FORUM

Real and Illusory Interactions Enhance Presence in Virtual Environments

Abstract

It has long been argued that the possibility to interact in and with a virtual environment (VE) enhances the sense of presence. On the basis of a three-component model of presence, we specify this hypothesis and argue that the mental representation of possible actions should especially enhance spatial presence, and to a lesser extent the involvement and realness of a VE. We support this hypothesis in three studies. A correlative study showed that self-reported interaction possibilities correlated significantly with spatial presence, but not with the other two factors. A first experimental study showed that possible self-movement significantly increased spatial presence and realness. A second experimental study showed that even the illusion of interaction, with no actual interaction taking place, significantly increased spatial presence.

1 Introduction

Many 3-D computer games excel in creating a sense of "being there" in the game's virtual environment. The players' attention is absorbed by the game's action, they feel as if they are really *in* the virtual space, and they frequently move their body as if they were there. This psychological phenomenon is known as the *sense of presence,* commonly defined as the sense of being in a virtual space that is presented by technological means (Slater & Wilbur, 1997; Witmer & Singer, 1998). Recent computer games are probably the most widely used types of virtual environments, and they provide an interesting field for researchers who are interested in the sense of presence. One example for a game that creates a high amount of presence is the adventure game *Riven*. It presents photorealistically rendered landscapes and artifacts. Unlike other 3-D games, however, the players cannot freely move their point of view but instead "wander" between prerendered and mostly static views onto the game world. Despite this movement restriction, most players of *Riven* will agree that they develop a high degree of presence in the displayed environment. Readers who are familiar with the game will probably consent that they do not remember a series of separated images, but rather places that they seem to have visited.

How does the game accomplish this feat? We think that the key lies in the *interactions* the player can engage in. In principle, there are three kinds of interactions with a virtual environment (VE): navigation of the own point of view and body, interactions with inanimate objects, and interactions with animate characters (Regenbrecht, Schubert, & Friedmann, 1998). On the most basic level, *Riven's* navigational technique creates the illusion of moving and turning a virtual head: a click of the left mouse button and the view to the left scrolls into view from the left side of the screen. Next, the player can interact with objects by "touching" them with a virtual hand: the mouse pointer changes into a symbolic hand and even seems to pull on some objects. Together, these interaction techniques simulate head and hand and provide the player with a very simple sense of a bodily presence in the virtual world. The most dramatic effects for a player of *Riven,* however, are the interactions with the game's characters. One carefully designed interaction sequence, usually the first close encounter for the players, occurs with the character of a girl: after entering a new room, a small girl suddenly

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stands before the players. Apparently, she is as shocked by the appearance of another "person" as the players are of hers. After a brief moment, the girl runs away before the players can even think about proper ways of reacting. In a sense, the girl's reaction provides the players with a full proof of being in the VE: she is frightened of me, therefore I must be there.

The ability to interact with a VE, as described in this example, has long been regarded as a central feature of virtual reality. The possibility of interacting with the virtual world distinguishes VEs from a range of other media, such as cinema. Together with *vividness,* "the ability of a technology to produce a sensorially rich mediated environment," *interactivity,* "the degree to which users . . . can influence the form or content of the mediated environment," characterizes virtual reality (Steuer, 1992, p. 80).

At first sight, it seems almost trivial to state that the ability to interact with a VE enhances the sense of being in it, but the difficulty of showing this effect becomes obvious when we look at the results presented by Snow (1996). He found that "perceived presence was not affected by the number of interactions possible in the VE" (p.106). Snow suspects that special conditions in his study diminished the influence of presence: a strict focus of the participants on the task and therefore no exploration of possible interactions, and a 2-D mouse as the interaction device.

When one tries to explain how this effect occurs psychologically, it becomes clear that the answer requires a model of the cognitive processes leading to presence, and that the causation of presence by interactivity may offer insights into the psychology of the sense of presence. We have recently proposed an embodied presence model that tries to describe the cognitive processes that lead to presence (Schubert, Friedmann, & Regenbrecht, 1999, 2001). Its central idea is that presence develops from the cognitive representation of possible actions that can be performed in the virtual world. On the basis of an embodied cognition approach (Glenberg, 1997; Lakoff & Johnson, 1999), it is argued that a VE, like every other environment, is conceptualized in terms of possible actions. These actions can be functionally related to navigation, manipulation of objects, or interaction with other agents. A sense of presence develops from the mental representation of movement of the own body (or body parts) as a possible action in the VE, or from the meshing (Glenberg, 1997) of bodily actions with objects or agents in the VE. The more possibilities there are of interacting, the more cognitive meshings are possible, and presence increases.

The embodied presence model, in analogy to arguments from other researchers (Witmer & Singer, 1998), furthermore argues that the mental representation of the own body as being part of a VE should be distinguished from an attentional component of presence. We call the former component *spatial presence* to emphasize its spatial-constructive nature, and the attentional component *involvement*. Interactivity should first and foremost influence spatial presence because it directly determines the meshings formed between body and VE. It should affect involvement only as far as it draws additional attention to the VE. In a recent factor analytic study, we have also found a third presence component, namely judgments of realness of the VE, which were largely independent from both spatial presence and involvement. The empirical investigations in this paper will always distinguish between these three components of presence and assess each component separately.

The reasoning that presence should be increased by interaction possibilities is consistent with other accounts in the literature. Witmer and Singer (1998), building upon Sheridan (1992), mentioned the ability to actively search the VE as a determinant of presence: "An environment should enhance presence when it permits observers to control the relation of their sensors to the environment" (p. 230). Modifying the own viewpoint, Witmer and Singer argued, should enhance presence. Note, however, that our model emphasizes that presence develops from the mental representation of possible bodily interactions, and not the objective possibility to interact per se. It follows that, under some circumstances, objective possibilities for interactions should not enhance presence, for example, when they are not seen or ignored, or when actions and consequences cannot be causally linked (that is, when the interaction is not understood), or when the interaction is not framed as an interaction of the virtual body with the virtual environment, but as a mediated interaction through some mechanism. Still more interestingly, one can also argue for the reverse. From assuming that it is not objective possibilities to interact but *perceived* possibilities to interact that determine presence, it follows that the mere illusion of an interaction should enhance presence, even when objectively no interaction takes place. This hypothesis is supported by previous work by Pausch, Snoddy, Taylor, Watson, and Haseltine (1996) observing the reactions of a couple of thousand guests at a Disney installation at EPCOT Center regarding their "illusion that they are in a different place": "We can improve the experience by telling a pre-immersion "background story" and by giving the guest a concrete goal to perform in the virtual environment." (p. 193)

Although the importance of interactivity for presence has been widely acknowledged, direct empirical evidence is rare. We are aware of only two directly relevant experimental studies (Hendrix & Barfield, 1996; Welch, Blackmon, Liu, Mellers, & Stark, 1996; Schuemie, van der Straaten, Krijn, & van der Mast, 2001). Hendrix and Barfield (1996) found in a within-subjects design that head tracking (that is, that moving the head caused a corresponding change in the perspective on the virtual environment viewed over a head-mounted display) increased the subjective sense of presence, as measured by two items. Welch et al. (1996), who also used a within-subjects design, showed that driving a virtual car created higher presence than merely being a passenger in it; presence was assessed with one item.

2 The Present Research

The goal of the present work was to investigate the impact of interaction possibilities on presence more closely. The empirical approach went beyond previous work in two respects. First of all, a three-component presence scale, based on the embodied presence model previously described, was used instead of a uniform presence measure. Schubert et al. (2001) recently showed that, in factor analyses, items assessing subjective experiences of presence split into three different components. One factor contained items measuring a sense of spatial presence, that is, that the own body is actually located in the virtual space. A second factor, involvement, measured how much attention is absorbed by the VE and how much attention is still paid to the real environment. The third factor finally assessed a judgment whether the VE seems as "real" as a real environment. (For a more detailed description of the three components, see Schubert et al. (2001)) and the following example items. Following the preceding argumentation, we expected that interaction mainly has an impact on spatial presence, and less impact on involvement and realness. We explored this hypothesis first in a correlative study and then in two experimental studies. In the first experimental study, we manipulated actual possibilities to interact by allowing or disallowing the participants to perform self-directed navigation. In the second experimental study, we manipulated merely the participants' sense that they could interact with virtual agents, without any interaction actually taking place.

In the two experimental studies, we extended previous work that used within-subject designs by manipulating the conditions between subjects. This is important because it rules out experimenter demand effects: one could imagine that the participants in a within-subjects study try to understand the difference between the two occasions on which they have to fill out the same questionnaire, because "alert, aware participants are actively seeking cues in the research setting to inform them of what they are expected to do or what they should do in order to present themselves in a favorable light" (Brewer, 2000, p. 8). If only some participants become aware of the hypothesis that one condition offers more interaction possibilities and that the experimenter expects this to lead to higher presence measures, the validity of the results is at risk. Therefore, our participants took part in only one condition and were not aware of the existence of other experimental conditions or the research question.

3 Study 1

3.1 Overview

In this first study, we were interested in whether the sense of presence, and especially spatial presence, would correlate with an assessment of the interaction possibilities. We surveyed players of computer games, asking them first to describe their possible interactions with the game world, and then to assess how comprehensive they deemed these interaction possibilities. Next, they answered the three-component presence scale (Igroup Presence Questionnaire, IPQ) (Schubert et al., 2001).

3.2 Participants

Of the 35 participants, 32 were men and two were women (missing data for one case). The mean age was 25.1 (s.d. = 7.0). The survey was posted on the web (Müller & Funke, 1998) and advertised in appropriate Usenet newsgroups. Each participant could take part in a lottery in which two gift certificates for 20 DM (about 9 USD at the time) were awarded. To participate in the lottery, participants had to provide an email address. Anonymity was assured.

3.3 Materials

The questionnaire asked the participants to remember a recent episode in which they had played a 3-D computer game. In an open-ended question, they were then asked to list the possible interactions that they could perform in the game. (The example of a racing game with three possible interactions was given.) The purpose of this open question was to remind the participants of their interactions, and the answers were not analyzed. The next question asked them to rate whether they had the sense that they could interact with the virtual environment in manifold ways, scored from 0 (not at all) to 6 (absolutely). This item was our measure of experienced possibilities for interaction. Subsequently and not in any way separated from this item, the participants were given the fourteen items of the three-component presence scale by Schubert et al. (2001), which measures spatial presence, involvement, and realness. Spatial presence was assessed by six items,[1] for instance "In the virtual environment I had a sense of being there . . ." (Slater, Usoh, & Steed, 1994), "I had a sense of acting in the virtual space instead of operating something from the outside," and "I had the impression that the virtual environment continued behind me." Examples for the four involvement items are "I was completely captivated by the virtual world" and "I still paid attention to the real environment." Realness was assessed with four items, for instance "How real did the virtual world seem to you?"[2] The order of items was randomized. All items were anchored with −3 to +3, but scored from 0 to 6 in the following analyses. The questionnaire was concluded by items on the used hardware, perspective on the VE, and presence of other virtual and real characters.

3.4 Results

Most of the participants ($N = 26$) played the game on a monoscopic monitor; six used a stereoscopic monitor, and two played with a monoscopic head-mounted display (HMD) (missing data for one case). Almost all ($N = 33$) heard stereo or surround sound. Asked about their main perspective on the VE, 26 indicated that they had a first-person perspective, seven had a third-person perspective, and one had an isometric third-person perspective (that is, the "camera" did not rotate with the movements of the player's character). Twenty-seven of the participants encountered simulated characters in the VE, and fourteen met characters of other real players. The values for interaction possibilities ranged from 0 to 6, m = 4.59, s.d. = 1.31.

After reversing the scores of the three reverse-coded presence items, reliabilities of the subscales were estimated. Cronbach's alphas equaled 0.85, 0.72, and 0.79 for spatial presence, involvement, and realness, respectively. For each subscale, items were combined into a single score.

To assess the effect of interaction possibilities on presence, each subscale score was regressed on the interaction possibility score. The regression was significant only

1. Originally, Schubert et al. (2001) identified the item "I had a sense of being there" as a general presence item that loaded most strongly on spatial presence, but also on involvement and realness. For the present purposes, however, it makes most sense to add this item to the spatial presence subscale, with which it was highly correlated ($r = .83, p < .001$).

2. The complete questionnaire can be retrieved from http://www.igroup.org/pq/ipq/.

for spatial presence. Here, the regression weight of interaction possibilities was $\beta = 0.36$, $p = .039$. Neither for involvement nor for realness did the interaction possibilities explain a significant amount of variance, $\beta = 0.11$, $p = .523$, and $\beta = 0.20$, $p = .249$, respectively.[3]

3.5 Discussion

This correlative study surveyed players of 3-D computer games. After remembering their interactions with the game, they rated how comprehensive their interaction possibilities were and then completed a three-component presence scale that measured spatial presence, involvement, and judgments of realness. As predicted, interaction possibilities predicted only the spatial presence scores significantly, but neither involvement nor realness.

This study was the first attempt to examine the effect of interaction possibilities on different facets of presence. As predicted by our model (which explains spatial presence in terms of mentally presented patterns of (inter)actions), the sense of spatial presence was predicted by perceived possibilities to interact. Of course, no causal implications can be drawn from this result, and the time span between using the virtual environment and answering the questionnaire might have an influence on the results, although we see no reason why it should have produced the reported pattern.

4 Study 2

4.1 Overview

In study 2, our participants experienced a VE by means of a fully tracked HMD. Our goal was to manipulate the possibility of interacting with the VE. For this purpose, our participants could either move freely through the VE or they were shown a prerecorded interaction sequence from a first-person perspective. Thus, the manipulation was comparable to those from Hendrix and Barfield (1996) and Welch et al. (1996); but, in contrast to their studies, our design was between subjects. As a second manipulation, we either showed a static environment or included animated characters. The aim of this second manipulation was to provoke interactions with the characters. Both factors were crossed in a 2 (interaction) × 2 (animation) between-subjects design. We hypothesized that both self-movement and the potential to interact with animated characters would increase spatial presence and affect involvement and realness to a lesser extent.

3. When the general presence item "I had a sense of being there" was excluded from the spatial presence subscale, the regression remained significant ($\beta = .40$, $p = .020$).

Figure 1. *User's view into the virtual environment, with the animated characters (shoes).*

4.2 Participants

Fifty-six students and staff members of the Bauhaus-University Weimar were recruited as participants. They were not paid, and age ranged from 19 to 61, m = 29.3, s.d. = 10.5, and 34 participants were male.

4.3 Procedure and Materials

For studies 2 and 3, we used a Silicon Graphics workstation with a Polhemus FASTRAK tracking system and a Virtual Research VR4 HMD connected to the computer. Figure 1 shows a user's view into the virtual environment. The visual quality was quite good compared to other VR environments, and the frame update rate was approximately 15 Hz. The resolution was limited by the HMD (PAL TV normal quality).

Participants were randomly assigned to the conditions (fourteen to each cell of the experimental design). First, they were introduced to the technical equipment. They were informed that they would enter a virtual space resembling a floor of an office building. They were also told that the walls of this space would be covered by a number of plates and posters, and that their task during the 5 min. of interaction was to count these plates and posters. Then they put on the HMD. Participants in the self-movement condition were told that they could move freely in the virtual space. For their movement, they were restricted to a circle with a diameter of 5 m, which was equivalent to the wooden platform on which they stood. This circle was visualized in the VE by a red line. Participants in the condition without self-movement were told that on the HMD they would perceive a prerecorded sequence that replayed the movements of an earlier participant, and that their own movement would not influence the sequence. All participants in this condition saw the same prerecorded sequence.[4] Then, all participants put on the HMD and explored (actively or passively) the virtual space for 5 min. Participants in the animation condition saw additionally the doors in the virtual office floor open and close, and virtual characters entering and exiting through these doors. The characters consisted merely of two shoes, which walked along the floor and stopped once in a while. The characters never came inside the participants' circle. Their paths were prerecorded and constant across all participants. It was our intention that the participants would get interested in the characters and try to interact with them, for instance by getting closer to them. In fact, the characters did not react to the participants' actions. After 5 min., the experimenter interrupted the participants and gave them the questionnaire. The questionnaire also included two manipulation check items: "I could move freely through the VE" and "I saw characters moving through the VE." After completing the questionnaire, the participants were debriefed, thanked, and dismissed.

4. From a methodological standpoint, a "yoked-control" design would have been preferable. In such a design, the path of each subject in the self-movement condition would have been shown to exactly one subject in the control condition. On the basis of pretests, however, we decided to show all subjects the same prerecorded sequence because many paths from naive participants were simply too chaotic and shaky. The recording was made by an experienced user of the virtual reality system, who moved in a smooth fashion through the VE.

4.4 Results

To ensure a base level of reliability, the answers on check questions built into the questionnaire were analysed first. Three participants in the self-movement condition were excluded because they indicated that they had not been able to move themselves through the VE autonomously. One additional subject in the animations condition had to be excluded because he indicated that he did not see moving characters. A total of 56 participants were retained in the analysis. Reliability analyses revealed Cronbach's alphas of 0.82, 0.86, and 0.69 for spatial presence, involvement, and realness, respectively. Three 2×2 (self-movement $\times$ animation) ANOVAs were performed on the subscale scores. For spatial presence, the only significant effect was a main effect of self-movement ($F(1, 48) = 5.81$, $p = .020$), which enhanced spatial presence. Neither the main effect of animations nor the interaction condition reached significance (F's < 1). For involvement, no effect was substantial (all F's < 1). Finally, self-movement had a significant increasing effect on realness ($F(1, 48) = 4.21$, $p = .046$). Additionally, there was borderline significance for animations ($F(1, 48) = 2.94$, $p = .093$). The interaction was not significant ($F < 1$). Means and standard deviations are given in table 1.

4.5 Discussion

The effects of self-movement as a basic possibility to interact with the VE were as predicted: it had an increasing effect on spatial presence. Furthermore, it increased judgments of realness. These results imply that the possibility to move oneself freely through a virtual space increases the sense of being in this space and acting in it, as well as the sense that this space is real. There was no effect of self-movement on involvement. It

Table 1. *Effects of Animations and Kind of Movement on the Three Presence Components (Means and Standard Deviations) in Study 2*

		Presence Component		
Animations	Movement	Spatial Presence	Involvement	Realness
No Animations	Self-movement	3.80 (1.06)	3.32 (1.36)	2.64 (1.51)
	Prerecorded Path	2.92 (1.16)	3.38 (1.42)	1.86 (1.15)
Moving	Self-movement	3.74 (1.00)	3.10 (1.29)	3.45 (1.19)
Characters	Prerecorded Path	3.20 (.97)	3.38 (1.24)	2.50 (2.04)

might be argued that watching a recorded sequence with an HMD, which significantly reduces stimuli from the real world, can be as absorbing as moving in the space at one's own pace. These results both replicate and extend earlier findings from Hendrix and Barfield (1996) and Welch et al. (1996). They found increased presence after allowing participants to manipulate their own viewpoint, either by head tracking, or by steering a virtual car. However, these comparisons were made within subjects and did not distinguish between multiple components of presence. The present findings show that the results do not hinge on experimenter demand effects, and that earlier results cannot be explained as artifacts created by participants who are aware of the researchers' hypothesis. Furthermore, the results show that self-movement first and foremost affects the spatial component of the presence experience.

The effects of the presented animations were not as expected. It had no effects on spatial presence and involvement, and only a weak effect on judgments of realness. Our explanation for this result is that the virtual characters were not seen as possibilities for interaction. We had originally hoped that their mere presence in the same space would invite our participants to try whether they could interact with them (for instance by moving towards them). But apparently this did not happen. This speculation was supported by informal interviews with the participants; they told us that they did not pay a lot of attention to the characters. This might be the case because the characters were not that convincing (shoes) or because they did not cross their way and were not important for their task of counting the plates.

From this perspective, it does not seem surprising that the characters had no impact on presence. As stated previously, possibilities to interact, be it objects or characters, can enhance presence only when they are indeed understood as such possibilities. Although we planned the characters to look like such interaction possibilities, we (and they) failed to communicate this to the subjects. This led us to the idea for study 3: if the mental representation of interaction possibilities itself is the decisive variable, then an illusory interaction could be sufficient to increase presence.

5 Study 3

5.1 Overview

In study 3, our goal was to test whether the mere instruction that virtual characters would interact with the user of a VE would increase his or her spatial presence in the VE. Therefore, we conducted an experiment with two experimental conditions. In one condition, we told the participants that they could interact with virtual characters and that these would react to them, and in the other condition we told the participants that they would see characters, but that these would not react to their actions.

5.2 Participants

Originally, 32 students (university and high school) were recruited for the experiment. Some male high school students, however, had difficulties following the experimental instructions and using the HMD. Following the same criteria as in study 2, we excluded six

Table 2. *Effects of Illusory Interaction on the Presence Components (Means and Standard Deviations) in Study 3*

	Presence Component		
Interaction	Spatial Presence	Involvement	Realness
No interaction	3.33 (.98)	3.24 (1.21)	2.09 (1.36)
Illusory interaction	4.00 (.75)	3.74 (1.03)	2.75 (1.55)

participants because they either had not noticed the characters, or because they indicated that they were not able to move themselves on their own will. Of the remaining 26 participants, 22 were female; age ranged from 15 to 41 (m = 24.6, s.d. = 5.37).

5.3 Procedure and Materials

For this purpose, we used the same VE and technological setup as in study 2. All participants could move freely through the VE (self-movement), and all participants saw the animated characters walk out of doors, cross the office floor, and disappear in other doors. Again, no characters came into the circle in which the participants could move themselves. The introduction to the technology and the task to be performed by the participants (again, counting plates) was provided on paper. On this paper, participants were also told that other characters would be with them in the VE, and, depending on the experimental condition, that these would either react to their actions or they would not. This information was casually repeated by the experimenter while the participants put on the HMD. Participants were randomly assigned to conditions. After 5 min., the participants were interrupted and given the presence questionnaire, which was identical to that used in study 2. After answering the questionnaire, participants were debriefed, thanked, and dismissed.

5.4 Results

Cronbach's alphas equaled 0.80, 0.82, and 0.70 for spatial presence, involvement, and realness, respectively. The three scores were subjected to *t*-tests. Because we had specific hypotheses on both theoretical grounds and the previous studies, we report here one-tailed test probabilities. Only for spatial presence, was there a significant effect of the experimental manipulation ($t(24) = 1.19$, $p = .038$). Neither for involvement ($t(24) = 1.09$, $p = 0.14$) nor for realness ($t(24) = 1.14$, $p = 0.13$) did the effect reach significance. Means and standard deviations are given in table 2.

5.5 Discussion

In contrast to study 2, in which we manipulated the actual possibilities to interact with the VE (self-movement), in study 3 we merely influenced the participants' mental representation of possible interactions with virtual characters. One group of participants was told that the characters would react to their own movements, and another group of participants was told that the characters would not be responsive. In fact, the characters responded to neither group, they moved always in the same way. The conditions differed only in the instructions given, but the results suggest that the anticipation of possible interactions increased the spatial presence in the environment that was shared with the characters. Neither the participants' involvement nor how real they judged the environment to be was influenced to the same extent, although the means differed in the same direction.

We think that this result is important because it demonstrates that it matters how the users understand and construct the virtual environment. Presence is a subjective experience, an outcome of cognitive processes like perception and categorization of environmental features in terms of possible actions. Considering the well-known distinction between immersion (the objective features of the used hardware and software) and presence (the subjective experience, cf. Slater (1999)), this result reminds us that, between the two sides, cognition works as the mediating bridge and that objective qualities of VEs have their impact only through this mediator. There is no one-to-one relation between immersion and presence, and stable personality variables are not the only moderators of their relation. Instead, it matters what the users expect of the environment, and what they have in mind in terms of anticipations, goals, and experiences. These variables influence how they mentally construct the environment in terms of possible actions in it, and therefore these variables influence the sense of presence.

6 General Discussion

Spatial presence, the sense of being in a virtual environment, was hypothesized to depend on perceived and experienced possibilities to interact with the VE. The general hypothesis of the present research was that perceived possibilities to interact with a VE increases first and foremost spatial presence, and to a lesser extent or not at all experienced involvement in the VE and judged realness of the VE. In one correlative and two experimental studies, we found evidence that supported this expectation. In the correlative study, self-reports of the amount of possible interactions in a VE correlated with spatial presence, but not with the other two components. In the first experimental study, the possibility to interact with the VE increased spatial presence and also the judged realness. In this study, the possibility to interact with the VE was a very fundamental one, namely the possibility to move oneself freely through the VE, as opposed to seeing a film-like sequence on the HMD. In our view, this could explain that the manipulation also had an effect on realness. In the second experimental study, the mere expectation that artificial characters in the VE could be interacted with increased spatial presence, but not the other two presence components.

Designers of virtual environments who aim at creating a high sense of presence, be it in games or in architectural simulations (Regenbrecht, 1999), can conclude from these results that, to create high spatial presence, they must allow the users to choose their own point of view in the VE and to navigate their virtual body, give them possibilities to interact with objects in the VE, and enact simple interactions with virtual characters or other real users. However, it should be noted that what counts are the users' representations of these interactions, not their objective availability per se. So, if the interaction technique for moving the body is not understood, or, in the terms of our cognitive model, if it is not represented as an action performed with the own body located in the VE, then it will have no effects. The flip side of this coin is that the mere pretense of an interaction possibility, when it is believed by the users, will likely enhance spatial presence, as it did in study 3. An interesting question resulting from these conclusions is how to suggest interaction possibilities, if not by explicit instructions as we gave them in study 3. One possibility might be to give the user simple interaction possibilities within the VE and let them believe that they can be applied to other objects as well, and that they also generalize to other situations or environments. In fact, it might be the default that users expect an interaction technique that was successful in the past to be successful in other situations as well.

In study 2, we also observed an effect of self-movement on judged realness of the VE. We interpret this result as implying that there are basic interactions which, when they are missing, reduce not only spatial presence but also judged realness of the VE. This could be important for applications that require a high judged realness. Although we have so far no empirical evidence for this, we suspect that this could be the case for instance for training applications, and for virtual reality treatment of phobias (Regenbrecht et al., 1998; Rothbaum & Hodges, 1999). Both rely on a transfer of learning from the virtual to the real world, and we think that this is facilitated by a high judged realness of the VE.

The computer game *Riven* creates its high sense of presence not with a high-end, real-time graphics engine, but by offering plenty of simple interactions, which range from opening doors to operating machinery, to girls and funny marine creatures running away from the player. The players are transported into this world because they see that their actions have consequences. Suddenly, the discrete pictures become a sequence of perspectives on a world one is in. The simplicity of this effect should remind us that presence is not something that is created inside a multiprocessor "reality engine," but inside the perceiver's mind.

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