

The Cyborg's Dilemma: Embodiment in Virtual Environments

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Abstract

This paper poses the question: How does the representation of the body in virtual environments affect the mind? This article considers how virtual reality interfaces are evolving to progressively embody the user. The effect of embodiment on the sensation of physical presence, social presence, and self presence in virtual environments is discussed. The effect of avatar representation on body image and body schema distortion is also considered.

Keywords: Human-computer interaction, virtual reality, embodiment, presence, cyborgs.

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1. Time for questions about minds in virtual environments

As a young student sitting in the back of the room of a lecture hall, I remember Marshal McLuhan arguing that the most important part of science is not theory, methods, or instrumentation, but asking the right question. For McLuhan these were accompanied by "probes," a kind of intellectual flare shot into the darkness. Of course, asking the right question means not only asking an important question, but also asking the right questions for your time, place, tools, and your abilities. Otherwise, the flares burn out like Roman candles instead of burning bright like torchlights. The right question at the right time implies its answer. The right question and the answers it engenders can be more than a flare. It can

be explosive, lighting the horizon as it casts long shadows on the intellectual terrain.

For this researcher, now is a time of searching for the right questions. It's not that anyone can ever stop searching. But since January 1997, I have been watching a place called the Media Interface and Network Design Lab slowly emerge in both physical space and cyberspace. Students, colleagues, and I have been building a new human-computer interaction lab. Even as I speak at the Cognitive Technology conference in Aizu, I can hear the sound of hammers and drills thundering across the Pacific. These construction noises are the birthing cries of new places and ideas.

M.I.N.D. is an unusual acronym for a lab in a telecommunication department, a place know more for its discussions of fiber optic wiring and government connections, than neural wiring and synaptic connections. The very name suggests a core interest in questions about the interaction of telecommunication technologies and the mind. The lab exists today as a networked conversation among minds about minds.

Research at the M.I.N.D. Lab is dedicated to understanding how virtual environments interact with the minds of users and assist, amplify, adapt, or alter cognitive processes. Because technologically augmented cognition is best studied as situated cognition (Suchman, 1987), we iteratively build virtual environments as we observe users and generalize about their interaction with the interface and each other. The interaction of minds and interfaces can be situated in the context of surgical training and medical visualization, or cyberplaces like the Amazonian Carnival, a large, network social

environment to be built by an international cast of designers over the next five years.

2. Minding the body, the primordial communication medium

New media like virtual reality sometimes force us to take a closer look at what is fundamental about communication. Before paper, wires, and silicon, the primordial communication medium is the body. At the center of all communication rests the body, the fleshy gateway to the mind.

1.1 The senses as channels to the mind

The senses are the portals to the mind. Consider for a moment, the body as an information acquisition system. As aliens we would see it is an array of sensors propelled through space to scan, rub, and grab the environment. Immersive virtual reality designers tend to be implicitly or explicitly Gibsonian (Gibson, 1966, 1979). Immersive virtual environments are places where vision is meant to be active. Users make use of the affordances in the environments from which they perceive the structure of the virtual world in ways similar to manner they construct the physical world. Through motion and collisions with objects the senses pick up invariances in energy fields flowing over the body's receptors. When we walk or reach for an object in the virtual or physical world, we guide the senses in this exploration of the space in same way that a blind man stretches out a white cane to explore the space while in motion. What we know about the world is embodied, it is constructed from patterns of energy detected by the body. The body is the surface on which all energy fields impinge, on which communication and telecommunication takes form.

1.2 The body as a display device for a mind

The body is integrated with the mind as a representational system. In some ways, the body is primordial display device, a kind of internal mental simulator. The body is a representational medium for the mind. Some would say that thought is embodied or modeled by the body. Johnson and Lakoff (Johnson, 1987; Lakoff & Johnson, 1980; Lakoff, 1987) argue against a view of reasoning as manipulation of prepositional representations (the "objectives position") a tabulation and manipulation of abstract symbols. They might argue for a kind of

sensory based "image schemata" that are critical to instantiating mental transformations associated with metaphor and analogy. In a way virtual environments are objectified metaphors and analogies delivered as sensory patterns instantiating "image schemata."

In his book, *Descartes' Error*, the neuroscientist Damasio, explains how the body is used as a means of embodying thought,

"...the body as represented in the brain, may constitute the indispensable frame of reference for the neural processes that we experience as the mind; that our very organism rather than some absolute experiential reality is used as the ground of reference for the constructions we make of the world around us and for the construction of the ever-present sense of subjectivity that is part and parcel of our experiences; that our most refined thoughts and best actions, our greatest joys and deepest sorrows, use the body as a yardstick" (1994, p. xvi).

Damasio's title, *Descartes' Error*, warns against the misleading tendency to think of the body and mind, reason and emotion, as separate systems.

1.3 The body as a communication device

The body is also an expressive communication device (Benthall & Polhemus, 1975), a social semiotic vehicle for representing mental states (e.g., emotions, observations, plans, etc.) to others. The body emits information to the senses of other bodies, whether intentional or not (Ekman, 1974). Observers of the physical or mediated body read the emotional states, intentions, and personality traits by an empathic simulation of them (Zillman, 1991). The body transmits information to other bodies through a kind of affective contagion.

Thinking of the body as an information channel, a display device, or a communication device, we emerge with the metaphor of the body as a kind of simulator for the mind. But as in a simulator, the software and the hardware cannot be cleanly separated; they both contribute to the fidelity of the simulation.

2 Embodiment as the teleology of interface design

If the body is the fundamental communication hardware, a simulator for a mind, what is its relationship to media made of steel, plastic, or

silicon? Instead of pulsing blood, pulses of electrons and light animate these media. McLuhan long ago pointed out that modern communication interfaces attach themselves to the body. In the words of McLuhan, "Media are extensions of the senses."

This is a slightly different vision than the one advanced by Licklider (1960) in his famous article on "man-computer symbiosis." For him, "man-computer symbiosis" is a subclass of "man-machine systems." The human brain would be coupled to its machine equivalent:

"The hope is that, in not too many years, human brains and computing machines will be coupled very tightly, and that the resulting partnership will think as no human brain has ever thought and process data in a way not approached by the information-handling machines we know today." (1960, p. 4).

But here we see another version of Descartes' error. This coupling was of one brain to another, in a day when the computer was a giant brain. The

communication between human and machine was one of conversation. Instead of a mind communication through a body to another body, we have only two disembodied conversations, a sterile coupling of abstract symbol generators.

At the close of this century, the development of advanced computer interfaces is characterized by what we might call *progressive embodiment*. Progressive embodiment is the steadily advancing immersion and coupling of the body to advanced communication interfaces.

This pattern of progressive embodiment is most evident in the discourse, research, and development of advanced immersive virtual reality and augmented reality systems (Biocca & Delaney, 1995; Durlach & Mavor, 1995). Figure 1 displays the range of virtual reality devices and their connection to sensory channels or the motor and autonomic channels. The evolution of these devices is the evolution of the progressive coupling of sensors and display devices to the body. The vision of such a system foresees

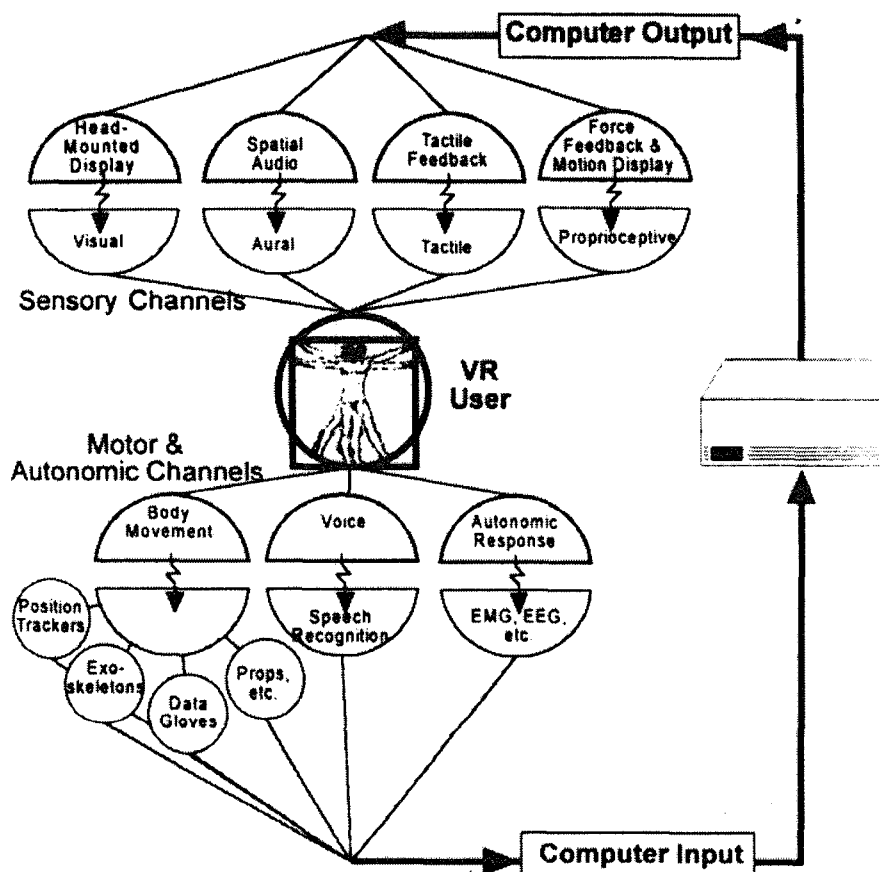


Figure 1. Range of possible input (sensors) and output (effectors) devices for a virtual reality system. Illustrates the pattern of progressive embodiment in virtual reality systems. (From Biocca & Delaney, 1995)

some applications where the body of the user is to be completely immersed in the interface, and the mind is set floating in the telecommunication system – in cyberspace. Like a body entering a sink, a bath, or a pool, communication demands and contexts will determine how much the body needs to be immersed in the electric-cool waters of cyberspace.

The teleology of human-machine symbiosis in advanced communication interfaces is towards total embodiment during key periods of information intensive communication (e.g., sensorimotor training in flight, battle, sports, etc.; certain forms of entertainment where simulations of the past places, telepresence to existing places, and the subjective experience of others is critical). There has been some temporary retreat from the aggressive pursuit of this vision because of the immaturity of the display and sensing devices. Early attempts to immerse the body in these immature technologies have led to imperfect mapping of the body to the interface. Physiological reactions of the body to this imperfect mapping has taken the form of simulation sickness (Biocca, 1992; Kennedy et al., 1992) and visuomotor adaptation (Biocca & Rolland, in press).

Virtual reality is an immature technology. But simulation technologies are developing rapidly. Figure 2 shows the classes of variables that are critical to the continued refinement of virtual environments and progressive embodiment. Looking only at the evolution of the hardware and operation systems of virtual reality interfaces, we can characterize the design of progressive embodiment by developments in the following classes of variables:

2.1 Sensory engagement

2.1.1 Number of sensory channels engaged by the virtual environment.

In this century displays for the visual and aural senses have been steadily perfected. In the last twenty five years sophisticated tactile and proprioceptive devices have been incorporated into some simulators, and in the last few years nasal displays are beginning to evolve from the crude aroma releasers of a few decades ago to more sophisticated devices. More of the senses are entering cyberspace.

2.1.2 Increasing sensory fidelity of displays for each sensory channel.

Our knowledge of the senses is being directly applied to the design of increased fidelity (e.g., Biocca &

Delaney, 1995; Durlach & Mavor, 1995). Over time the display devices will approach and exceed the full sensory capabilities of the each sensory channel. At the moment, even the most advanced displays, those for the visual channel, fall short of the full capabilities of vision (Durlach & Mavor, 1995; Kocian & Task, 1995). Display devices are evolving to be closely coupled to needs and processes of the senses.

2.1.3 Increased saturation of the sensory channels engaged by the virtual environment and suppression of sensory channels not engaged.

In an effort to fully embodied the user's mind in the virtual environment the capacity of those senses engaged by the system must be immersed in the representation of the virtual world. Saturation of a sensory channel is defined as the percentage of the channel occupied by stimuli from the virtual as opposed to the physical environment. For example, when a user looks at a typical monitor only a fraction of the visual field is occupied by stimuli from the virtual environment. But monitors are becoming progressively larger, and VR head mounted displays are moving to larger fields of view with the ambition of saturating the field-of-view of the user with the virtual environment. A similar pattern of progressive saturation is found in other sensory display systems. The bandwidth of each sensory channel is being steadily taken up by stimuli from the virtual world.

The use of display systems during communication often also includes the suppression of stimuli from the physical environment. A good example is the movie theater. Dimming the lights so that the screen (the virtual environment) is dominant diminishes visual information from the physical environment. Sound volume and social rules about making noise suppress sound from the ambient environment. Soft comfortable seats suppress awareness of the haptic channel. It is all designed to immerse the users' senses in the virtual environment of the movie screen. Communication flows to senses outside of cyberspace are decreased.

2.2 Motor engagement

The body's movement and activity is increasingly part of the interface (Biocca & Delaney, 1995; Durlach & Mavor, 1995). Historically the mapping of the body begins with the mouse, because the keyboard was primarily a symbolic input device for textual "conversation" with the computer. But

over time more of the body's motions are being captured by the interface.

2.2.1 Number of motor channels engaged by the virtual environment.

Progressive embodiment can be seen in the form of interface sensors that map the motion of the body including joysticks, head trackers, eye

immersive virtual reality systems between motor movement and sensory feedback is a significant source of simulation sickness and decrements in human performance (Held & Durlach, 1991).

The process of progressive embodiment is occurring at a time when there is increasing social integration of the interface. Social integration means that the interface is being integrated into everyday

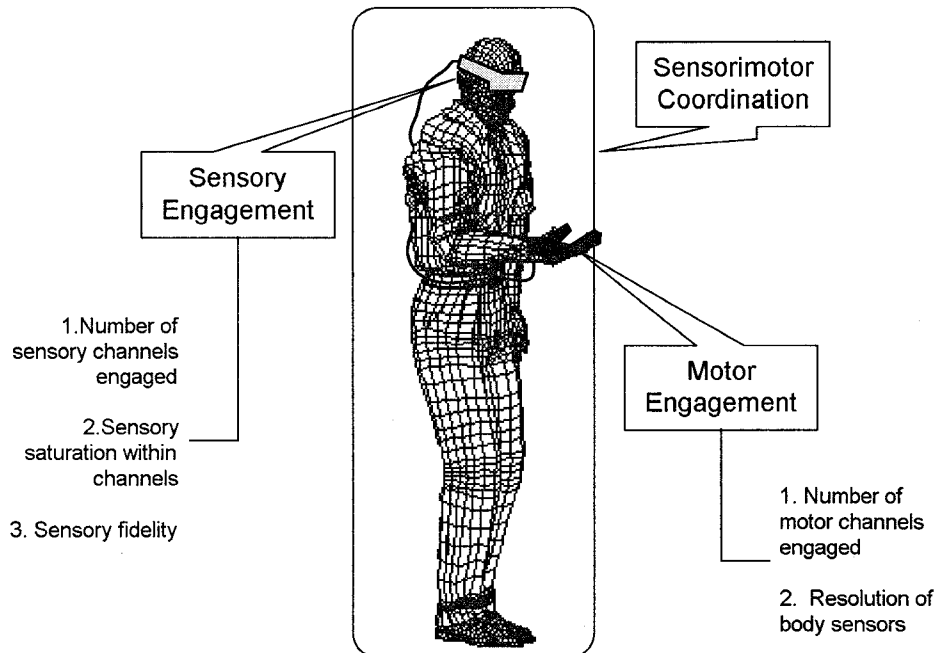


Figure 2. The users are progressively embodied in virtual environment interfaces through evolving technologies of sensory engagement, motor engagement, and sensorimotor coordination.

trackers, facial motion systems, etc.

2.2.2 Resolution of body sensors.

Sensors, like displays, are capturing finer and finer resolutions of body motion and physiological activity.

2.3 Sensorimotor Coordination

One of most important factors in defining embodiment and the senses of presence in VR systems is sensorimotor coordination. It is the essence of feedback, especially the kind of feedback we experience in our interaction with the physical environment. Sensorimotor coordination is defined as the degree to which changes in body position correlate immediately and naturally with appropriate changes in sensory feedback. The presence of lag in

activity at work, home, and on the street. Increased social integration of the sensorimotor interface into everyday communication is giving rise to longer and more contextually varied access to cyberspace. The interface enters the social sphere via easier coupling with the body through miniaturization, portability, and wearability.

3 Embodiment: Thinking through our technologically extended bodies

In most virtual environments systems, but especially in immersive virtual reality systems, progressive embodiment of the user inside the interface presents significant design challenges.

3.1 Designing of a space for bodily action

How do we create the illusion of a stable and coherent spatial environment with at least most of the sensory properties of the physical world (i.e., visual space, auditory space, tactile resistance and pressure, smell and appropriate free floating molecules, etc.) (Durlach & Mavor, 1995)

3.2 Design of other intelligent beings

The space the body enters cannot be ghost town, as many early VR worlds were. So the challenge is to create the perception of other intelligent beings. These issues are normally found under the discussion of the design of agents and avatars, and virtual humans.

The most pressing design issues are:

1. The design of body morphology.

Here the concern regarding embodiment focuses on the design of the shape of represented beings, especially the engineering of their motion (Badler, et.al. 1991).

2. Expressiveness of the body.

Here the debate over embodiment dwells on the capability of the represented being to communicate the full range of human and non-human expression. Concern often focuses on the engineering of an expressive face from the 3D geometry of avatars and agents.

3. Perceived intelligence via bodily action and expression

The only evidence we have of another being's intelligence is the motion, motor behavior, and symbolic behavior of that being. By directly controlling the motion and behavior of an avatar, a human operator provides the intelligence in real time. Baring the expressive and kinematic inadequacies of avatar embodiment, the intelligence of human embodiment is perceived very quickly. The challenge -- best expressed by Turing, but evident in the work of previous designers of automata -- is to have an agent who somehow possesses or creates the illusion of intelligence. The ambiguity of intelligence can be a source of pleasure and not necessarily a flaw in virtual environments. As Randy Walser pointed out early in the design of VR environments (Walser, 1991), part of the pleasure in VR narrative environments might come from not quite knowing when a dynamic form is either an object, an avatar, or an agent. The challenge to the

user's expectations about the correlation of morphology with intelligence might be a source of great art in virtual environments.

Clearly animation can communicate all of the above to a satisfactory - if not ideal - degree. So have we not achieved the illusion? The real challenge is not achieving these goals under controlled point of views and interactivity such as that of a third person voyeur (i.e., as in the way film and animation present us with intelligent behaviors). Nor is it experiencing second person interaction in the way some video games allow the user to experience the interaction of a puppet with other, apparently intelligent (i.e., intentional), puppets. The challenge is giving the user full first person interaction with other intelligent beings animated by a complex expressiveness.

3.3 Design of the represented body

The represented body is, of course, the avatar of the user. In immersive virtual reality systems the avatar is not the small puppet of second-person systems, those in which an iconic representation of the self is moved in a world via a mouse or joystick. In immersive VR the whole interface defines the boundaries and shape of the body by defining the boundary between inside and outside, between the part of the VR world that is "me" and the part that is "the world" (see Loomis, 1992). Both, of course, are just perceptual illusions generated on a display. For example, users readily accept the virtual hand of the immersive VR systems as their own. A part of the continuum of light, the visual illusion, is given the distal attribution of "me" and the rest "other." It is good to keep in mind that the world constructed in immersive virtual environment is all distal attribution derived from coherent patterns of the proximal stimulus impinging on the senses.

In immersive VR, more so than in any other medium before it, the representation of the user's body is a psychologically profound issue. This is especially true when the systems maps the user's body directly to a full virtual body, as when the virtual body provides feedback about the location of limbs and head in space. As I will discuss later, this is the source of most current problems in coupling of the body to the VR system.

4 User embodiment and three forms in which the body “feels” present in the virtual environment

Embodiment plays an important role in the design of virtual environments, especially collaborative virtual environments (e.g., Benford, et al., 1995). In immersive virtual environments the environment surrounds the body, often engulfing the senses, and, therefore, the mind. We sometimes speak of sound environments, architectural environments, natural environments, etc. All suggest fields of stimuli that somehow engulf one or more of the senses.

Embodiment of the user is a critical dimension of the program for intelligence augmentation that motivates the advancement of virtual reality systems (Biocca, 1996b). The phrase intelligence augmentation describes the design theory that communication technologies can be cognitive prostheses amplifying or assisting cognitive processes or by developing cognitive skills. This postulate has a long history in telecommunication and human-computer interface design. In one form of another it is an implicit or explicitly goal in the work of Vannevar Bush (1945), Douglas Englebart (1962), and Licklider (1960; Licklider & Taylor, 1968) and numerous others.

This leads us to ask of ourselves and the VR design community, if embodiment contributes to intelligence augmentation what does it mean to be embodied? In other words, what are the psychological effects of goals of embodiment in virtual environments? Most commonly the psychological effects or goals of progressive embodiment can be expressed as various forms of what is called presence.

5 The concept of presence

The concept of presence is central to theorizing about virtual reality design (Barfield et al., 1995; Lombard & Ditton, in press; Sheridan, 1992; Steuer, 1992). For example, a leading VR journal out of that bastion of engineering, MIT, enshrines the psychological goal rather than the technology by calling itself, “Presence.”

The concept of presence started as a telecommunication design goal and has evolved into an intriguing theoretical problem and philosophical issue (e.g., Biocca, 1996a; Loomis, 1992). The

concept emerges in the HCI literature first as “telepresence,” the illusion of being present in a distant location (e.g., Minsky, 1980). The word telepresence meant using sensors and effects to link the body of the user via telecommunication channels to a robotic system. The robot would move when the user moved. Sensors, such as cameras and force detection devices, would provide feedback to the user. The user would sense what the robot “senses.” In a phrase, the user would be remotely embodied in the robot. Telepresence is about the telecommunication of the body, the transmission of sensory and motor data.

According to some of the early users of the term, Akin, Minsky, Theirl and Kurtzman (1983) the conditions for telepresence would be met when:

“At the work site, the manipulators have the dexterity to allow the operator to perform normal human functions. At the control station, the operator receives sufficient quantity and quality of sensory feedback to provide a feeling of actual presence at the work site (quoted in Held & Durlach, 1992).”

From the beginning the term presence has meant the compelling perceptual sensation of being in a place other than where your physical body is located.

A dictionary definition of presence refers to a spirit inside a body or to “immediate proximity in time and space.” In telepresence, this sense of “immediate proximity” is no longer proximal, but transported using technology to a distal location that is not proximal to the physical body. Telepresence has since been generalized to a sense of transportation to any “place” created by media (Steuer, 1995). It is the illusion of “being there” whether or not “there” exists in physical space.

When you are present, the medium that took you there -- the VR system, the television set, etc. -- should disappear. At least it should disappear phenomenally. Like someone wearing a pair of glasses, you cease to be conscious of the prosthetic device that allows you to experience the environment. For Lombard & Ditton (1997) presence is the sense of non-mediation *although* a medium is being used, an acceptance of the environment represented in the medium to a point where the user ceases to be aware of the medium. This meaning, the notion of presence as a user temporarily unaware the he or she is looking at medium or representation, is much older going back at least to the 15th century work of Alberti (Alberti,

1966) on painting, and further back as well (Biocca, Levy, & Kim, 1995). Biocca, Levy & Kim refer to it as the desire for the “essential copy” and “physical transcendence.”

The concept of presence became theoretically intriguing, practical, and urgent with the arrival of immersive virtual reality (See the first volume of the journal, *Presence*). Practical design problems made issues of conceptualization and measurement critical (Held & Durlach, 1992; Sheridan, 1992; Zeltzer, 1992). It can be argued that advanced forms of virtual reality only differ from previous media in quantity and quality of presence, but the experience of

presence certainly does not suddenly emerge with the arrival of virtual reality (Biocca & Levy, 1995; Lombard & Ditton, 1997; Steuer, 1995). But with virtual reality presence becomes more of an explicit design goal.

The linking of head tracking to the head-mounted display brought the whole issue of presence to the fore. The interactivity resulting from the sensorimotor coordination of the moving head with visual displays created a sensation not found with non-headcoupled media like film and television. *Users became aware of their bodies*; their head movements altered what they saw. The world was

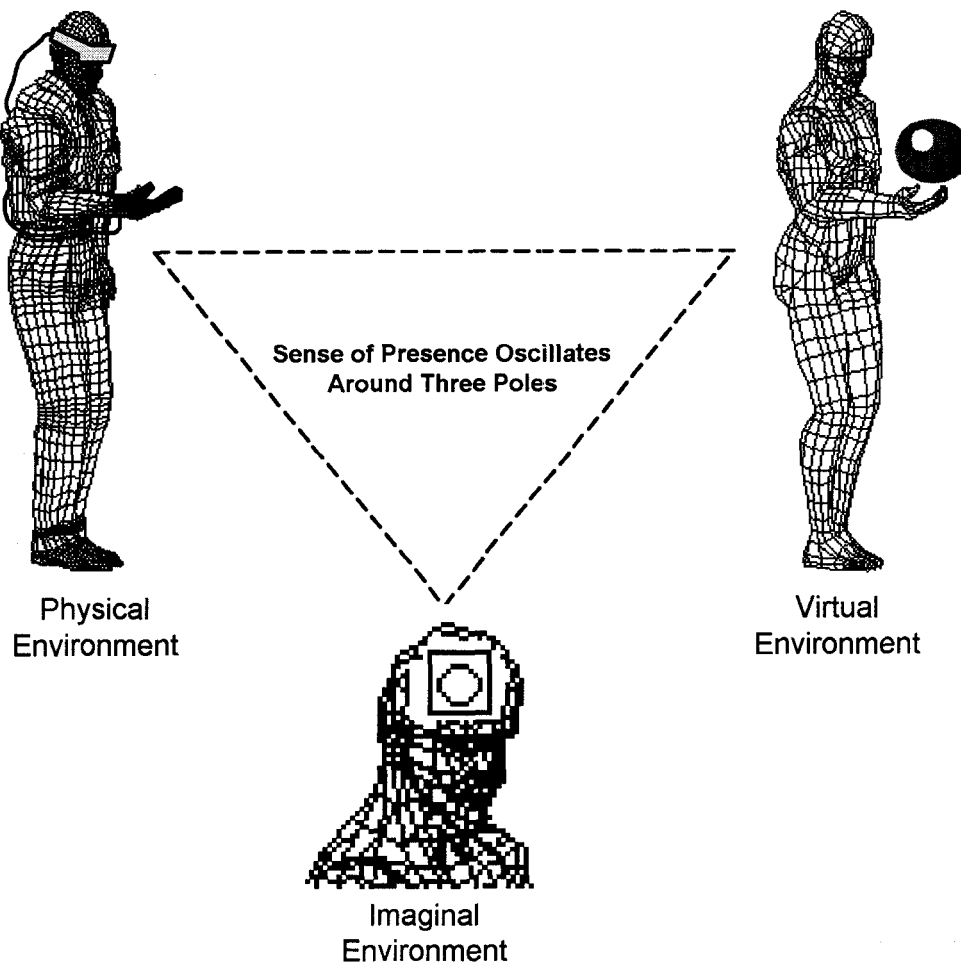


Figure 3: Users' sense of presence is not stable but labile. They variously feel present in the physical environment, virtual environment, or in the imaginal environment (e.g., dreaming, day dreaming).

now all around the user's body. With advanced virtual reality technology, presence emerged not be just a side product of advanced communication media, but an end goal.

Immersive virtual reality immediately distinguished itself from other media when user's reported a strong sense of "being there" in the virtual environment. Early user's of VR systems were struck by the compelling sensation that their body was in a different place (e.g., Rheingold, 1991). For some, the experience was powerful. They felt they were no longer in the lab, office, or entertainment floor, but "there," inside the virtual world. It was hoped that this surprising experience could be made more compelling. The pursuit of this sensation of presence is the *sine qua non* goal of many immersive virtual environments, labs and companies.

Of course, few designers seek just to create a sense of presence in the abstract. Rather designers seek a strong sense of presence in a specific place: the cockpit of a 777, the interior of a destroyed church, the inside of a tank in battle, or the surface of gold molecules.

The pursuit of presence or sense of place is rarely sought as an end in itself. The goal is always situated in some context. Designers seek presence because they are guided by an implicit or explicit theory that the sense of presence is highly correlated with learning, training transfer, attention and motivation, pleasure and other hedonic responses (Barfield et al., 1995; Lombard & Ditton, 1997).

The day-to-day design of presence has temporarily outstripped the theory of the presence. Designers know that presence is something their users experience, but don't know exactly what it is. What is presence? This is one of the important questions in VR design. Most discussions of presence thus far (e.g., Heeter, 1992, 1995; Steuer, 1992; Zeltzer, 1992) can be subsumed into the following conceptualization of three forms of presence

6 Being There: The sense of physical presence in cyberspace.

"We do not mean a place or space in which there is absolutely nothing, but only a place in which there are none of those things which we expected to find there." (Descartes)

Clearly the sense of presence was not created just for use with virtual environments. But as Loomis (1992) points out, presence is a basic state of

consciousness, it is part of the attribution of sensation to some distal stimulus, or more casually, to some environment. A topic that has traditionally been discussed by philosophers and perceptual psychologists as "externalization" and "distal attribution" is now a practical matter of virtual environment design. It has even been proposed that VR might be used to study the classic epistemological topics of consciousness (Biocca, 1996a). When we experience our everyday sense of presence in the physical world, we automatically generate a mental model of an external space from patterns of energy on the sensory organs. In virtual environments, patterns of energy that simulate the structure to those experienced in the physical environment are used to stimulate the same automatic perceptual processes that generate our stable perception of the physical world.

As Loomis (1992) points out, the mediation of virtual environments leads us to reconsider how the active body mediates our construction of the physical world:

"The perceptual world created by our senses and the nervous system is so functional a representation of the physical world that most people live out their lives without ever suspecting that contact with the physical world is mediated; moreover, the functionality of perception impedes many reflective individuals from appreciating the insights about perception that derive from philosophical inquiry. Oddly enough, the newly developing technology of teleoperator and virtual displays is having the unexpected effect of promoting such insight, for the impression of being in a remote or simulated environment experienced by the user of such systems can be so compelling as to force a user to question the assumptions that the physical and perceptual world are one and the same." (Loomis, 1992, p. 113)

Note that Loomis says that all "contact with the physical world is mediated," by which he means the primordial communication medium, the body. The default sense of "being there" is the basic state of consciousness in which the user attributes the source of the sensation to the physical environment. We have been present in this environment for so long and it is so natural, that the idea that presence might be a psychological construct is only raised by philosophers and perceptual psychologists. The experience of compelling virtual environments has disturbed this common complacency. The discussion of virtual reality and the strong sense of being there

that it generates is often accompanied by questions about the stability of our perception of the physical world (e.g., Lauria, in press). If the senses can be so easily fooled, then how can we trust the day-to-day experience of physical reality? This is the century old insight born of all illusions, especially in dreaming where we directly experience interaction of the body and the mind as the primordial simulator.

6.1 Where are you? : Oscillations in the sense of presence

The compelling sense of presence in virtual environments is unstable. At best it is fleeting. Like a voice interrupting a daydream in the imaginal environment, presence in the virtual environment can be interrupted by sensory cues from the physical environment and imperfections in the interface (Slater & Usoh, 1993; Kim & Biocca, in press).

At one point in time, users can be said to feel as if they are physically present in only one of three places (see Figure 3): the physical environment, the virtual environment, or the imaginal environment. Presence oscillates among these three poles.

6.1.1 The physical environment

Here users are attentively constructing a mental model of the physical space, responding and attending to cues in the physical non-mediated environment as the user plans and guides engagement with the natural world.

6.1.2 The virtual environment

Users are primarily constructing a mental model of the virtual space and responding to and attending to cues in the virtual mediated environment. Presence in the virtual environment can be readily engaged, but can rarely be maintained at the same level as presence in the physical environment (Kim & Biocca, in press).

6.1.3 The imaginal environment

When the user has withdrawn focal attention to incoming sensory cues and is attending to internally generated mental imagery and the user is not as responsive to sensory cues from either the physical environment or the virtual environment (i.e., daydreaming or dreaming), we can say that the user is present in the internally simulated, imaginal environment.

From a design viewpoint, physical presence is critical in applications that must involve spatial cognition, the transfer of spatial models from the

virtual environment to the physical environment, or for sensory bombardment and escape from the physical environment. Applications where physical presence is critical include architectural walkthroughs, battle simulations, engineering design, and some entertainment rides.

7 Being with another body: Designing the illusion of social presence

For many theorists, communication is essentially the connection of one intelligence with another. In this view, communication is the experience of another being. Even in telecommunication model of Shannon and Weaver (1949), where communication is an abstract relationship between two machines, the source and receiver of communication are most often interpreted as one intelligent being connected to another. In an elaborate book length attempt at a taxonomy of all present and future media, Ciampa (1989) presents all media as vain attempts to recover the immediacy of face-to-face communication.

It is against this background that the concept of social presence first emerged. If mediated communication is an inadequate substitute for face-to-face communication, then to what degree does a medium simulate the presence of another? Or to what degree does a user feel the social presence of another. There are two practical design problems that have always been there in the design of media:

- 1) Transporting and displaying patterns energy (e.g., light of video, the sound energy of a telephone) to generate the illusion of another (e.g., puppets, pictures, and avatars).

This is the perennial quest of telecommunication, the transportation of the senses. How can we use telecommunication technology to collapse space and storage devices to collapse time so that communication between two distant human beings is possible? At present, further advancement of this long standing design goal takes the form of the design of social virtual environments populated by avatars who display the real time transmission of some of the body's communication cues (e.g., morphology, motion, sound, and physical force).

- 2) Creating an artificial other (robots and animals).

This is the age old, God-overthrowing dream of human creativity, (i.e., robotic, artificial intelligence, etc.), the desire to create a device that can mimic the

morphology, motion, and communication behaviors of intelligent sentient beings (i.e., humans, animals, etc.) or serve their creators in the performance of menial tasks (Sheehan & Sosna, 1991). In virtual environments this social presence is the social presence created by agents.

On the surface the goal of social presence seems simple enough. But the design of truly interactive social presence is horrendously complex. The symbol of this challenge is the Turing test, even though it requires little embodiment -- the computer only types. A convincing, fully articulated being is more challenging. On the other hand, if convincing morphology is present, less intelligence may be required to fool the user into believing that a human intelligence is "present." Users may be fooled by convincing morphology and believe an agent is an avatar.

In past research it has been useful to consider what aspects of social presence are supported in media such as the telephone or email systems (Short, Williams, & Christie, 1976; Rice, 1993). Researchers in this tradition have listed social cues and semiotic devices that are present or absent in a particular technology. The emphasis has been on the consequences of the absence of such cues on comprehension, collaboration, and other forms social interaction. Discussion focused on whether the glass of social presence was half-full or half-empty.

But if we dig a little deeper, we find that social presence may be a little more complicated and interesting than this initial discussion. The perception of social presence might be defined as:

The minimum level of social presence occurs when users feel that a form, behavior, or sensory experience indicates the presence of another intelligence. The amount of social presence is the degree to which a user feels access to the intelligence, intentions, and sensory impressions of another.

How does this definition help? As Husserl (1973) pointed out, we have phenomenal access to our intelligence, intentions, and sensory impressions. The perception of the other is the empathetic simulation of internal states of another "if we were there in space" based on bodily motions and cues. It occurs so easily that we fail to see the artifice of it all. A few, like severe autistics, cannot do it all. Others overdo it when they anthropomorphize animals, the sun, plants, and other physical phenomena. It is not surprising when recent research reminds us that we tend to anthropomorphize computers and treat them

as "social actors" (Reeves & Nass, 1996). So social presence is a simulation run in the body and mind of the perceiver of the internal experience of a moving, expressive body. It is a simulation because the simulation occurs whether or not the moving object has intelligence or intentionality. The definition above suggests that social presence applies to the mediated experience of all forms of "intelligence." This perceived intelligence might be another human, a non-human intelligence such as an animal, a form of artificial intelligence, an imagined alien or a god.

The definition also suggests that although mediated social presence should be measured against the yardstick of face-to-face communication between two human beings, it may be possible to develop a medium in which one feels *greater* "access to the intelligence, intentions, and sensory impressions of another" than is possible in the most intimate face-to-face communication. One aspect of what might be called *hyperpresence* (Biocca, 1997) may be possible in the social presence domain as well.

Of course, it is hard for us now to imagine a medium that can create greater intimacy than face-to-face communication. But this misses the point of social presence and the very artifice of the body itself. In face-to-face communication the body is used to communicate one's sensory experiences, observation, and inner states to another. The body is the medium for this transfer. Communication codes such as spoken language and non-verbal codes such as facial expression, posture, touch, and motion are used. But, for example, inner states might be communicated more vividly through the use of sensors that can amplify subtle physiological or non-verbal cues. These can augment the intentional and unintentional cues used in interpersonal communication to assess the emotional states and intentions of others.

8 Is this body really "me"? Self presence, body schema, self-consciousness, and identity

When the user's body enters the virtual world and inhabits an avatar, a number of changes in self-presence are possible. Self-presence is defined as the effect of virtual environment on the perception of ones body (i.e., body schema or body image), physiological states, emotional states, perceived traits, and identity. To use a phrase, self-presence refers the effect of the sensory environment on

mental models of the self, especially when that model of the self is foregrounded or made salient. As with other forms of presence, designers share the assumption that increases in self-presence are correlated with higher levels of cognitive performance, and, possibly, emotional development. In the words of Socrates, the goal to “know thyself” is a worthy journey. It may be the only journey.

Questions of identity formation and self-consciousness are very broad issues pertaining to the formation of the individual. Most processes are by no means unique to virtual environments. Though the interaction with computers raises some interesting questions in this domain (e.g., Turkle, 1985). So in assessing the role of virtual environments in influencing self-presence, we should concentrate on those aspects of the environment that are radically different from the physical world.

Two issues emerge as most pertinent to virtual environments as opposed to physical environments. Both pertain to the effect of progressive embodiment, that is the embodiment of the user’s body via close coupling to the interface and representations of coupled body via first person avatar geometry and behavior.

8.1 Embodiment in an avatar and the effects of mental model of self

When the user is embodied in an avatar two things are occurring:

- the mental model of the user’s body (body schema or body image) may be influenced by the mapping of the physical body to the geometry and topology of the virtual body,
- The virtual body may have a different social meaning (i.e., social role) than the user’s body.

The latter, the social meaning of the avatar, is situationally or environmentally dependent. For example, a “cowboy” avatar will have different social meaning in historic “wild west” environment, a “New York Bar” environment, or inside a pickup truck in contemporary southern rural environment. The social role of avatar body is partially determined, but not defined, by its geometry and kinematics. Implicit and explicit social norms that may be partially idiosyncratic to the virtual environment and imported from the user’s social environment finalize the social-semiotic role and identity of the avatar. Issues of class, gender, occupational role, body type, etc. are raised when considering this aspect of embodiment. The social meaning of body morphology and social role and its effect of the self-

schema is a rich area. But most aspects of it (i.e. stereotyping) are not particularly unique to virtual environments, and only partially in the control of designers. I will not pursue it further here.

Rather I will pursue a topic more unique to virtual environments. The interaction of the virtual environment with the user’s body schema in immersive virtual environments may have a number of implications for the design of virtual worlds. We can say that in almost any virtual environment system with any significant level of embodiment, there are three bodies present: the objective body, the virtual body, and the body schema. These three bodies may present even in comparatively primitive, non-interactive virtual environments like standard television (Meyers & Biocca, 1992). The objective body is the physical, observable, and measurable body of the user. The virtual body is the representation of the user’s body inside the virtual environment. The body schema is the user’s mental or internal representation of his or her body.

Our body schema is a not stable, but labile (Fisher & Cleveland, 1968; Fisher, 1970). The use of media can radically alter one’s body schema. In virtual and augmented reality systems, changes in the location of the represented head or hands can significantly distort the body. Biocca and Rolland (in press) found that a small displacement the vision in an augmented reality system triggered disruptive visuomotor adaptation (Welch, 1978), or to put in another way a recalibration of the body schema. When the users exited the virtual environment and reached for objects in the physical environment, they exhibited significant distortions in hand-eye coordination. In this case, the coordinate system of the visual system and the motor system (specifically, the hands) had adapted to the geometry of the virtual body. The objective body was now “out of sync.”

Distortions in body schema can also result from exposure to implicit representations of the self, even in non-immersive environments. Meyers & Biocca, (1992) found that exposure to videos that emphasized an ideal body shape for women led to distortions in the body schema of young women.

We know that the mapping of the objective body to the virtual body is never completely free of some form of mismapping between user action (motor outflow) and sensory feedback (sensory inflow). This mismapping usually leads to some form of intersensory conflict. This may lead to simulation sickness (Biocca, 1992). But more importantly, it appears that embodiment in virtual

environments should not be seen as some virtual environment equivalent of the selection of clothing or costume. It appears that embodiment, especially in immersive virtual environments, can significantly alter body schema. In a way we might say that the virtual body may compete with the physical body. The result is a tug of war where the body schema may oscillate in the mind of the user (see Meyer & Biocca, 1992).

9 The cyborg's dilemma

As we approach the beginning of the next century, the problem of embodiment, the representation of the body, has become a central problem in a number of overlapping, intellectual debates. Most appear to be directly or indirectly stimulated by the progressive development of technologies of the body, especially the development of new sensing and display devices. In the neurosciences the development of sensing devices such as MRI, CAT, and PET scans has contributed to a discussion of the role of body in fundamental representational processes associated with reason and emotion (e.g., Damasio, 1996). In the design of artificial intelligence, embodiment is debated in discussions of the role of body, its function in ongoing representations of the external world, and its role in plans and action (e.g., Brooks, 1990, 1991; Dreyfus, 1979; Haber & Weiss, 1996; Johnson, 1987; Lakoff, 1987; Lakoff & Johnson, 1980). In the humanities, a concern over embodiment, fanned by feminist studies, concerns the role of representations of the body, mostly as circulated in media technologies such as film, TV and internet, with social roles and the identity. Here we see Foucault-influenced (Foucault, 1980) debates about "technologies of the body"

As we approach the year 2000, another version of our grappling with embodiment is coming to the fore. It is evident in our fascination with the idea of the cyborg, the interface of the physical body with technology (e.g., Gray, Figueiroa-Sarriera, & Mentor, 1995). The embodiment advanced in the form of virtual environment technology can be characterized as a form of cyborg coupling. This coupling underscores what I call the cyborg's dilemma, a kind of Faustian trade off: Choose technological embodiment to amplify the body, but beware that your body schema and identity may adapt to this cyborg form. This suggests a possible simple escape from the cyborg's dilemma: we can

reject the technology and avoid the uncertain choices implied by the cyborg's dilemma. It is not that simple. Anyone who believes that there is a "natural" place, where the body is not wedded to technology, may be embracing both technology and self-deception. Cyborg theorists point out that "we are already cyborgs." We have been for centuries. The cyborg's dilemma is present in a piece of clothing, in a wrist watch, in a baseball bat, in short, in all technologies that attach themselves and augment the body.

The pursuit of presence and the telecommunication of the body pushes a tight coupling of the physical body and the computer interface. To the degree that cognition and identity are embodied in the simulations run by our sensors and effectors, then the mind is adapted to the simulation of the cyborg body. Observing the day-to-day movements between our unmediated body and our mediated virtual bodies, we may come to ask: Where am "I" present?

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