J. A. Waterworth
John.Waterworth@interactiveinstitute.se

E. L. Waterworth
Interactive Institute
Tools for Creativity Studio
Tvistevägen 47
Box 7964,
SE-907 19 Umeå, SWEDEN

Being and Time: Judged Presence and Duration as a Function of Media Form

Abstract

We briefly describe a novel immersive environment—the interactive tent—and an artistic production within it, the Illusion of Being. In this production, immersants experience a vivid cycle of the elements in a way that depends on their bodily movements. This elemental "story" has four versions in all, with each created to have differential effects on sense of presence and of subjective duration, according to a theoretical model. The model proposes three orthogonal dimensions of experience: *focus,* the level of abstraction; *locus,* real versus virtual; and *sensus,* the overall level of attention of the observer. An experiment, conducted to assess the effects of the different versions, is reported. The results confirmed the model's prediction that rated presence is relatively high when experienced media is of a form that elicits predominantly concrete (perceptual) processing, and relatively low when the emphasis is on more-abstract (conceptual) processing. But the concrete-abstract dimension had no direct effect on judged duration, contrary to our predictions. However, some evidence suggests that judged presence and estimated duration were positively correlated for media categorized as virtual, but not for content captured from the real world.

1 Introduction: Virtuality and the Three Dimensions of Experience

At the Tools for Creativity Studio, part of the Swedish Interactive Institute, we work at the borders between art, technology, media production, interaction design, and science. Our method includes the creation of working prototypes that illustrate, and can be used to test, theories of how people relate to, and are changed by, technological innovations and new media productions.

We often use standard experimental techniques—carefully controlled conditions, manipulation of independent variables of interest, measurement of changes in relevant dependent variables—to test hypotheses that predict how some aspect of new technology will affect mental experience and behavior. But we also create media productions that exemplify theories of human-IT interaction and test these using a different model of research that is more common in the world of art and the media: Does the production "work"? Are people moved and changed by it? Do they laugh, cry, and gasp? Does it affect them as we predict it will?

We are currently experimenting at the studio—using both research models just outlined—with the factors that determine the nature of subjective experi-

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ences in virtual and mixed reality environments. Sense of presence and the subjective experience of duration are of particular interest, because changes in these subjective factors have often been associated with powerful artistic (and, interestingly, religious) experiences. Such changes are also a feature of interacting with recent information technology, for a wide variety of purposes including education, psychotherapy, social interaction, and teleoperation.

Our current approach to these two factors is based on a three-dimensional model of experience, comprising *locus, focus,* and *sensus* (Waterworth & Waterworth, 2001).

Locus captures the extent to which the observer is attending to the real world or to a virtual model.

Focus describes the nature of the user's attention, specifically whether they are attending mostly to currently present stimuli (from the real or a virtual world), in which case we hypothesize that they will experience a high degree of presence, or are attending mostly to internally accessed information that is not currently realized in the real or virtual environment. The former can be characterized as mostly perceptual (or concrete) processing, the latter as mostly conceptual (or abstract) processing. We refer to this latter, more reflective state of mind as *absence*, corresponding to a low level of presence, and suggest that position on the focus dimension determines the degree of experienced presence.

Finally, the *sensus* dimension refers to the level of attentional arousal of the observer and ranges from alertly awake to totally unconscious. (See Figure 1.) Waterworth and Waterworth (2001) outlined the model and its potential application in detail. Principally, the model provides a conceptual design space in which potential and actual interactive applications may be placed, as an aid to both design and evaluation.

According to our model, if the balance of mental activity is weighted towards attending closely to the external world (real or virtual) with which the individual is interacting (a low level of abstraction of information), the individual will tend to feel relatively present in that world. If, however, the balance is more towards attending to the internal world of thoughts, images, and so on (a relatively high level of abstraction), the individual will not feel as present in the surrounding world. As examples, reading a book involves attending to an internal world, because the description is in abstract symbols that must be realized in the head of the reader, and so will produce a low level of presence, whereas watching an action movie mostly involves attending to a displayed external world, and so will tend to produce a higher level of presence. Similarly, difficult downhill skiing will yield high-level presence because of the need to attend to the external world closely, and thinking about the day ahead while habitually driving to work will tend to result in a low level of presence because little attention will be paid to the surrounding world.

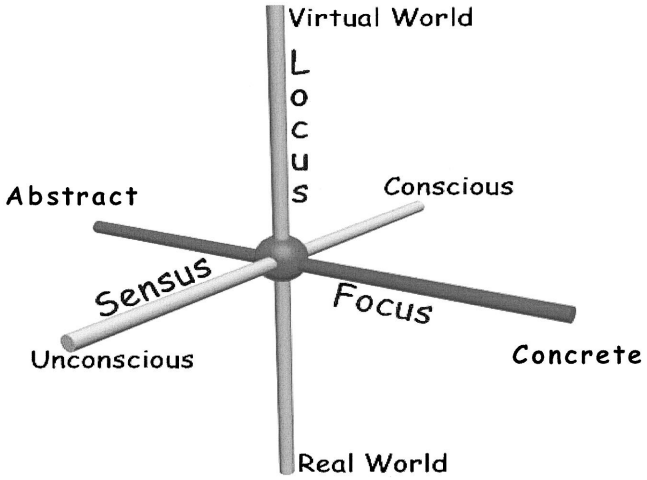

Figure 1. *The three dimensions of experience.*

Whether the surrounding world is real or virtual does not, by our account, affect the experience of presence; focus and locus are hypothesized to be orthogonal dimensions of being. The factors that stimulate sense of presence in the real world specify some of the ways in which a virtual world may also stimulate presence, although not necessarily the only or the most effective ways.

The model is meant to capture and reinterpret several currently widespread formulations of the factors underlying presence, such as attention level (Stappers, Flach, & Voorhorst, 1999), shifts in attention between the real and the virtual (Slater & Steed, 2000), immersion (Slater, Usoh, & Steed, 1994), and fidelity (Bystrom,

Barfield, & Hendrix, 1999). It will be noted that, according to our view, presence and the sense of engagement that can arise from reading a gripping novel (the suspension of disbelief) are different things. This is the aspect of our model that has attracted most criticism, and we discuss this contentious view in more detail in Section 2.

In this paper, we investigate some of the implications of our model in two ways. First, we describe an interactive artistic production, the Illusion of Being, that exercises the model, and we report on people's reactions to experiencing the production within the environment for which it was designed, the interactive tent. Secondly, we report the results of a more controlled experiment to test some of the predictions of the model, using the media materials from the production, again within the tent. Thus, we present two kinds of evidence: the first kind is based on unstructured interviews and spontaneous comments from members of the public who experienced the interactive production during public exhibitions at various events; the second kind is based on the results of an experiment conducted at the studio, during which volunteers made judgments about experienced presence and duration when exposed noninteractively to the material used in the production. Before describing the tent environment and the Illusion of Being production for it, the next section outlines the scientific and artistic context for the present research.

2 The Scientific and Artistic Context of the Work

In this section, we selectively review work—from the worlds of both science and art—that bears on our view of presence in general, and the current research in particular.

2.1 Presence as Core Consciousness

According to our model, sense of presence arises from attending to the current, external world around the individual, as opposed to the internally generated world of thoughts, images, fantasies and so on. In other words, sense of presence arises from the operation of core consciousness, as opposed to extended consciousness (Damasio, 1999). We expand on this distinction in two recent publications (Riva & Waterworth, 2003; Waterworth & Waterworth, 2003), where we present an evolutionary account of the origins and meaning of presence. In the rest of this section, we highlight a few relevant aspects of our view.

However engaging and emotionally stimulating an internally generated world may be, we suggest that this experience is not the same as the sense of presence. The rationale for this position is twofold. First, from our perspective it seems that, if all cases of emotional engagement are regarded as instances of the sense of presence, then the concept of presence loses any distinctive meaning because presence becomes synonymous with attention. Second, and more importantly, we see sense of presence as a fundamentally distinct biological phenomenon. Our view is that presence is the feeling we get when something that might affect our biological survival is happening in the present—in our here and now—and it is different from the feeling we get when we suspend disbelief. In this respect, we follow evolutionary psychology (Balling & Falk, 1982; Herzog & Smith, 1988; Kaplan, 1987) and explore how a consideration of feelings can inform psychological understanding and interaction design. (See also Waterworth, Lund, and Modjeska (2003)).

People differ from most other animals in their capacity for extended consciousness—consciousness that deals with information that relates to events beyond the here and now of the organism (Damasio, 1999). Extended consciousness developed because it gives us evolutionary advantages. However, this only applies if we can distinguish between information coming from the external world and information generated internally. A graduated sense of presence is the feeling that evolution has given us to make this distinction.

In normal individuals, current events from the surrounding external environment (perceptions) are never confused with mentally constructed events (conceptions), irrespective of how vivid or emotionally engaging the mentally created world may be. As Velmans (2000) points out, what we perceive seems to be outside us, but

what we conceive seems to be inside our heads, even though they are both the result of brain activity. Suspension of disbelief (in a mentally constructed world) is confused with presence (in an externally surrounding world) only when the organism's sensory systems are impaired or artificially "turned off." This can occur, for example, in accident-related brain damage or in sensory deprivation experiments (Humphrey, 1992). Hallucinations, which arise from the mistaken interpretation of the imagined as the real, are one manifestation of not having the feeling of presence. The other is the mistaken interpretation of the real as the imagined, when an individual refuses to accept that an event actually happened outside her imagination (Ramachandran & Blakeslee, 1998).

People divide their attention between the internal and external (real or VR) worlds, and the balance of this division is their position on the focus dimension of our model. Presence and suspended disbelief feel different, and only the former produces an "illusion of nonmediation" (Lombard & Ditton, 1997). Suspended disbelief is to presence as fantasizing about sex is to actually taking part.

2.2 Presence and Time

How does presence relate to experienced duration? An intense sense of presence is sometimes accompanied by distortions in judged duration. For example, changes in the experience of time are often reported in exceptional circumstances: extreme physical danger, as a result of taking psychotrophic drugs, during religious experiences, and—suggestively—while immersed in some interactive artworks. (See subsection 2.3.) A common feature of most of these situations may be an emphasis on intense perceptual processing of incoming stimuli, with a corresponding reduction in attention to internally generated information.

Waterworth (1984, 1985) suggested that subjective duration reflects the level of ongoing activity in working memory, which is one of the features of extended consciousness (Damasio, 1999). Working memory is often portrayed as the "active scratchpad" of mental life (Baars, 1988; Baddeley, 1986, 1992; Hitch & Baddeley, 1976), and it is here that the internal world we are currently experiencing is held for inspection by consciousness. Waterworth (1984) suggested that the balance of attention between the external world and the internal world held in working memory determines how the duration of an interval is experienced. More specifically, when tasks demand a high level of active information processing in working memory, this tends to yield relatively short-duration experiences, as compared to an interval of the same clock duration for which the task-driven processing load in working memory was relatively light. Working memory load will be high when we are solving a difficult mental problem, or imagining a detailed vivid scene, or engaged in interesting conversation, for example. It will be relatively low when we are attending closely to the external world, such as when dealing with a sudden, potentially serious, situation while driving.

2.3 Interactive Environments and Artistic Productions

A great many artists have experimented with the potential of interactive environments to expand the vocabulary of possible expression, and several technologists coming, as it were, from the other direction, have developed applications that are more concerned with self-expression and communication than with the traditional task-related focus. It is ironic that, as the interactive technology for what might be called truly perceptual art has become available, many—but not all—artists have moved towards the conceptual. The point of much modern art seems not to be the experience, but the idea. However, the field of interactive art is huge, and the following is a highly selective review covering a few examples that are particularly relevant to our work.

One influential strand is to mix the real and the virtual in so-called mixed reality environments, often using augmented reality glasses to superimpose virtual objects on the real world. For example, Murakami (2001) developed a system in which up to four participants can sit in a group and exchange virtual dolphins that seem to swim on and between handheld paddles. Another approach is to use video projection to include virtual ob-

jects in real-world installations. Tosa (1999), for example, projects avatars of a mermaid and merman into a bucket of water in which an interacting, human couple have dangled their hands. She uses heart rate and heart rate variability to control the behaviors of the relevant avatars, ostensibly as a way to help couples communicate their feelings. But this is more an art piece than anything else. The Japanese water theme is also exemplified by Sugihari's work with "water domes" (Sugihari & Tachi, 2000) and other enclosing fluid structures onto which virtual material can be projected from the outside. Her work has some resonance with the development of the interactive tent, to be described in Section 3.

Satoko Moroi and Shinji Sasada (Moroi, 2001) also use a water bath, this time to allow participants to play with words—literally. Voice recognition technology is used to generate candidate text streams from participants, displayed as 3D graphic letters that "drip" out with water drops that gradually fill the bath. The letters of the words float around, under partial control of an electromagnetic "wand" held by each of the players. The piece is intended to be fun rather than useful. Text Rain by Utterback and Achituv (1999) is a similarly playful text-and-water piece.

Biotica (Brown, 1999) represents another strand of interactive art, by using participants' interactions partially to control the development of artificial life forms within an environment that could also been seen as a form of mixed reality.

The interactive artworks of Char Davies (2003), Ephémère and especially Osmose, have exerted a strong influence on our thinking about the potential of interactive environments to affect experience in profound ways. In Osmose, immersants wear a head-mounted display and a body vest that measures chest expansion and the orientation of the spine. Immersants navigate in a compelling set of interlinked 3D virtual spaces using only breath and balance. This embodied style of interaction, combined with graphics that evoke the beauty of nature, coax immersants into a contemplative state of mind and many report a deeply moving experience. Based on our own experience of the environment, our interpretation is that Osmose evokes an extraordinary sense of presence. It has also been reported that Osmose alters the sense of time passing for many immersants (Char Davies, personal communication).

The rationale for many artworks is exploration of the relationship between the participant and the way information is presented and, increasingly, behaves. Although we share this rationale, our focus was rather unusual, because we were interested in creating an artistic installation based on a particular psychological model of the effects of interacting with information in different forms.

3 The Interactive Tent and the Illusion of Being

In this section, we firstly describe the tent, the interactive environment we used for this work, and then outline the Illusion of Being, an artistic production for that specific environment. This is followed in Section 4 by an account of the reactions of members of the public who have experienced the illusion in a variety of exhibition locations between February 2001 and September 2002. In Section 5, we go on to describe an experiment conducted at the studio, and during which volunteers were exposed to the media materials of the illusion under more controlled conditions.

3.1 The Interactive Tent

The tent is a testbed for experimenting with the nature and possibilities of experience in virtual environments. (See Figure 2.) Video images are projected onto the outside of the tent, the roof and sides of which are constructed from Plexiglas covered in professional-grade gray PVC back-projection material, and viewed from inside as an enveloping visual display. There is also a simple stereo sound system, consisting of two small speakers placed on either side of the head, and a powerful subwoofer. This set-up was found to be more effective in evoking a sense of space in the tent than commercially available surround sound systems. One design aim was to use easily available, and relatively inexpen-

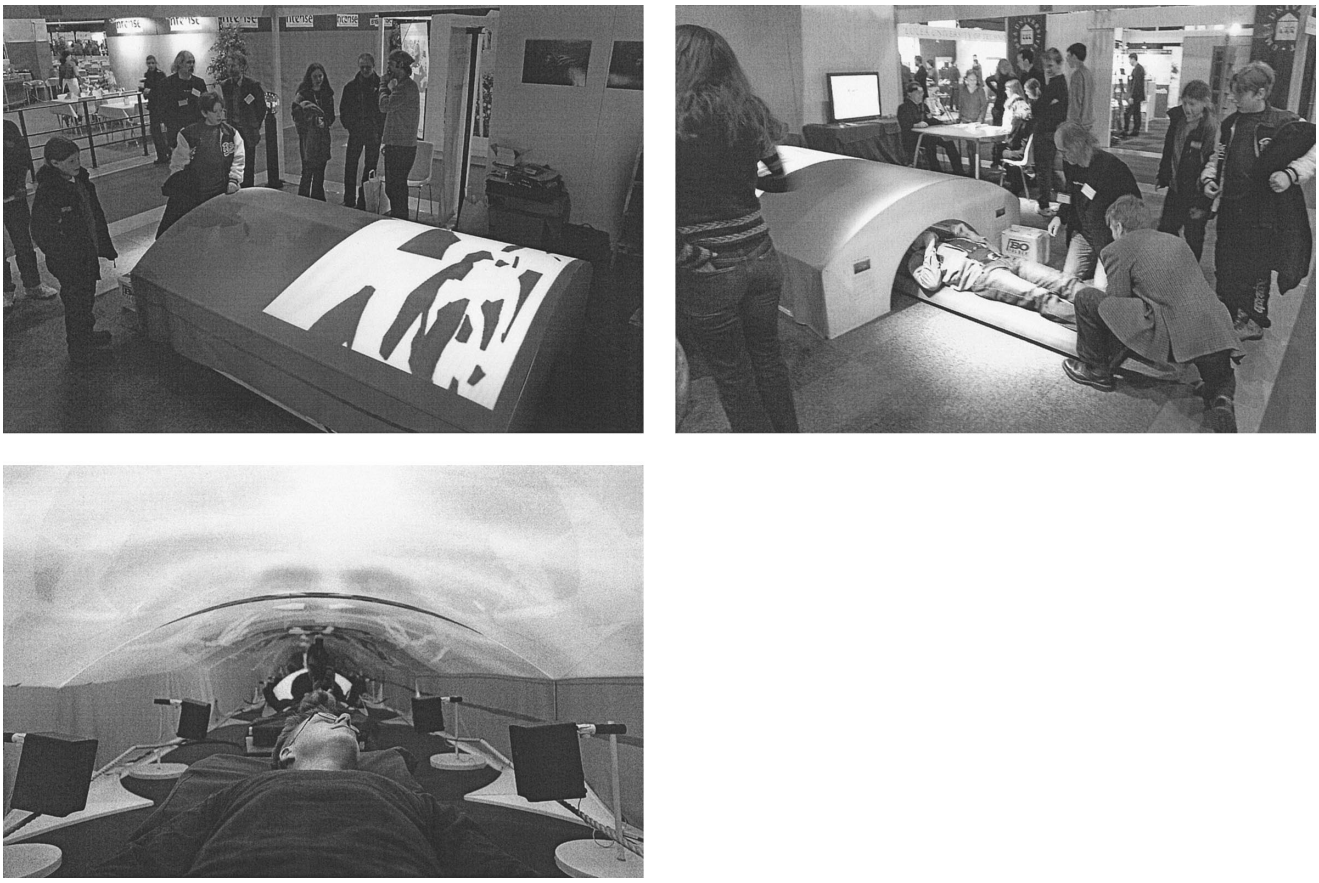

Figure 2. *An immersant is wheeled into and lies inside the interactive tent.*

sive, equipment and yet also produce vivid and engaging interactive experiences.

We can manipulate, and/or allow the immersant to control, the nature of displays: to stimulate presence or absence (focus), and vary the degree of realism—effectively moving the immersant along the real-modeled dimension (locus). Exactly how the immersant interacts with the tent is also of great importance; this can be more or less conscious and deliberate. For example, if we use depth of breathing or general posture to control the display in some particular way, this has quite a different effect on the level of consciousness needed to interact than if we use arm gestures or spoken commands (in other words, these vary on the sensus dimension). In the production to be described here, we used pressure sensors to detect head movements. The effect of varying the means of interaction is a main focus of our ongoing and planned research.

3.2 The Illusion of Being

The Illusion of Being is an artistic production for the tent, designed to allow participants to experience the three-dimensional model of experience outlined earlier, in a vivid and moving way that is poignant and thought provoking. We do this by transporting the tent immersant between states of excitement and calmness, between materials created synthetically and those captured from reality, and between forms of presentation that involve varying levels of abstraction.

In the Illusion of Being, the tent immersant is carried through a relentless cycle of four "elements": snow, fire,

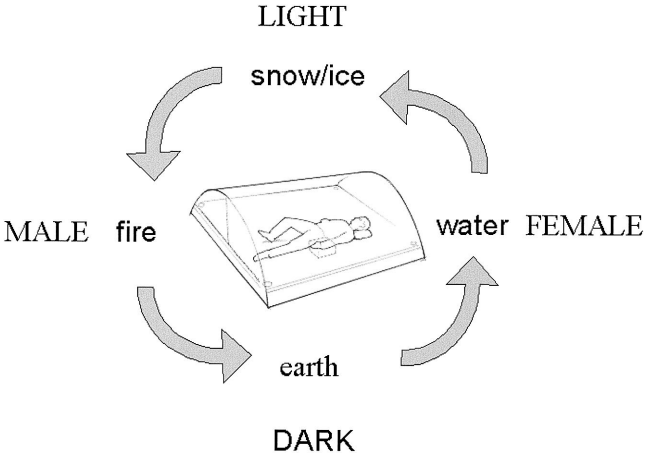

Figure 3. *Cycle of elements in the Illusion of Being.*

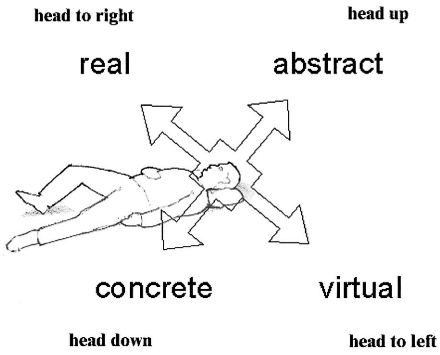

Figure 4. *Four media streams in relation to head movements in the Illusion of Being.*

earth, and water, as shown in Figure 3. The light (snow)–dark (earth) opposition symbolizes the poles of the sensus dimension of conscious-unconscious. Both extremes of white (pure consciousness) and black (pure unconsciousness) are silent and still, whereas the other poles, fire and water, are both extremely noisy and visually lively.

The other two dimensions are exercised dynamically through the behavior of the tent immersant. In its current implementation, we use pressure sensors to detect head movements. Moving the head up or down determines whether the elemental cycle is experienced in a concrete, perceptual way or in a more abstract version requiring conceptual processing (exercising the focus dimension). Moving the head to the left or right determines whether what is experienced is captured from reality or is entirely synthetic (the locus dimension). See Figure 4.

To make this possible, we have produced four versions of the same elemental "story," which run in synchrony and continuously, although the immersant experiences only one at any one moment. A shift in head position causes the presentation to change to the appropriate parallel stream: real/concrete, real/abstract, virtual/concrete, or virtual/abstract. The idea was that "attitude" (interpreted somewhat metaphorically as head position) determines our experience of being, and in particular ways. The streams are characterized as follows:

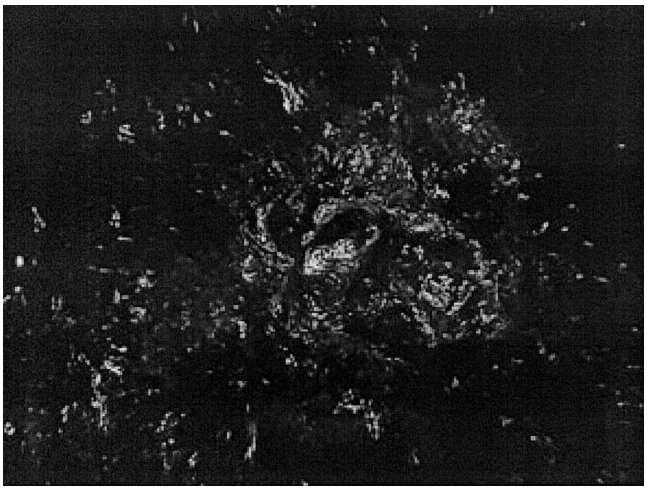

Figure 5. *Camera stream (real/concrete): filmed events with natural soundtrack.*

- *Real/concrete:* filmed events with natural soundtrack (Camera stream, Figure 5)
- *Real/abstract:* text, sketches and spoken words describing events (Words stream, Figure 6)
- *Virtual/concrete:* detailed virtual reality version, with synthesized sound effects (3D stream, Figure 7)
- *Virtual/abstract:* wireframe 3D, text labels, stylized synthetic sound effects (Wire stream, Figure 8)

Each stream tells the same story: a cycle of changes from snow/ice to fire to earth to water, and back to snow/ice. In public exhibitions, each immersant experienced the

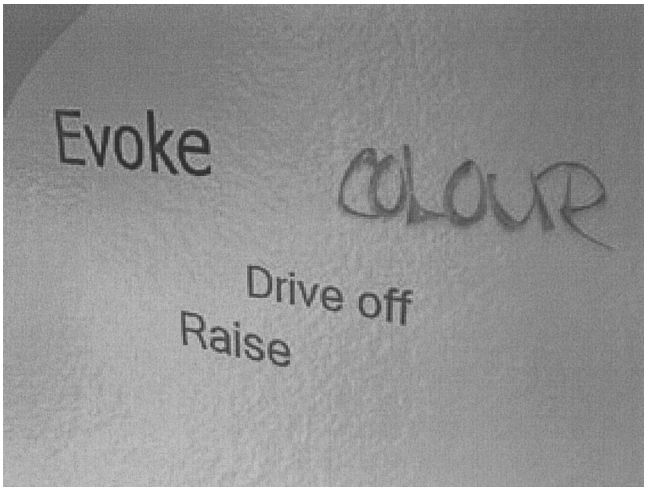

Figure 6. *Words stream (real/abstract): text, sketches, and spoken words describing events.*

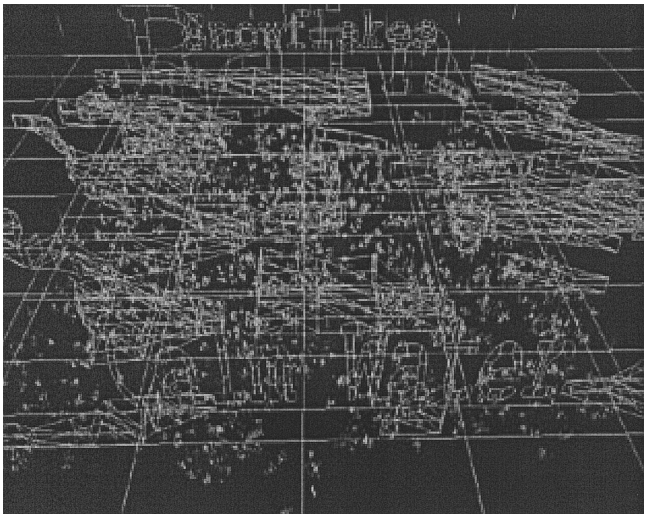

Figure 8. *Wire stream (virtual/abstract): wireframe 3D, text labels, and stylized synthetic sound.*

Figure 7. *3D stream (virtual/concrete): detailed virtual reality version, with synthesized sound.*

complete cycle twice (total time just over 7 min.). The cycle of elements is thus the same for all immersants, irrespective of which streams they follow. But the path of each participant through the cycle, in terms of the timing and identity of stream changes, depends on their head movements. In summary, the cycle of the elements is the content for all streams, and for each person's experience, but each stream has a different form and each person takes a different path through the streams.

3.3 Testing the Illusion

In the following two sections, we present two very different ways of assessing the psychological effects of the illusion. First, we report audience responses to the complete interactive experience in the tent during public exhibitions of the piece. We believe that important lessons can be learned from this "naturalistic" evaluation. Second, we report the results of a controlled experiment designed specifically to test the predictions of our model of presence and its relation to experienced duration.

4 Evaluating the Illusion on Tour

The Illusion of Being has been publicly exhibited on numerous occasions in Sweden, and once in the United States. (On this one occasion, we did not use the complete tent set-up, and did not gather audience responses.) During the exhibitions with the tent proper, several hundred members of the public have experienced the illusion. We have collected immersant responses informally during these exhibitions, as people come out of the tent, and in this section we summarize the information we collected.

4.1 Method

The Illusion of Being has been displayed at several large public exhibitions in Sweden. Our method was to allow free access to the tent, for one person at a time. We collected as many accounts as possible to try to understand how individuals experienced the illusion in the tent.

4.1.1 Respondents and Instructions. We did not inform visitors about what to expect, but discussed their experience with them afterwards if they were willing. Immersants were told to lie down on the trolley (placed in front of the tent entrance), to put their heads on the pillow (where the sensors were placed), and to relax. They were told that they could leave the tent whenever they wished. They were told that everyone's experience of the illusion is different, but the operation of the sensors was not explained beforehand.

In total, approximately four hundred visitors experienced the illusion in the tent between February 2001 and September 2002.

4.1.2 Procedure. Once the visitor was lying comfortably on the trolley, she was wheeled head first into the tent. The show was started immediately. After two complete cycles of the elemental story, lasting a little over 7 min. in total, the immersant was pulled out feet first on the trolley. Verbal responses were collected from most immersants, usually after the next visitor was in place in the tent. It should be emphasized that, although each immersant experiences the same story twice, the version of the story is unique to the individual. This is because changes between media streams are controlled by the way in which an immersant moves her head, and so are not predictable nor exactly repeated for two immersants.

4.2 Reported Experiences of the Illusion

4.2.1 General Observations. About 80% of immersants reacted favorably, as reflected by a willingness to discuss the experience at length, make suggestions for changes, modifications, or other improvements, or try it a second or third time. The remaining 20% were not particularly impressed, and a quarter of these (5% of all immersants) gave a clearly unfavorable response. The negative comments fell into a few categories: too loud (the sound), too close to the eyes (back projection surface), too low resolution (the graphics), too scary at times (the content). A small number of older people (60 plus) queried the need for such technology and suggested that it would be better to go out into nature ("unspoiled" physical reality). In all, only four people asked to come out of the tent during the show. Of these, two had a fear of water and were disturbed by the concrete/real water scenes. One thought the low-frequency sounds from the subwoofer speaker might damage her internal organs, and the other gave no specific reason. Several people expressed reservations about entering the tent, because of their tendency to feel claustrophobia. Interestingly, none of these immersants experienced distress in the tent. A commonly expressed observation was that the images on the surface, although it was very close to the face, gave a sense of space above the body.

Their unusual posture (in the context of exhibition displays) made a strong impact on many of our immersants. When entering, many displayed some anxiety about surrendering themselves to the interior of the tent. It was often likened to a brain scanner.

Few immersants realized what was triggering changes of media stream until it was explained to them afterwards. We observed that head movements were most frequent when immersants became bored, or found the material too stimulating. This pointed to the naturalness of the (unconscious) interaction; people simply turned away from what was too strong for them, or too dull. The most frequent guess about what triggered stream changes was that we were in some way measuring brain activity. A small number of immersants seemed to think we were somehow imaging their thoughts and projecting them onto the tent in a changed form.

About one in twenty reported finding the experience in some way mystical, and a few talked in terms of being transformed by the experience: of entering and re-emerging from the womb, of death and rebirth, of a religious or spiritual catharsis. Of the 65% of immersants who were very impressed by the experience, many com-

mented on the close integration of sound and vision, the tight coupling of what they could see and what they could hear into a unified, bodily experience. Perhaps the most common of the observations was that the experience was in parts relaxing, and in other parts exciting. Other very common remarks included that it was fun, new, and different. Children in the age range 10–16 seemed to enjoy it, but were not particularly surprised by it.

Many commented that lying down for the show had affected their feelings, often by making them very relaxed. But only one immersant actually fell asleep. Many thought it would be good to have something like the tent at home, over their beds, and some suggested that this would help them get new ideas.

4.2.2 The Media Streams. A particularly relevant outcome was that several tent immersants reported psychological changes depending on which media stream they were experiencing at the time. Different people preferred different streams, or were more or less intrigued by them. The abstract streams—wireframe plus labels (virtual/abstract) and text plus voices (real/abstract)—provoked the most comments, whereas the most popular sequences came from the concrete streams, especially the fire and water sequences. Most comments about the sound were aroused by the most-vivid action sequences in the concrete streams (too loud), the voices (very dispersed in space), and, less frequently, the wireframe soundtrack (confusing). A common observation was that each voice seemed to come from a different location, which surprised many people. Although we were using simple stereo with only two small speakers, one close to each ear, plus a powerful subwoofer, many immersants commented on the clearly spatial character of the sound, especially the voices. Many people thought the sound was of high quality and was very important to the effectiveness of the show. However, several found the sound effects too loud at times. In general, people were most confused by the wireframe stream, and several commented that in this stream the combined sound and vision was less realistic and hard to interpret. Some thought the sound in this stream contributed to making the visuals seem strange.

4.2.3 Experienced Duration. In terms of judgments of duration, by far the most common observation was that the show had been shorter than it actually was; people were surprised that they had been in the tent for 7 min. Because immersants experienced all four streams, but for varying lengths of time, there was no indication of whether the different streams affected duration perception differently.

4.3 Conclusions from the Shows

We have been delighted by the effect that the Illusion of Being has had on members of the public. We feel that we have succeeded in building an interesting and compelling artwork on the structure provided by the focus-locus-sensus model. Respondents' comments suggest that the model has some psychological validity.

The Illusion of Being exemplifies one aspect of our research approach, whereby we explore theoretical formulations about performance or experiences in an innovative interactive environment by creating an artistic production around the predictions of the theory. If the production is a success in artistic terms, we take this as partial validation of the theoretical and implementational approach taken. Because of the interaction driven character of the show, it is not possible to control the streams each immersant will experience, nor for how long. The other, more scientific, aspect of our research approach is exemplified next, where we test the effect of the media streams used for the illusion in a more controlled way.

5 The Experiment: Presence and Subjective Duration as a Function of Level of Abstraction of Media Contents

We have suggested (Waterworth & Waterworth, 2001, 2003) that the level of abstraction of information processed during an interval affects both the experience of duration of that interval and the experienced sense of presence. This means that an interval spent processing mostly concrete material, which requires little abstract thinking, should be experienced as having a longer du-

ration and result in a greater sense of presence than an interval filled with material that mostly requires a lot of abstract thinking for its interpretation. The experiment to be described was designed to test these claims, using the tent as an immersive environment and the four streams produced for the Illusion of Being as test materials. It should be noted that, although the environment was the same, the illusion production as a whole was not used for the experiment. Rather, we simply used portions of the media streams from the production. Unlike the illusion show, participants in the experiment could not interact with the environment. This allowed us to control which media stream they experienced and for how long.

The relation between presence and experienced duration is a contentious issue. Different researchers disagree on how presence affects the subjective experience of duration. Several researchers have suggested, contra our model, that, if the degree of experienced presence of an interval were high, then the subjective duration would tend to be short (IJsselsteijn, Bierhoff, & Slangen-de Kort, 2001; Lombard, 2000). More-informal observations from artworks such as Osmose (Davies, 2003) suggest that periods of high presence may result in less accurate time estimation than periods of lower presence.

We tested the question of whether or not the relation between presence and the experience of duration exists, with high presence yielding overestimates of duration, as suggested by Waterworth and Waterworth (2001). This is an important question, not least because, if subjective duration indicates level of presence, it could be a useful additional way of measuring presence. We chose to assess presence in the experiment with a subjective method, a simple questionnaire, and obtained verbal estimates (in minutes and seconds) of experienced duration.

5.1 Method

The experiment was conducted with individual volunteers in the tent and using the four different "media streams" produced for the Illusion of Being, as described in subsection 3.2. As already mentioned, two of the streams were designed to elicit predominantly concrete processing, and two were designed to elicit relatively more abstract processing. One of each of these pairs of streams contained real content, captured by camera and microphone, whereas the other contained virtual (3D modeled) content, as described in subsection 3.2 and illustrated in Figure 4.

5.1.1 Respondents and Instructions. Sixteen people were involved in the experiment. The respondents were all students at Umeå University who had volunteered for the experiment. Most of them had done this by answering an email that was sent to all students at the Department of Informatics. All the respondents were aged between 20 and 40, and all except one were male. This was not our choice, but it simply reflects the people who selected themselves by responding to our request.

The respondents were informed that they would be shown four sets of four media clips inside the tent and that they would be asked to estimate the duration immediately after each media clip. However, they were also asked to try to concentrate on what they experienced inside the tent during the media clips, and not make too much of an effort to keep track of elapsed time. We chose to let the subjects receive this information in advance, because it would have been impossible to keep them naïve as to the purpose of the experiment while asking them the same questions several times.

Every respondent experienced the same experimental protocol. We talked as little as possible with the subjects before and during the experiment, and all instructions were read from a manuscript to avoid giving the respondents information that could have biased the results.

5.1.2 Materials, Measures, and Procedure. The media clips had four different durations (23 sec., 50 sec., 77 sec., and 104 sec.). For each respondent, all durations were used exactly four times. The durations were mixed in a balanced way according to a Latin Square design that made it difficult for the respondents to recognize the duration of one clip to be the same as another. Immediately after each media clip, the respondents were asked to estimate the duration of the media

clip using minutes and seconds, and report this verbally when asked, from their position inside the tent.

After each stream (a set of four media clips), the respondent was brought out of the tent to complete a questionnaire, which was used to measure the presence experienced during that stream. For this we used eight questions from the Igroup Presence Questionnaire (IPQ) of Schubert, Friedmann, and Regenbrecht (2001), as shown in Appendix 1. The IPQ was chosen because the questions cover the experience of presence in a wide sense, and also because it takes the respondents' attention to the surroundings into account. The original IPQ consists of fourteen questions, but we chose to disregard some of them. One of the questions was removed because it presupposes the respondent being able to control the virtual world, which they were not in our experiment. The other five were removed because they were very similar to other questions in the questionnaire. One of the remaining questions needed some modification to apply to our experiment. This question also presupposes that the respondent is able to somehow control the virtual environment, but because the question was otherwise relevant to our experiment, we felt that it was better to modify it than to disregard it altogether.

For each volunteer, the experiment took about 45 min. and an additional 15 min. was available for informal discussions.

5.1.3 Expected Results. As mentioned earlier, two of the streams used in the experiment were designed to elicit concrete processing and the other two to elicit more abstract processing. Our hypothesis was that the concrete streams (camera and 3D, real/concrete, and virtual/concrete, respectively) would cause the respondents to feel more present than they would while experiencing the abstract streams (wire and words, virtual/abstract, and real/abstract, respectively), because, when exposed to the concrete streams, they would focus more on the things they perceived and would do less abstract thinking.

In addition to a varied sense of presence, we expected the general perception of duration to differ between the abstract and concrete streams, which differ in the level of conceptual processing they invoke, because subjective duration can be affected by "the amount of conceptual processing performed during an interval, relative to the level at which an individual habitually performs" (Waterworth, 1984, p. iii). Because of this, it is not possible to assess individual accuracy in time estimation independently of the context in which it occurs. In the experiment, we were examining how duration estimates varied according to the media we provided as context. Specifically, we predicted that the respondents would feel that time passed more quickly while experiencing the abstract streams than the concrete streams, and that variation in duration estimates from individuals would be positively correlated with changes in their presence ratings for the different streams.

5.2 Results from the Experiment

5.2.1 Media Streams and Presence. We found a highly significant statistical effect of media stream on rated presence ($F[1, 15] = 41.14$, $p < .0001$), using an additive index of presence (across all questions) for each subject (Cronbach's alpha $> .7$). Across all subjects, arithmetic mean presence ratings for 3D (virtual/concrete) and camera (real/concrete) streams were significantly higher than the ratings for the two abstract streams. The concrete camera stream gave the highest presence (arithmetic mean value 0.805), with the 3D stream just beneath it (arithmetic mean value 0.688). The wire (virtual/abstract) stream gave a rather low presence rating (arithmetic mean value -0.203), much lower than the two concrete streams, but with a higher presence rating than the words (real/abstract) stream, which gave the lowest presence rating of all (arithmetic mean value of -0.742). Apart from the differences between the two concrete streams (camera and 3D), all of the differences between means for the different streams were highly significant (Fisher's PLSD test, $p < .001$). This suggests that respondents felt much less present while experiencing the abstract streams than the concrete streams.(See Figure 9).

This is in accordance with the view that degree of experienced presence is a reflection of the competition in consciousness between concrete and abstract process-

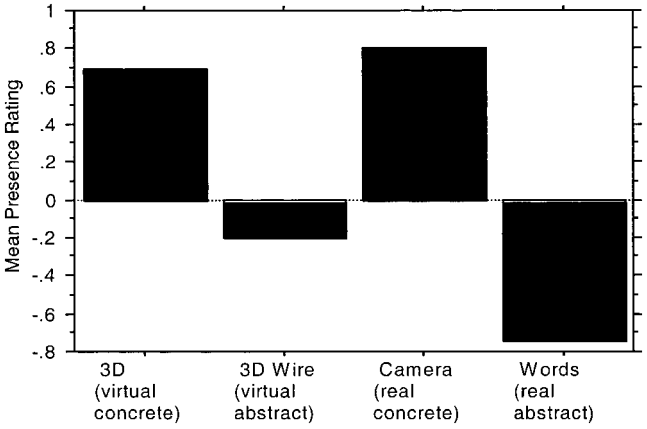

Figure 9. *Sense of presence (mean values for each stream).*

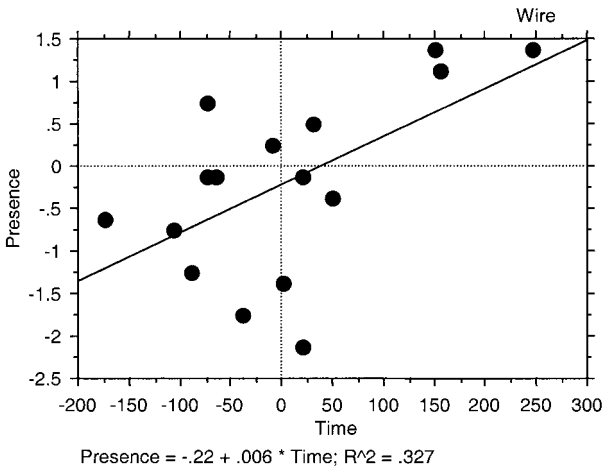

Figure 10. *Bivariate scattergram for wire stream, including regression.*

ing (Waterworth & Waterworth, 2001). In conditions designed to encourage abstract thinking, participants tended to report less presence, and in conditions designed to encourage less abstract thinking they reported a higher level of presence. (See Figure 9).

5.2.2 Media Streams and Experienced Duration. There was no main effect of media stream on estimated duration, which suggests that the abstraction level of a stream does not affect the estimated duration in the way we predicted, at least in this experimental situation where respondents were merely observing the materials presented. There was a highly significant effect of the actual duration of the intervals estimated ($F[1, 15] = 103.46$, $p < .0001$).

5.2.3 Rated Presence and Estimated Duration. We compared each respondent's perception of duration with his or her individual presence ratings. We had predicted that an individual who experienced a high level of presence would also tend to give a long estimation of duration. Figure 10 and 11 show the plots for the two virtual streams: wire (abstract) and 3D (concrete).

The plot in figure 10 shows a statistically significant ($p < .05$), but relatively weak, positive correlation for the wire stream, which was the abstract/virtual stream. The higher the presence an individual experienced while viewing this stream, the longer the duration estimate tended to be. There was also a positive correlation for the plot shown in Figure 11, the concrete/virtual 3D stream, 3D, but here the relationship was even weaker and only approached statistical significance. With the two other streams, the abstract/real words stream and the concrete/real camera stream, there was no evidence of any correlation between rated presence and judged duration.

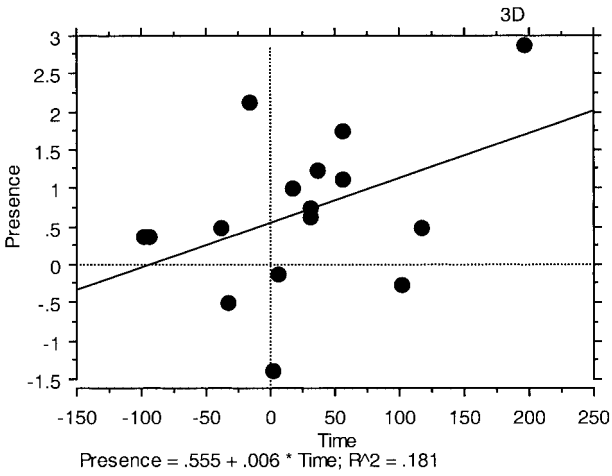

Figure 11. *Bivariate scattergram for 3D stream, including regression.*

Although the evidence is not strong given the noneffect of content on judged duration, the pattern of correlations reported here suggests that the real-virtual (locus) dimension may have an effect on the relationship between rated presence and estimated duration. Specifically, these two factors tend to be positively, although weakly, correlated with virtual content, but unrelated with real content.

Different participants produced very different presence ratings in absolute values and so the between-subjects variance was very high. On the other hand, relative to the stream that was experienced, changes in rated presence for each individual were relatively consistent. Our experimental comparisons were within-subjects, meaning that ratings of the different streams were compared for each individual, not across individuals, so that variability between individuals had no effect on our findings. Because we found a highly significant statistical main effect arising from the effect of level of abstraction on presence, we suggest that this represents a solid finding. We also suggest that the noneffect of abstraction level on duration judgments is reliable because there was a highly significant effect of actual duration on this dependent variable. In other words, we obtained duration estimates that closely reflected actual changes in interval durations, but showed no effect of abstraction level.

5.3 Conclusions from the Experiment

Our main intention with the experiment was to test the predictions of our three-dimensional model (Waterworth & Waterworth, 2001). The suggestion that presence increases with more concrete processing but decreases with more abstract processing was confirmed, emphasizing the importance of what we have called the *focus* dimension of experience. But the suggestion that duration estimates can be used as an indicator of presence was not supported. It should, however, be noted that these findings may be specific to the type of environment tested. Although we believe that our model has some generality, we are unsure about the generality of the results obtained.

There was a tendency for duration estimates to be positively correlated with rated presence, but only with content categorized as virtual. With real content, there was no correlation at all. This could be taken as weak confirmation of the validity of the locus (real-virtual) dimension of our model, because it suggests a differential relationship between aspects of the experience according to the position of media on this dimension.

There was no evidence that sense of presence and duration judgments are inversely related, as IJsselsteijn et al. (2001) and Lombard (2000) have suggested.

The overall presence ratings for different respondents indicate very different ratings after having seen the same film clips. A situation in which one individual will feel very present may create a very weak sense of presence for another individual.

In summary:

- When the abstraction level of an experience increases, the feeling of presence decreases, and vice versa.
- The sense of presence is highly subjective and individual.
- Under certain conditions, when the subjective experience of presence increases, experienced duration also increases.
- There was no evidence that presence is inversely related to experienced duration.
- Duration estimates cannot generally be used as indicators of sense of presence.

While talking to participants after the experiment, we noticed that individuals who were interested in computers and study or work with them a great deal often commented and asked about the equipment used in the experiment. They would talk about the resolution of the visual display, the quality of the sound, and such things. The individuals who were not as used to computers seemed to prefer talking about their experiences instead. This could be an indication that people with experience of VR and computers generally pay more attention to the technological surroundings than people inexperienced in this field, in line with the suggestion of Lombard and Ditton (1997).

Even though the different streams used in the experiment produced highly significant differences in the respondents' experience of presence, it might be possible

to create virtual experiences that have an even larger effect on the experience of presence. It would, for example, be interesting to see if the results of the abstract streams would be stronger if the respondents had to perform different kinds of problem solving requiring high levels of abstract processing. If the results followed the same pattern, this would make the respondent feel even less present than was the case here.

6 Discussion: Level of Media Abstraction and the Experience of Presence

The Illusion of Being is unusual as an interactive artwork, in that it was designed around the predictions of a specific psychological theory: our focus-locus-sensus model (Waterworth & Waterworth, 2001). Focus was exercised in the contrast between abstract and concrete media streams and locus in the contrast between entirely virtual media and those based on materials captured from physical reality. Sensus was less explicitly manipulated, but was suggested in the contrasts between lively and tranquil poles during the cyclical events of the story conveyed. Responses from immersants indicated that the different aspects of the work had an effect on the nature of their experience. For example, some individuals preferred the VR-like 3D sequences, and others the more realistic portrayal of natural scenes. Some were intrigued by the abstract sequences, but the majority indicated a preference for concrete media. There was also evident variation on the sensus dimension: a few immersants found some scenes too intense, whereas others remained unexcited and one fell asleep. We found reactions to the illusion encouraging, but public exhibition of an artwork does not constitute an experimental test of the model.

In the experiment, we again used the tent environment, but participants did not interact with the media. This allowed us to control which media stream was experienced and for how long. Because both kinds of evidence suggested that level of media abstraction affected the level of experienced presence, this also confirms that interaction is not essential to changes in presence, although it probably tends to enhance such changes. In the experiment, judged presence was clearly a function of the level of abstraction of the materials presented. Specifically, abstract materials yielded lower presence ratings than more concrete materials. We take our experimental results as confirmation of the validity of the focus dimension of our mode. This also implies that suspension of disbelief should be distinguished from presence because suspension of disbelief is necessary only with relatively abstract information that must be realized in the mind of the observer. We suggest that there is, in Lombard and Ditton's (1997) phrase, no "illusion of non-mediation" with abstract media that do not address the senses directly.

According to their own comments, some participants experiencing the Illusion of Being show seemed to feel extraordinarily present in the environment—more so, in fact, than in the real world. We hypothesize that this is because of the combination of bodily interaction with concrete media, combined with a sense of physical and social safety, in a personal, protected world. In the tent, we can safely afford to be more present than we normally are in the world, because in the outside world we must almost always reserve some conscious capacity for abstract reasoning about our own safety, both physical and social. We think that this tendency for "hyperpresence" is enhanced by a bodily and largely unconscious way of interacting with the media presented, an effect previously demonstrated even more strongly by Char Davies' Osmose environment (Davies, 2003).

We suggest that presence is reflected at the level of the individual organism as a feeling when concrete information is experienced, and that the strength of this feeling ensures that we do not confuse internally constructed worlds with an external world (whether real or virtual). But can we also feel a difference between the real and the virtual at the level of the organism, and, if so, is this different from focus? VR often (although not always) engenders the feeling of presence rather less effectively than, say, life-threatening events in the real world. Is there more to the obvious difference between the real and the virtual than degree of presence engendered? In other words, is locus a meaningful dimension of experience or is it reducible to focus? We suggest that locus can best be seen as a separate dimension from lo-

cus, by the following reasoning. Although it might in principle be possible to create a virtual world that is exactly equivalent to the real one and engenders the same type and level of presence, this is unlikely to be achieved in the foreseeable future, if at all. It is also possible to create synthetic worlds quite unmistakable for the real and yet which engender equal or even greater levels of presence than most experiences in the real world.

Presence is not synonymous with consciousness as a whole, but it does reflect the functioning of core consciousness, of awareness of what is happening in the here and now, the present world in which the body is immersed. Presence is the feeling that comes from interacting with concrete information offered directly to the senses and from outside the body, either from the real world or when realized for us in a virtual world. Presence is how it feels to be in a perceptual world that exists outside your imagination.

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Appendix 1. Presence Questionnaire

1.				Somehow I felt that the virtual world surrounded me.				
Fully disagree	−3	−2	−1	0	1	2	3	Fully agree
2.				I felt like I was just perceiving pictures. (*perceive = uppfatta, märka*)				
Fully disagree	−3	−2	−1	0	1	2	3	Fully agree
3.				I felt present in the virtual space. (*present = närvarande*)				
Fully disagree	−3	−2	−1	0	1	2	3	Fully agree
4.				How aware were you of the real world surrounding while experiencing the virtual world? (i.e. sounds, room temperature, other people, etc.)?				
Extremely aware	−3	−2	−1	0	1	2	3	Not aware at all
5.				I still paid attention to the real environment.				
Fully disagree	−3	−2	−1	0	1	2	3	Fully agree
6.				I was completely captivated by the virtual world. (*captivated = fängslad, förtrollad*)				
Fully disagree	−3	−2	−1	0	1	2	3	Fully agree
7.				How real did the virtual world seem to you?				
Completely real	−3	−2	−1	0	1	2	3	Not real at all
8.				The virtual world seemed more realistic than the real world.				
Fully disagree	−3	−2	−1	0	1	2	3	Fully agree