive issues. Social psychology and psychology focus on internal states and how interaction in groups affects these states. For example, Blascovich [2002] defines social presence as 'a psychological state in which the individual perceives himself or herself as existing within an interpersonal environment'. With this type of definition, social psychological research will be able to explore how findings about real world group influence [Paulus, 1989] apply to SVE settings – which includes areas like the influence of the presence of others, social distance, deindividuation, self-categorization, and the like.

Social psychology and psychology provide powerful knowledge because hypotheses can be tested, revised and build on each other. To do this, internal states are typically taken as the point of departure and experimental methods used. But although we will need to support our understanding of social interaction with data about controlled conditions, this data will need to complemented by data about social interaction *apart from* laboratory conditions.

Social psychology and psychology will thus be useful in the same way that they are useful for studying offline behaviour, to provide testable knowledge about the building blocks (internal states) of social behaviour from its constituent elements. Whichever combination of disciplines will be used in the study of SVEs, it will be necessary to integrate our knowledge such that it allows us to bring all interaction in VEs into a single framework within which all hypotheses and data can be incorporated.

5. The Range of Findings

We can now move on to the range of findings from studies of SVEs, beginning with studies that cover the range of technologies, moving on to the range of participant observation studies, and finally those which fall into neither of these categories. In each case, it will be useful, under the subheading 'Extending our Findings', to point to the major gaps and some interesting ways forward - which we will then able to integrate in the conclusion.

5.1 Findings about the Influence of the VR System

To get a sense of how the range of systems affects copresence and interaction, we can examine a large-scale trial which has investigated this effect. This trial has been the most extensive investigation to date involving the range of VR systems, with 128 pairs doing a Rubiks-cube type puzzle using different VR systems. The systems used were CAVE-type [Cruz-Neira, Sandin and deFanti, 1993] (also known as walk-in or immersive projection technology systems), desktop, and HMD, with pairs using either the same or different systems (see [Schroeder et al, 2001] for detailed specifications of the systems and the results, though the results for those who used HMD systems have not yet been published), and the equivalent real setting with cardboard box cubes.

This experiment builds on and extends previous experimental trials [Slater, Sadagic, Usoh and Schroeder, 2000]. The focus of all these trials has been on presence, co-presence, collaboration and performance.

Clearly, technology as a variable has important effects on presence, copresence, collaboration and performance. We have data for the Rubik's cube trial both about when two participants are using the same technology (partner in CAVE-type system collaborating with partner in a CAVE-type system, desktop with desktop, and face-to-face) and where they are using different systems (CAVE-type with desktop system, CAVE-type with HMD system). Participants in all cases were not aware of the technology or system that their partner was using.

One result that is consistent across these studies is that, other things being equal, a more immersive VR system creates a greater sense of presence and copresence. Also, the more immersed participant is identified as the leader in a pair (or in a group of three participants in earlier [Slater, Sadagic, Usoh and Schroeder, 2000] studies) – other things being equal – even if they are not identified as the leader in the equivalent real setting. We also know that presence and copresence often co-vary; that is, if users have a stronger sense of copresence, they also have a stronger sense of presence.

Apart from presence and copresence, there are important effects of the technology and the VE on what each particpant *does*: for example, there are great differences in what participants focus on when they use different systems – the person using the desktop system may focus on communication, whereas the more immersed person may focus on navigating and manipulating the objects. Put differently, a division of labour occurs where two people work on different systems.

Another result is that for a spatial task in a fully immersive CAVE-type system, two people can perform the Rubiks-cube puzzle task just as effectively in a virtual setting as face-to-face.

Overall then, we know that, for groups of two or three who are doing short collaborative tasks, certain technology and social factors both play a strong role, and that in this case highly immersive CAVE-type systems can povide an experience that is like 'being there together'.

5.1.1 Extending our Findings about the Influence of the VR System

These findings are robust across many studies, but they still depend on the task and the VE. It would therefore be very useful to study – not, as hitherto, the use of different systems to do the same task, but rather persons carrrying out different tasks (or the same task in different types of environments within the VE) with the *same* system.

With the system held constant, and therefore applying Ellis' measure of 'equivalence classes'[1996], and based on what we already know, it would be useful to test the following hypotheses:

- the more involved in the task, the more presence and copresence. Note that this hypothesis is non-obvious: if users are intensely involved in an activity/task, they might 'forget' that they are in a VE, which may take away from presence or copresence.

- the more rich and complex the VE, the more presence and copresence. Again, this is not obvious: rich VE's may 'overwhelm' or 'alienate' the user, whereas simple ones may make the users more 'at home'. A separate hypothesis under this rubric concerns the realism of avatars; ie. the more realistic

the avatar, the higher the presence/copresence. Again, it may turn out that people are more at ease with each other in the case of 'simpler' avatars.

- the more realistic (in the sense of true-to-the-real-world) the VE, the more presence and co-presence. Again, this has often been assumed by VR researchers, but anecdotal observations suggest that people regard 'fantastic' or abstract scenes as highly engrossing. It will be difficult to separate realism in the sense of 'detail' as against realism in the sense of 'true-to-the-real-world'.

Generally, in relation to these hypotheses, it may be difficult, perhaps impossible, to disaggregate the influence of realism and the 'intensity' of the activity (or interactivity) in the VE: highly 'unrealistic' scenes like the Rubik's cube, for example, can be very engaging because of the high level of interaction, but this is hardly a rich or realistic environment (a simple Rubik's cube floating in the middle of the 3D space, with no other features). At the same time, a highly realistic scene with highly realistic avatars will also yield a powerful experience of presence and copresence, even with little or no interactivity.

In relation to the realism of the representation of the other person, that the more realistic the appearance of the other person, the higher the copresence (or 'social presence', in Blascovich's [2002] terminology), this hypothesis has already been confirmed in some instances [Blascovich, 2002; Slater and Steed, 2002].

Experimental studies which investigate one factor or one measure of how the individual experiences the SVE – *other things being equal* – are therefore an important way forward. But this type of study will need to be integrated with studies that analyze a number of factors together since when two or more factors interact with each other (realism and level of interactivity, for example), one may override the other. Hence we need to approach copresence and interaction from the experimental side, but also in a way that takes several factors into account. The separate complication is that laboratory studies and findings, as indicated earlier, may or may not travel well outside of the laboratory.

5.2 Findings from Participant Observation and Other Studies of Internet-based VEs

Participant observation or ethnographic studies do not necessarily go hand-in-hand with internet-based desktop 'social' VEs. And not all internet-based or online VEs are 'social' VEs, VEs where the main purpose is to socialize or which are used for entertainment and gaming. Some, for example, are used for education. And experimental methods, such as setting up a social world with certain parameters, or quantitative methods [Smith, Farnham, and Drucker, 2002], can equally be used in the study of online VEs.

We should also note that the effects of the technological system are not limited to high-end systems, but also apply to internet- based desktop SVEs such as Activeworlds (AW) and others. Examples of how the technology or the system affects interaction include bandwidth, communication capabilities, and ease of navigation [Axelsson, 2002; Becker and Mark, 2002; Nilsson et al., 2002]. Nevertheless, in what follows, and despite the fact that internet-based SVEs are quite varied, I shall concentrate on the findings for 'social' desktop SVEs with larger populations.

Presence and copresence have not often been studied for online desktop VEs (see [Schubert, Friedmann, and Regenbrecht, 2002] for an exception), but clearly they should be since they are central to the experience and interaction among users. And although 'presence' in desktop systems may not generally be experienced as powerfully as in an immersive system, it is not easy to say the same for copresence.

Be that as it may, the main issue here is interpersonal relationships, and the rules governing these relationships are very different from those governing zero-history relationships. Among the findings here are that long-term relationships can be meaningful and rewarding for users [for example, Cheng, Farnham and Stone, 2002], that long-term users trust each other [Schroeder and Axelsson, 2001], that they tend towards stable identities in terms of appearance and name [Smith, Farnham and Drucker, 2002; Schroeder and Axelsson, 2001], that they use non-verbal communication less the longer they inhabit the VE [Smith, Farnham and Drucker, 2002], that they take an active interest in the choice of their appearance and in shaping the VE [Cheng, Farnham and Stone, 2002; Anderson, Ashraf, Douther and Jack, 2001], and that they develop 'stake' in the social environment [Axelsson and Regan, 2001; Schroeder, Huxor and Smith, 2001].

We also find that many rules of interpersonal interaction apply to social VEs, such as following the conventions of interpersonal distance [Becker and Mark, 2002; Smith, Farnham and Drucker, 2002; see also Blascovich, 2002 for immersive systems] and of greeting, addressing and taking leave of others [Becker and Mark, 2002], and that they prefer avatar representations that are neither too realistic nor too unrealistic [Cheng, Farnham and Stone, 2002]..

Other findings [Axelsson, 2002; Reid, 1999; Schroeder 1997] are concerned with hierarchy and stratification - insiders/outsiders and other forms of stratification emerging inside the VE, as well as stratification based on system capabilities and on forms of stratification 'imported' from the real world into the VE.

Overall, we find that many norms are imported into these SVEs, albeit in a form that is adapted to the virtual setting. But whether they are norms imported from the real world into the virtual setting, or those that have developed within the system, they make the interaction within the SVE highly structured on a micro- and macro-level. Thus the sense that one often gets when one initially enters these SVEs, of the novelty of the environment and of the playful interaction, diminishes over time - or at least, one adapts to this new setting as one would to a foreign place that one visits for the first time.

Copresence in internet-based SVEs is thus something 'one gets used to', and one can then concentrate on communicating and engaging with others. This interaction, in turn, revolves around making suitable use of the possibilities and constraints of this medium.

5.2.1 Extending Findings from Observation Studies in Naturalistic VE Settings

Since it is unclear to what extent rules governing longer-term interaction in SVEs relate to the rules governing short-term trials, one question that would be useful to investigate in the future is:

- what is the impact of a short and delimited task/activity, as opposed to an unstructured and longer one, on presence and copresence?

This question lies at the intersection of experimental studies and studies of 'naturalistic' or day-to-day online socializing, and could be formulated from the experimental side as a hypothesis to be tested: the longer the task or time spent in the VE, the greater presence or copresence. Again, it may turn out that the opposite is true: that with adaptation, the sense of being in a VE and being there with others will 'fade'. Still, it is clear that it will be difficult to study longer periods experimentally. But the larger question - how can we apply the insights from longer-term and non-task-centred interpersonal relationships in VEs to the design of short-term tasks/activities in shared VEs, and vice versa – will be useful to both sides.

5.3 Findings from studies apart from those covered in 5.1 and 5.2

As regards 3, findings not covered under 1 and 2, these are mainly studies of specific aspects: navigation [Munro, Höök and Benyon, 1999], collaborative tasks [Churchill, Snowdon and Munro, 2001], and adaptation [Anderson, Ashraf, Douther and Jack, 2001]. Put differently, these studies have little common focus and they do not generally build on each other (unlike many of those in the previous two sections), and thus it is difficult to integrate this group of studies into an emerging body of generalizations.

Perhaps the most interesting findings in this category that are related to copresence and interaction, the ones which push beyond the range of the other two, are those that are neither limited to a short task, nor those which simply concern 'everyday' behaviour in 'social' VEs, but which combine day-to-day and experimental behaviour: for example, in a series of virtual meetings involving an acting rehearsal [Slater and Steed, 2002], or in a series of virtual meetings involving building and other activities [Nilsson et al., 2002]. Here we can see how small groups (two and four participants respectively), over a number of sessions (five half-hour sessions and ten one hour sessions respectively), adapt to collaborating with each other and being there together – that is, to how interpersonal relations are affected by the environment.

Here it may also be useful to mention again that behaviour in SVEs is different from behaviour in real settings, but that some 'real' behaviours are also imported into virtual settings: for example, the findings that avatars are more inclined to maintain interpersonal distance in Online Traveler, an online SVE with audio, than in a SVE like Activeworlds with text-only communication [Becker and Mark, 2002] - in this case, there is no 'objective' reason why this 'real' convention should be imported into the virtual setting. Equally, however, it is possible to get used to doing some things that are not possible in the 'real' world: ie. flying or moving rapidly, or being able to manipulate virtual objects. Going through objects or through other people is an interesting inbetween case here: in some cases it is easy, in others it is uncomfortable. Another interesting inbetween case is avatar appearance: on the one hand, people want to be able to influence their avatar appearance [Cheng, Farnham and Stone, 2002]; on the other, some users seem to pay little attention to it – as one long-term user put it [Schroeder and Axelsson, 2001], 'it's just graphics'.

Another question that these 'inbetween' investigations of SVEs raise is to what extent SVEs will in fact be used outside of the two typical forms as I have described them under 5.1 and 5.2. This is not an idle question if we consider that experimental SVEs like those in 5.1 will need to move beyond the laboratory and into applications if they are to have a long-term value, just as online SVEs like those in 5.2 will need to become more 'inhabitable' if they are to offer more than a temporary diversion.

5.3.1 Extending the Findings Betwixt and Between

Here the various aspects of research on SVEs come together, not only immersive and desktop, small and large groups, and experimental/quantitative and participant observation studies, but also the different kinds of behaviours and how we can generalize from them. Future hypotheses might therefore link different areas of research. One example of such a hypothesis, and where research from short-term experimental trials and from long-term online 'social' VEs could complement each other, would be: which is more important for presence - realism of the other participants - or that of the scene? This might have an important bearing on co-presence and interaction and on the design of VEs.

6. CONCLUSIONS: FOCUSING AND ADVANCING THE FIELD

The advance in the study of SVEs has not been driven by any one particular set of methods, types of VR systems, or uses and applications. Instead, a number of methods and settings have yielded results that *can* be integrated. Nevertheless, much remains to be done to integrate these various findings.

The two types of findings that I have reviewed have developed mostly in isolation from each other. Nevertheless, one can envisage that the features of long-term social behaviour within VEs affect the types of technologies used for short-term tasks, for example, just as one can argue that task-specific technology factors will affect longer-term socializing.

There are bound to be continuing differences in the foci of the two different types of study. For short-term interaction (regardless of system), these will primarily be:

- common focus of attention
- mutual awareness
- collaborative task performance

Here the analysis of copresence and social interaction will in *any* case be closely tied to the specific purpose of the session, with all else being left to one side.

For longer-term interaction, the features to be analyzed will be:

- persistence of character, of groups and of the environment
- which social rules and conventions apply
- the relation between real and virtual

Note that these features *all* relate to the social rules governing day-to-day behaviours.

Putting these two side-by-side allows us to notice several things:

The first is that – role is not important for short-term trials, but it is 'taken for granted': when participants interact briefly in an experimental situation, they 'bracket' the question of the identity of their co-participant, even though they feel compelled to follow certain social conventions.

Conversely, for longer-term interaction, participants will take short-term task performance 'for granted' and will adapt to the given limitations of the system. Moreover, researchers here will not look at individual interactions one at a time, or step-by-step.

Against this background, we can summarize the range of experiences and settings jointly in order to focus the research agenda. The absence of smell, taste and touch is something that SVE users will not necessarily 'miss', with the exception of the question of touch or collision detection, which affects copresence and interacting with others in important ways. Though what is 'imported' from real settings for visual touch, and what the conventions are in virtual settings – whether to go through things or people or not, as mentioned above - depends on the type of interaction.

It would be useful to be able to make the assumption that audio quality is sufficient to enable fluid interaction. Trials show that this assumption should in fact *not* be made since poor audio is often the single-most important obstacle to fluid shared interaction. But the obstacles to technical improvements are not as great here as for the visual environment. If, then, we can assume that audio is as good as in a real setting or as in a telephone conversation, we can leave audio to one side in situations where voice between participants is the only issue, and as long as we keep in mind the effect of having a voice attached to an avatar as opposed to a real person. It may not even be necessary to have full 3D sound, as long as we are somehow made aware of how the others' voice(s) belong to.

If we have perfect audio, and this question aside, then we can focus entirely on how the visual environment, including avatar appearance and the content of communication (which both gain added importance in this setting because they are almost exclusively what participants concentrate on) influence copresence and interaction. Taking this further, this means comparing the visual conditions for

interaction with those apply that apply to real face-to-face encounters. For investigating this topic, in turn, only certain rules of real world social interaction apply.

Within this narrowed field, copresence will remain an important issue in the sense that SVEs will always provide a different experience from face-to-face and other types of CMC settings. Zhao [2001] claims that the 'face-to-face situation undoubtedly generates the most vivid sense of copresence', but in my view it would be interesting to test this for various comparable virtual and real settings. At the same time, we have seen that 'copresence' is diffuse because 'being there together' - as opposed to presence, or being in a place other than the one you are physically in - can have different meanings in different circumstances, quite apart from the system used: how do you experience the other(s)? how are you able to engage with them? And how does your experience of who you are with, and what you are able to do with them, shape the sense of where you are? If we think back to some of the examples discussed in this essay - collaborating on a Rubik's cube puzzle, building something together in AW, rehearsing acting together - the differences are perhaps shaped more by what you are *doing* together than by the experience of being *there* together.

So, how should we think about copresence and interacting with others in SVEs? Copresence needs to be both narrowed and widened: Narrowed, because it can for the most part be reduced to certain shared experiences only – visual, in settings where we can assume that audio communication is similar to real settings. Broadened, in that it is not only awareness of the other's presence in the environment that matters, but also how *joint* interaction affects this awareness.

Presence, or being there in another place, can be measured, with important implications for system and environment design. But being there *with other(s)* depends on what we are able to do together with them. Copresence is interesting to measure in relation to presence – how do they vary with each other – but apart from that, the usefulness of this measure is unclear. Copresence is influenced by a number of factors, and although much remains to be done in investigating how the level of immersiveness affects interacting with others (or social relations), the many aspects of these interactions or social relations – how used to the VE people are, how many participants there are, what they are jointly aware of – may

override presence and copresence (if copresence is measured separately) as factors shaping the experience.

Two examples will suffice to illustrate how difficult it is to separate copresence in the sense of co-immersiveness from copresence in the sense of doing things together: in the trial discussed earlier involving two networked CAVE-type systems where two subjects were carrying out a Rubiks-cube puzzle together, it was observed how several pairs of collaborators tried to shake hands together after successfully completing the task! How do we best understand copresence here: is it because of a joint sense of achievement that participants try to shake hands? Or is it because they have become used to picking up cubes together, and they are therefore used to following the conventions of working with their hands and arms together? In a different trial in the same networked CAVE-type system setting, after spending more than two hours collaborating in various environments, it could be observed that one of the participants continually leaned towards his partner in order to hear him better – despite the fact that there was no 3D audio! Again, for copresence, we can ask here: would this kind of behaviour stop after many lengthy sessions and becoming more used to the fact that this kind of leaning is pointless? (But if not after more than two hours, when?) This question has (non-obvious) design implications: would it be better to have audio in which leaning to hear each other better could be avoided altogether (for example, with earphones, which is technically straightforward, but perhaps awkward for users to adjust to), or is it better to produce an environment in which 'leaning to hear each other better' is as realistic as possible with 3D audio (technically difficult, and it may be even more difficult for participants to adjust to in a VE setting)? Many other such examples could be given, which show that copresence is more about what participants do together rather than being aware of each other's presence.

As we use come to use highly immersive SVEs more extensively, it will become more apparent – once the novelty of the situation 'wears off' – what social or interpersonal conventions apply in these environments. Similarly, once, in online 'social' VEs, the value of online gaming as such wears off, and the focus is more on interpersonal relations, the constraints and possibilities of interacting with others and shaping online worlds (outside the roles and rules of the game) will also increasingly come into the foreground. Thus the limitations – but also the possibilities – of SVEs will crystallize: to what extent do others and objects need to be treated like real people and objects (avatar appearance, property relations

[Schroeder, Huxor and Smith, 2001], joint manipulation of objects, being able to pass through people and objects, when real world conventions of jointly doing a task apply or not, etc.)?

Finally, the relation beween the real world setting and experience in SVEs, or between laboratory trials and how systems eventually work in the day-to-day world, is still subject to a great deal of flux. SVEs, with the exception of internet-based desktop 'social' VEs, have not yet become a widely used day-to-day tool. Moreover, we don't know yet how the technology will mature - walk-in CAVE-type, large-screen, HMD, more sophisticated online desktop SVEs, or some other. It is a good bet, however, that *some* kind of technology for interacting with others inside VEs, with graphics that provide a sense of being there and high quality audio, *will* become widespread. Research should therefore be oriented towards cumulative knowledge that will apply to a range of possible systems and types of environments that enable 'being there together'. Luckily, it is not difficult to anticipate what many of these will be.

CVE or SVE researchers are in the enviable position that there is a valuable research goal - no matter how the technology develops: how copresence and interacting with others works in future devices that make being there together possible. The differences from face-to-face interaction will always be a research question, since 'being there' and interacting with virtual others will always be unlike in real world settings. The research agenda for SVEs - what people do with each other and with objects within the environment, with what appearance, and with what capabilities, and how these affect their effectiveness and enjoyment – is therefore 'given'. As I have tried to show in this paper, this agenda can also be more focused than is often supposed.

REFERENCES

Anderson, J., Ashraf, N., Douther, C., Jack, M. (2001), Presence and Usability in Shared Space Virtual Conferencing. Cyberpsychology and Behaviour, **4**(2): 287-305.

Axelsson, A.-S. et al. (2000), Cubes in the Cube; A comparison of collaboration in virtual and real environments. Presented at Presence 2000 Workshop, March 27-28, Delft.

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

Axelsson, A.-S. and Regan (2002), T. How Belonging to an Online Group Affects Social Behaviour – A Case Study of Asheron's Call. Microsoft Research Technical Report MSR-TR-2002-07, available online.

Becker, B. and Mark, G. (2002), Social Conventions in Computer-mediated Communication: A Comparison of Three Online Shared Virtual Environments, in R. Schroeder (ed.), The Social Life of Avatars: Presence and Interaction in Shared Virtual Environments. London: Springer, 19-39.

Blascovich, J. (2002), Social Influence within Immersive Virtual Environments, in R. Schroeder (ed.), The Social Life of Avatars: Presence and Interaction in Shared Virtual Environments. London: Springer, 127-145.

Cheng, L., Farnham, S. and Stone, L. (2002), Lessons Learned: Building and Deploying Shared Virtual Environments, in R. Schroeder (ed.), The Social Life of Avatars: Presence and Interaction in Shared Virtual Environments. London: Springer, 90-111.

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

Cruz-Neira, C., Sandin, D., DeFanti, T. (1993), Surround-screen projection-based virtual reality: the design and implementation of the CAVE. Computer Graphics Proceedings, Annual Conference Series 1993. ACM SIGGRAPH, New York: ACM, 135-42.

Daly-Jones, O. et al. (1998), Some Advantages of video-conferencing over high quality audio conferencing: fluency and awareness of attentional focus. International Journal of Human-Computer Studies, 49: 21-58.

DiMaggio, P. et al. (2001), Social Implications of the Internet. Annual Review of Sociology. 27: 307-36.

Durlach, N. and Slater, M. (2000), Presence in Shared Virtual Environments and Virtual Togetherness. Presence: Journal of Teleoperators and Virtual Environments, **9** (2): 214-7.

Ellis, S. (1991), Nature and Origins of Virtual Environments: a bibliographical essay. Computer Systems in Engineering, **2**(4): 321-47.

Ellis, S. (1996), Presence of Mind: A Reaction to Thomas Sheridan's "Further Musings on the Psychophysics of Presence", Presence: Journal of Teleoperators and Virtual Environments, **5**(2): 247-59.

Isselstein, W.A., Lombard, M., Freeman, J. (2001), Toward a Core Bibliography of Presence, Cyberpsychology and Behaviour, 4(2): 317-321.

Munro, A., Höök, K. and Benyon, D. (Eds). (1999), Social Navigation of Information Space. London: Springer.

Nilsson, A. et al. (2002), The Long-Term Uses of Shared Virtual Environments: An Exploratory Study, in R. Schroeder (ed.), The Social Life of Avatars: Presence and Interaction in Shared Virtual Environments. London: Springer, 112-126.

Paulus, P. (ed.) (1989 2nd ed.), Psychology of Group Influence. Hillsdale, N.J.: Lawrence Erlbaum Associates.

Reid, E. (1999), Hierarchy and Power: Social Control in Cyberspace. In M.Smith and P. Kollock (eds.). Communities in Cyberspace. London: Routledge, 107-133.

Sallnäs, E.-L. (2002), Collaboration in Multi-modal Virtual Worlds: Comparing Touch, Text and Voice and Video, in R. Schroeder (ed.), The Social Life of Avatars: Presence and Interaction in Shared Virtual Environments. London: Springer, 172-187.

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

Schroeder, R. (1996), Possible Worlds: The Social Dynamic of Virtual Reality Technology. Boulder, CO: Westview.

Schroeder, R. (1997), Networked Worlds: Social Aspects of Multi-User Virtual Reality Technology. Sociological Research Online, **2**(4) (available online).

Schroeder, R. (1999), Social Life in Virtual Worlds: Structure and Interaction in Multi-User Virtual Reality Technology. Communications & Strategies, **33** (1): 137-150.

Schroeder, R. et al. (2001), Collaborating in networked immersive spaces: as good as being there together? Computers & Graphics, **25** (5): 781-88.

Schroeder, R., Axelsson, A. (2001), Trust in the Core: A Study of Long-term Users of Activeworlds, in Digital Borderlands, a Cybercultural Symposium, Norrköping, Sweden, 12-13 May.

Schroeder R., Huxor A., and Smith A. (2001), Activeworlds: geography and social interaction in virtual reality. Futures: a journal of forecasting, planning and policy, **33**: 569-87.

Schroeder, R. (ed.) (2002), The Social Life of Avatars: Presence and Interaction in Shared Virtual Environments. London: Springer.

Schubert, T., Friedmann, F. and Regenbrecht, H. (2002), The Experience of Presence; Factor Analytic Insights, in Presence: Journal of Teleoperators and Virtual Environments, 10 (3), 266-232.

Scott, C. R. (1999), Communication Technology and Group Communication. in L. R. Frey (ed.), The handbook of group communication theory and research, Thousand Oaks, CA: Sage, 432-72.

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

Slater, M. and Steed, A. (2002), Meeting People Virtually: Experiments in Shared Virtual Environments, in R. Schroeder (ed.), The Social Life of Avatars: Presence and Interaction in Shared Virtual Environments. London: Springer, 146-171.

Smith, M., Farnham, S. and Drucker, S. (2002), The Social Life of Small Graphical Chat Spaces, in R. Schroeder (ed.), The Social Life of Avatars: Presence and Interaction in Shared Virtual Environments. London: Springer, 205-220.

Snowdon, D., Churchill, E. and Munro, A. (2001), Collaborative Virtual Environments: Digital Spaces and Places for CSCW: An Introduction, in Churchill, E., Snowdon, D. and Munro, A. (eds.) Collaborative Virtual Environments: Digital Spaces and Places for Interaction. London: Springer, 3-17.

Stanney, K. Mourant, R. and Kennedy, R.S. (1998), Human Factors Issues in Virtual Environments: A Review of the Literature. Presence: Journal of Teleoperators and Virtual Environments, **7** (4): 321-51.

Thie, S. and van Wijk, J. (1998), A general theory on presence: Experimental evaluation of social virtual presence in a decision-making task. Presence in Shared Virtual Environments Workshop. London, 11-12 June.

Walther, J. (1996), Computer-Mediated Communication: Impersonal, Interpersonal, and Hypersonal. Communication Research, **23** (1): 3-43.

Zhao, S. (2001), Toward A Taxonomy of Copresence. Presence 2001: 4th International Workshop, May 21-3.