5 Communication Applications of Virtual Reality

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Virtual reality's (VR) final destination may well be as a multipurpose communication medium—a combination of the television and telephone wrapped delicately around the senses. Even NASA scientists like Steven Ellis (1991a) admit that "Virtual environments . . . are communication media" (p. 321). Introductory VR books often describe virtual reality as the next logical step in the history of communication media (e.g., Hamit, 1993; Rheingold, 1991). A Delphi panel survey predicts that communication applications of virtual reality will amount to more than 60% of the marketplace when the technology matures (Miller, Walker, & Rupnow, 1992).

But what are virtual reality's communication applications? One could argue that *all* VR applications are communication applications. In some ways this is valid; after all, all applications involve man–machine communication and human-to-human communication. But, maybe we should ask a more confined question: What are VR's applications in the traditional domains of entertainment, news and information, and telecommunication? What shape might they take? What design challenges do they present?

As the opening chapters noted, the mid-1990s are full of turbulent change in the communication and computer industries. Virtual reality applications are being formed in this bubbling cauldron of activity. In this chapter we use the best available evidence and suggest the outlines of some key VR communication applications.

THE EMERGING MARKET

U.S. expenditures on communication technology and services account for between $7 trillion and $11 trillion, depending on what one counts as more advanced semiotic forms of persuasion, a new *rhetoric of the senses*. Rather than creating a capacity for "mass persuasion" the power of this rhetoric of the senses is likely to be buried by the chaos of competing realities. In the age of virtual reality the "sound byte" will get replaced by the "experience byte," and users will be swallowed byte-by-byte into Baudrillard's "gigantic simulacrum."

News Space as Database

The cybersurfing digital journalist is a new, information-devouring creature in the age of virtual reality. Increasingly journalists need to be adept organizers of information and data, technical wizards filtering the nets and extruding patterns of human activity. Journalists access and manipulate government and private text and databases (e.g., Nexus-Lexis) or surf the Net in search of virtual sources of news. Sometimes called "data-based journalism," this kind of information spade work is an important part of modern news work.

The telling of news is also an act of database organization, and as such it requires the construction of categories—economic news, human interest, and so forth. News has a structure. Take, for example, the average daily newspaper, a seemingly "primitive" interface by comparison to the possible VR interface under discussion. But in many ways the newspaper is a user-friendly, print-based database. Information is organized in a 2-D space; certain categories of information—business, weather, sports—always appear in the same physical location, in a specific section or a page. Important information appears up front and higher on the page. Index words—headlines—are made big for easy user searches.

Like the newspaper, the virtual news environment is also a database. But unlike the newspaper it may have bottomless depth—a string of articles, pictures, and video receding backward in time and out to the infinite horizon. The cyberspatial news environment is a place of information richness—but also information confusion and overload. As we suggested in chapter 2, virtual reality interfaces offer a way to tame the likely information management crisis threatening cyberspace. The "globe-trotting journalist" becomes a "cyber-trotting" agent navigating cognitive space, seeing, editing, and even listening to vast data arrays (e.g., Kramer, this volume; Nilan, 1992). Returning from cyberspace with a rich trove of data, the journalist will have to decide what to share with his or her "readers," and how to display this news. Indeed, the routinization of news production forces the creation of simplified (i.e., edited) news spaces into which audiences could enter by using VR technologies.

Although some (see Hallin, 1992; Katz, 1992) have speculated about "the end of journalism," particularly in an age of virtual reality, we do not share "communication." Also, three trends are evident: greater interconnectivity, greater information bandwidth between communication points, and greater information bandwidth between user and interface—the communication market is expanding.

The first trend—greater interconnectivity—has been going on for some time. For example, in the last decade cable television increased its penetration into U.S. homes by 300% and finally reached a majority of U.S. households (U.S. Dept. of Commerce, 1992). Evidence of communication expansion can also be seen by looking at past activity in the computer industry. According to the Software Publisher's association, entertainment software revenues rose by 29% and education software by 47% in 1992 (Gilder, 1993). At the same time sales of computers with modems increased by an amazing 1,000% and Internet burgeoned forth at the astounding growth rate of 15% per month. This is only the beginning. Only a small percentage of the general public has really been touched by this expansion of communication; whereas nearly every American household has a TV set (98%), little more than 40% of the households own a personal computer.

Where is all of this growth in mediated communication going? Let's consider the changes in communication interface only. In any media environment there is usually one communication medium (interface) that is dominant, one that most powerfully shapes how we communicate and see the world. In this century the newspaper, radio, and television have each risen to the top and then slowly declined in dominance, and with each new medium the cycle of rise and fall has accelerated (Shaw, 1991). The evolution of media technologies suggests that virtual reality may rise to become the next dominant communication medium. As some of the chapters in this volume point out (chapter 1, by Biocca, Kim, & Levy; chapter 3 by Steuer), the history of media is a history of interfaces that deliver information to more sensorimotor channels with increased sensory realism in each channel. At some point in the growth of communication services, it is probable that some form of immersive virtual reality will eventually become a general, home-and-office-based communication interface. By *general communication interface* we mean an interface used for interpersonal telecommunication, information retrieval, and information creation—a convergence of the telephone, television, and personal computer—the long-awaited metamedium (Kay & Goldberg, 1977).

Interactive mutlimedia systems are finally arriving at the nation's homes first. These multimedia platforms are evolving to incorporate VR-oriented input and output devices. For example, window-based, stereographic displays are already circulating in the marketplace at affordable prices (e.g., Simsalabim Systems, Stereographics, VREX). When will the home have some form of home-based reality engine? Predicting the exact pattern and diffusion rate of virtual reality technology is still hazardous and uncertain (see chapter 11, Valente & Biardini). But some patterns are emerging. At the time of this writing computer game companies had already anounced plans to network home-based, low-end systems together.

The shape of the virtual reality market has begun to emerge. Heading into the mid-90s the market for communication applications of virtual reality is still relatively small. The overall VR market in 1993 was estimated to be little more $110 million (Latta, 1993). Some believe that the market will grow slowly, rising to a modest $500 million by 1997. Others feel that the demand for VR technologies and services will grow at a much faster rate. But most analysts agree that the diffusion of virtual reality will be driven by communication applications, specifically, entertainment applications.

Playing with Virtual Reality

If entertainment applications of virtual reality take the lead, then we should expect to see virtual reality in the palaces of entertainment, the complexes of the location-based entertainment industry. The location-based market includes high-end entertainment experiences at large national and super-regional entertainment complexes, for example Disney World, Las Vegas, and various international Expos. These centers produce consumer-accessible, multisensory, entertainment experiences.

In the past multisensory experiences have been created by passive, cab-based simulators. The passive simulators use large-screen, 360°, or 3-D film for visuals, and high-quality audio, synchronized with motion platforms. Forty to 100 tourists are catapulted through a bone-jarring experience rarely lasting more that 10 minutes. As many as 500,000 to 3 million individuals experience some of these simulators every year. A classic example is Disney's Star Tours, which opened in 1987 (see chapter 6, Hawkins).

This sector of the communication industry is well positioned to introduce communication applications of virtual reality—it's a natural match. Companies such as Hughes, Spectrum-Holobyte, and Iwerks, to name a few, use technology to provide unique sensory experiences. These businesses are capable of assembling the capital and technology to build expensive VR systems and the settings to make it profitable. There are indications that theme park VR experiences are under development for theme parks in the United States, Canada, and Japan (see Hawkins, this volume). The entertainment at these sites might mature to develop more complex narrative experiences (discussed later; Meyer, this volume). Location-based entertainment is probably where most people will first experience high-end VR experiences.

VR entertainment needs to be a repeatable experience, not just a novelty at major tourist sites. The first[1] consumer-based applications of virtual reality emerged in the low-to-midrange segments of the location-based entertainment industry. These segments include complexes in regional entertainment centers and large shopping malls. Battletech™ by Virtual Worlds Inc. and various games by Virtuality[2] (Rowley, 1993) were among the first to incorporate interactive VR concepts into their entertainment (see Hamit, 1993; Hawkins, this volume; Heeter, this volume for consumer reactions). In these systems the user is immersed either in a cab-based VR unit or a head-mounted display.[3] Users are free to roam in a three-dimensional world inside a networked VR system that includes other people involved in competition or cooperation within themes of battle, exploration, or rescue. Such low-to-midrange VR entertainment experiences (see Biocca & Delaney, this volume) are closer to the user's home and more easily repeatable.

The full diffusion of communication applications of virtual reality crosses a threshold when significant VR experiences enter the home. The most likely platforms for the diffusion of virtual reality into the home are video game systems. In the early 1990s, 30% of U.S. homes and over 90% of homes with children already had some form of computer game. What many in the 1980s thought would be a small market generates from $4.5 billion to over $5 billion in yearly revenues.

Some virtual reality concepts have been introduced in the form of various new input and output devices for computer games. For example, in the early 1990s Abrams–Gentile Entertainment and Mattel introduced the Power Glove™ (Rheingold, 1991), a crude version of VPL's data glove (see Biocca & Delaney, this volume). In 1993 Sega, one of the largest manufacturers of computer games, announced a low-end, head-mounted display for only a few hundred dollars. The VR experiences it generated were of poor quality

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[1]Determining the "first" consumer application of VR depends on what one considers to be virtual reality. Some consider *Explorama,* Morton Heilig's 1960s passive arcade ride, to be a likely candidate. But if one establishes the criteria that the VR systems must (a) be highly interactive and immersive, (b) involve free movement over a complex, computer-generated spatial display, and (c) involve some form of 3-D sensory representation, then only a few remain. The insistence on 3-D sensory representation, for example, would eliminate Battletech as a full VR experience.

[2]Formerly W-Industries.

[3]Cab-based systems are in some ways a technological step back because the experience fails to incorporate full visual 3-D depth cues. Some question whether such systems can really be called virtual reality. On the other hand, head-mounted displays present a number of problems for location-based entertainment applications. The head mounts can potentially spread bacterial infections or head lice among users. The head mounts take some time to put on and adjust to the individual. Some VR games require a human attendant. This may slow down the "thru-put" necessary for some of the location-based systems that require high volumes of users and speedy user entry and exits.

and often limited to a single user, but this technology is affordable and puts VR technology into the consumer's hands. These early forms allow new and future consumers to get used to VR interfaces and helps pave the way for the later arrival of higher quality computer platforms attached to input and output devices that generate more vivid experiences. Brought into the home for entertainment, these systems also open the door for informational and educational applications of virtual reality.

Indeed, communication applications will take a further qualitative leap when immersive, consumer VR systems can be affordably networked over large spaces. Cyberspace will then come closer to becoming a "consensual hallucination" (Gibson, 1984). Although some network communication systems claim to offer "virtual reality," truly immersive, networked virtual reality is likely to emerge in the later phases in the diffusion of virtual reality, the phase that ultimately ushers in a VR-based, general communication interface. Researchers affiliated with telephone companies such as NYNEX and US West tout the use of virtual reality for telecommunications. But networked, immersive virtual reality needs the bandwidth of high-end cable or telephone-based transmission channels.

Some scenarios for immersive, networked virtual reality count on the explosive popularity of interactive television and the emergence of a family of powerful graphic, multimedia computers ("black boxes") into the home. This must come first. For example, Bell Atlantic forecasts more than 1 million of these high-powered home terminals by 1997 (Cook, 1993). Silicon Graphics, manufacturer of some popular VR-oriented workstations, has entered into alliances with powerful cable companies to provide a screentop black box with the power of its graphic workstations for less than $300. According to this scenario (e.g., Biocca, 1993), some of these powerful interactive systems will eventually "grow" new input and output devices to support more immersive networked experiences.

Scenarios for home-based, immersive, networked virtual reality also assume successful installation of some form of "information superhighway." Such a network can provide the backbone for the massive data exchanges required. A national system of home-based, highly networked, fully immersive virtual reality would constitute the construction of a radically different communication system (see Biocca & Levy, chapter 2) and an unpredictable range of communication applications.

A few successful communication applications of virtual reality exist, although most are found in the location-based entertainment market. But the present generation of virtual reality communication applications are only crude outlines barely suggestive of applications to come. These immature applications are as similar to and as different from mature applications as Milton Berle's live 1950s TV show is to MTV, or as the first *Pong* game is to *SimCity 2000*. Thinking about communication in the age of virtual reality requires that we not be limited by last year's commercial success.[4] In the sections that follow we do not limit ourselves to existing applications, but rather consider the shape and design challenges of more mature applications to come.

"IMAGINE A PLACE LONG AGO AND FAR AWAY

Many forms of entertainment attempt to do one thing well: They take the listener/viewer/player/user into another world—a telepresence ride to the far reaches of the imagination. Successful novels, for example, "transport" you to distant locations in space and time or into the minds and motivations of people you meet only inside the medium. Like ancient tribal ritual spaces, story space is a constructed sociopsychological place. It is a liminal world where the user crosses a threshold and "suspends disbelief." Alone or with others the storyteller–audience enters the simulated "world of make believe" of the novel, play, film, or arcade game. Discussions of these applications often refer to two essential ingredients:

Imagination. The replacement of everyday sensory reality for user-generated illusions driven by cues from a medium: for example, words of the storyteller; a storybook picture; and an action-packed, car chase; and so forth.

Illusory Space. A mutually accepted make-believe space, a "consensual hallucination," where the fiction, game, or entertainment takes place—"long ago and far away." Entertainment terms that refer to this illusory space include: story space, film space, theatrical space, playing field, and so on.

These are ancient ingredients. Entertainment using virtual reality is in some ways no different from listening to an old shaman tell a creation myth around the tribal fire, or sitting on a cold, marble seat in ancient Athens at the first performance of Sophocles' *Oedipus Rex.* Immersion into the story space stimulates the inner psychological engines of identification, role playing, conflict, and the clash of deeply felt emotions. VR technology may be new, but the emotions it plays to are very old. But unlike older media, virtual reality attempts to realize some artists' dreams to make the creations of the imagination more literal. To quote an oft cited passage:

[4]Therefore, in our discussion of the communication applications, we do not dwell on specific companies, products, and projects. These change constantly. Such developments and other business ephemera are best tracked in monthly publications like the *CyberEdge Journal, Wired, Virtual Reality Report,* and *Virtual Reality World.*

> Not till the poets among us can be
> "literalists of
> the imagination"—above
> insolence and triviality and can present
>
> for inspection, "imaginary gardens with real toads in them," shall we have it. (Moore, 1951)

Consider the "imaginary gardens" of dramatic narratives. Dramatic narrative is one of our most powerful forms of entertainment. How might a designer generate the emotional response of great storytelling in virtual reality? Some feel that virtual reality unleashes the possibility of an intensely rich and interactive storytelling. Laurel (1991), for example, speculated that an intelligent program, "an interactive playright," might write interactive narratives "on the fly," based on user actions. The interactive power of virtual reality seems to promise the possibility of great freedom for the user—he or she might be able to "go anywhere and do anything" in a VR story space. It has been suggested that the user may be the protagonist of a story, might choose to be any character, might change characters in the middle of a story, or might alter the sequence of events in a story. Others suggest that in VR storytelling, the user might not just experience the story but *live* it. Can virtual reality do this effectively in the near future? Maybe. Some pessimistic commentators suggest, however, that like early speculation about artificial intelligence, ideas about "go anywhere and do anything" storytelling seriously underestimate the complexity of programming storytelling environments. They argue that you cannot "go anywhere and do anything" because there are not a million roads to a emotionally powerful dramatic narrative, only a few.

In chapter 8, Meyer discusses the challenge of implementing classic dramatic narratives in virtual environments. He asks: How does a VR director orchestrate the dramatic narrative in virtual reality? Meyer points out various ways in which the use of virtual reality as a storytelling medium needs to be better understood. Consider, first, how a dramatic narrative works. Classic theories of dramatic narrative lay out how the emotional power and effects of a dramatic narrative rely on control over character motivation, plot structure, and timing of emotional effects. In a linear storytelling medium like books and film, *control* over these elements is more easily achieved. For example, think how story structure, timing, and emotional effects animate a mystery story whether it is told around a campfire, in a novel, or in film. The playright or director carefully controls the unfolding of the narrative and the amount of information available to the reader/viewer. The sequence and timing of events carefully stimulates emotional responses in the reader/viewer to create suspense. Can such effects be created in virtual reality if the user is completely free to roam around the story?

Unlike books or film, virtual reality is a nonlinear medium. The designer exerts a lot of control over all the *content* of the VR world but has limited control over the *sequence* of events. A freely roaming user inside a VR narrative can generate thousands of probable sequences of events. Artificial Intelligence (AI) storytellers must be ready to respond appropriately to all these sequences. Can AI story-making programs do this now or in the near future? Meyer (this volume) discusses the limitations of some of the early generation of AI narrative programs. Although the program may always produce *some* response, many may not be dramatically satisfying for the user. VR dramatic story makers are likely to face difficult trade-offs: Give the audience members too much freedom and the balanced effects of the story will suffer. Limit the choices of the audience member so that the user has a more emotionally orchestrated narrative experience, and you seem to underutilize the potential power of virtual reality. This is the paradox of VR narrative.

AI storytelling programs may be limited for some time to come. Even with better programs, a conflict may always exist between the need to control events and characters to effectively tell a dramatic story and the potential freedom of the "audience" member inside a VR story. When the user is free to alter all elements in a story, the user also becomes a playright. A basic contradiction exists. The user and the AI playright may be in conflict. User actions may disrupt the most effective timing of plot developments and emotional effects by the AI playright controlling the VR program. The result may be unsatisfactory dramatic narratives, nonnarrative sequences of events, or more anarchic story structures. These may still be narratives, but they may not be very good or emotionally satisfying.

Great VR storytelling is possible, of course. But as with the refinement of the arts in other media, VR playrights and directors will develop an understanding of both the possibilities and the limits of VR technology.

Managing, Altering, and Amplifying the Senses

There are some other interesting evolutionary connections between the needs of storytelling in older media and the likely needs of story making in virtual reality. Entering older story spaces often meant blocking information received from the senses (e.g., sitting in a quiet place to read or slumping in a comfortable, dark seat in a movie theater). Sometimes the imagination was released by suppressing the naysaying reality check of the senses. Phrases like: "This is not real" or "It's just a story," suggest the psychological tug-of-war between the compelling reality of the virtual story space and the physical reality surrounding the audience member. In successful moments of reverie, audience members ignore physical reality and project themselves into the story space. In the words of Coleridge (1817), "That willing suspension of disbelief for the moment, which constitutes poetic faith" (p. 87).

The blocking of sensory impressions from physical reality is a crucial part of the most compelling VR experiences. The senses are *immersed* in the virtual world; the body is entrusted to a reality engine. The eyes are covered by a head-mounted display; the real world is invisible. The ears are covered by headphones; ambient sound is muffled. The hands are covered by gloves or props: "touch only the virtual bodies." Virtual reality may share common elements with reading a book in a quiet corner, but this book has stretched in all directions and wrapped itself around the senses of the reader—the reader is swallowed by the story.

Instead of ignoring the senses, ancient story space sometimes altered or amplified them. This helped fire the illusion brewing in the imagination. Many forms of entertainment from shamanistic storytelling to Greece's dionysic festivals sometimes involved the consumption of drugs or alcohol, energetic ritualistic chanting or dancing, loud noises and flashing lights. With these the user could more easily enter the illusory space of the myth, story, or what have you. With a "magic" root or mushroom the user could "commune" with the gods.

In some ways, virtual reality continues in this tradition as well. The rhetoric of chemical and technological augmentations of experience permeate the pages of cyberspace-oriented magazines like *Mondo 2000*. This is not an accident. Neither is the fact that Timothy Leary,[5] LSD shaman of the 1960s, saw in virtual reality some of the same myth-making power he found in older chemical "media" (see Wooley, 1992). Awed by the possibilities of the technology for experiences he pursued by other means, he pronounced at one of the early virtual reality conferences: "I think this is one of the most

[5]For many VR workers, especially VR scientists, the presence of Timothy Leary at the early public promotion of virtual reality such as SIGGRAPH 1990 was met with much unease. For engineers and scientists in universities, the military, and major corporations, the 1960s jester was hot-dogging on a cresting wave created by years of their sweat. In a culture not comfortable with its use of drugs of modulate experience, people in the industry were eager to avoid public relations traps set by journalists and distance the technology from any hint of relationship with another technology of the imagination—drugs. But at a deeper level the two remained linked: one, drugs, an ancient, low-tech, hard-to-control means of altering sensory perception, the other, virtual reality, a silicon, sophisticated, increasingly capable engine for mind bending. In their private moments we would hear some of the VR scientists laughingly use the metaphors of drugs to describe certain aspects of the experience. But in their public performances all feared the sensation-seeking barbarians of the press and what they might do with the hints of connection—even a metaphoric one—between the two technologies.

important meetings ever held by human beings" (quoted in Woolley, 1992, p. 12).

Scientific discovery, artistic insight, and religuous epiphany may spring from a rearrangement of our sensory relations to the world. VR scientists often speak of the technology in terms of sensory rearrangement or intelligence augmentation, but in the same breath curse the day when the "pariah," Timothy Leary, embraced the technology. In this eager dismissal of Leary's self-serving "distractions," we may miss a deeper connection to a very old human tradition of using chemical and mechanical artifacts to alter mental functions.

VR pioneer Jaron Lanier tells anecdotes about virtual reality experiences where engineers at VPL experimented with reorganizing the relationship between bodily movement and sensory feedback. In a search for artistic effects, body parts were presented in different proportions in the virtual world for perceptual effect; body movements were linked to nonbodily activity. He even discussed the possibility of unusual sensory experiences only available in VR such as "crawling inside the mouth of a friend" (Lanier & Biocca, 1992). Lanier imagined linking such movements to events like the flying of birds or the eruption of volcanoes. Lanier speculated on linking physiological responses like emotion to visual changes: "if you were angry you could become a red lobster awhile" (Lanier & Biocca, 1992, p. 162). In some ways this seems less like the voice of modern technology and more like the voice of ancient shamanistic myth making. We should be excused if we detect a waft of ancient pipes and hear the chant of rituals in these anecdotes. This shape shifting is the modern equivalent of the animal and spirit costumes of primitive tribes. This is a virtual reality of masks, feathers, and mud-covered skin.

This electronic rearrangement and amplification of the senses suggests that the usage of virtual reality continues in the older traditions of sensory alteration and amplification. No doubt some will argue that perceptual amplification and the transformation of interaction with sensory stimuli yields "better learning" and "new insights." Maybe. If so, virtual reality will be called upon to make the senses raw and sensitive by altering the way we relate to the world.

Although virtual reality may incorporate all of the classic storytelling techniques, it is different. Like film, virtual reality facilitates the imagination not by depressing the senses but by immersing the senses in information from the illusory space. It will work most powerfully for entertainment when, like children's make-believe, it becomes in the words of Gibson (1984) a "consensual hallucination." Like all hallucinations, it will not be created solely by the evidence of the senses. VR technology merely calibrates sensory stimuli. Even the best VR technology will require the full cooperation of the imagination. As Heeter suggests in chapter 7, the ability to suspend disbelief (she calls it the Peter Pan principle) remains—and will forever remain—an important component of the enjoyment of VR entertainment.[6]

"AND NOW LET'S GO LIVE TO THE BATTLEFIELD

In this section, we engage in a brief *Gedankenexperiment* and try to imagine how virtual reality might affect the practice of journalism, say, 50 years from now, when communication in the age of virtual reality is in full bloom.[7] There is already much concern about the effect of interactive television on the delivery of news. We lay out a set of scenarios that extends emerging developments in interactive multimedia news systems and news simulations. For this discussion, we take as our general theoretical framework some standard notions drawn from media studies of popular culture. We take as given that important questions about communication can be identified and studied by seeing mass communication as a major site in which messages are created, reproduced and repaired and in which audiences create and share meanings based in substantial part on those mediated messages. We also assume that the study of journalism and the news has a special importance, because journalism and its messages is where the most significant aspects of social and political life are contested.

For virtual reality to have the impact we anticipate, it will be necessary for it to move out of the laboratory and to take on more of the characteristics of a mass medium. Some of those characteristics might well be borrowed from existing communication practices: the "live" coverage of world events brought to us by CNN; computer networks like Internet that have created virtual communities in cyberspace; interactive multimedia news systems and simulations; and electronic or hypertext publishing of academic journals and spicy novels—all offer codes, narrative structures, "models" for virtual news.

Telepresence and the Virtual News Environment

As a mass medium, virtual reality could fulfill the oldest dream of the journalist, to conquer time and space. Virtual news environments would

[6]As philosophers have pointed out for centuries, all experience, including the best VR experience, requires the constructive powers of the imagination.

[7]We are fully aware of the perils of predicting the future, especially the future of communication. A colleague of ours sat down in 1899 to predict the future of the newspaper in 1999 (Bird, 1899/1971). Although there are a few brilliant insights (e.g., the arrival of television), most of his speculations make for amusing reading today (e.g., the prediction of a national network of air tubes for news delivery). But if we accept that technology is socially constructed, then speculating about journalism's future and the relationship of that future to virtual reality might just contribute to the discourse that shapes journalism's present and VR's potential.

invest journalists with the ability to create a sense on the part of audiences of being present at distant, newsworthy locations and events. For over a century news has struggled to find ways to bring its audiences close to dramatic and historic moments. The very language of journalism suggests the goal of telepresence. Think of Edward R. Murrow's broadcast programs, *Hear it Now* and *See it Now.* Or Walter Cronkite's dramatized history with the prophetically cyberspatial title, "You are there." These phrases promise telepresence. Imagine what Murrow and Cronkite could have done with a virtual news environment. Instead of vivid language, they might have been better able to deliver the promise of telepresence inherent in the modern idea of news.

Indeed, as the chapters of this book and the visionary writings of the science fiction community remind us, the basic concepts and hardware also promise to take us "there" and more. In the influential novel, *Neuromancer,* Gibson (1984) conjured up what he called the "simstim" (simulated stimulation) deck, a virtual VCR through which the "viewer" experiences whatever has been taped for the deck or whatever the simstim communicator is experiencing "live." Gibson's simstim is clearly more immersive than today's VCR, but it is not really interactive. Still, one could imagine "jacking into" a simstim to experience a pre-recorded virtual documentary or a mult-sensory "story," reported by a trusted and/or celebrity journalist.

A mass telepresence system requires the development of: (a) remote, real-time cameras capable of transmitting a full 360° world, and (b) a digital model of such a world that can be simultaneously experienced by millions of people. Telerobotic systems work well for a single individual linked to a binocular camera system at some distant locations (see for example the linked systems offered by Fake Space Labs and Leep Optics). Figure 5.1 sketches the typical telepresence setup. But only one viewer is possible at a time, because the distant robot is slaved to the head movements of the human viewer—when the viewer looks to the right, the robot camera swings to the right. A million people cannot simultaneously don headgear and simultaneously control the viewing of a single remote binocular camera in

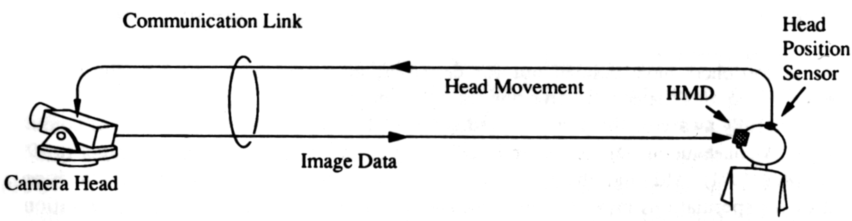

FIG. 5.1. In a typical immersive VR telepresence system, a single user is connected to a distant slave camera. The camera moves to match the user's head movements. From Hirose, Yokoyama, & Sato (1993). Copyright 1993 by IEEE. Reprinted by permission.

some distant environment. If the mass audience must be forced to view passively, then this experience fails to deliver the full promise of virtual reality. It becomes just another form of passive television, even if it is stereoscopic.

The *virtual dome* system prototype produced at the University of Tokyo (Hirose, Yokoyama, & Sato, 1993) suggests one way to create a mass simulation, and provide active experience of a remote environment. Figure 5.2 shows the concept behind the virtual dome telepresence system. The system begins with a camera located at a distant location, let's say, for example, the lawn at the White House. Fixed on a tripod, the telerobotic camera rotates continuously around the scene (the prototype rotates at 6 rpm). The images are sent via a transmission line to a graphics workstation. The graphics workstation digitizes the images. The computer then pastes (texture maps) the images to the inside of a virtual dome (the prototype dome is composed of 75 polygons; see Figs. 5.3 and 5.4). With some additional processing, the system can also calculate the relative distance of surfaces on the distant image (using binocular slits and motion-parallax cues). In a clever piece of image matching, the virtual dome is deformed so that close surfaces protrude. Borrowing an idea from relief sculpture, the researchers cleverly distort the dome screen to generate 3-D effects (i.e., motion-parallax cues).

The virtual dome generates a 360° screen inside a virtual environment that preserves 3-D cues. The image is completely digital. In future prototypes it may be possible for multiple viewers to don headgear and "sit" inside the center of the dome. They could turn their heads in any direction

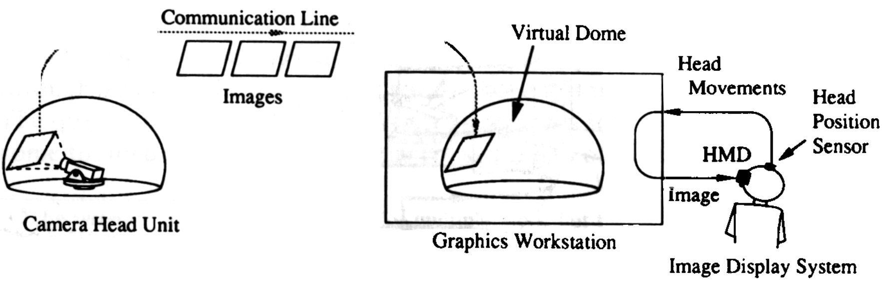

FIG. 5.2. In the prototype VR telepresence system called the Virtual Dome, a remote rotating camera continuously pans the 360o views of a remote environment and sends images back to a computer workstation. These camera images are digitized and pasted (texture mapped) onto the inside of a virtual, computer-graphic dome and continuously refreshed as new images arrive. Using a head-mounted display users are transported to the center of the dome and can turn their heads in any direction to view the live 360° image of a distant location. A future system like this one may make it possible for mass audiences to freely experience live news events with full 360° views beamed from news locations all over the globe. From Hirose, Yokoyama, & Sato (1993). Copyright 1993 by IEEE. Reprinted by permission.

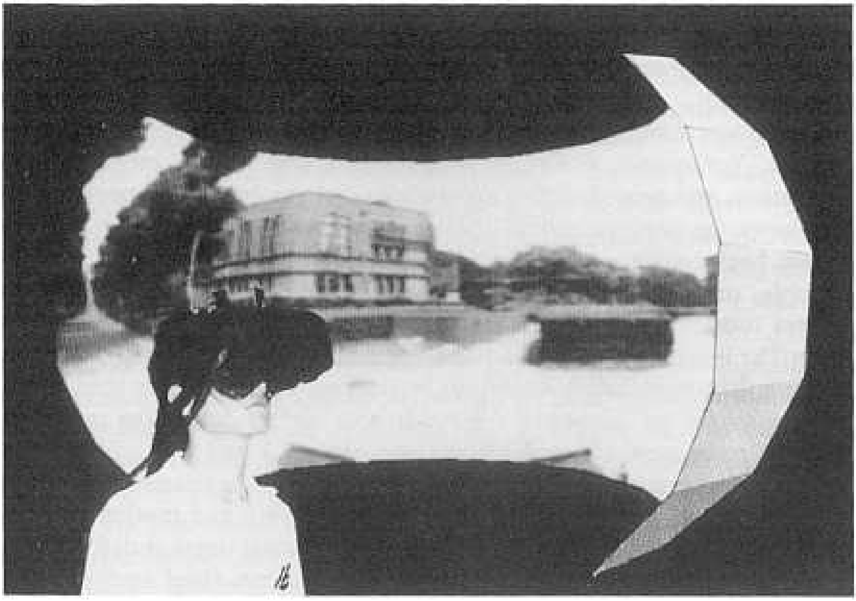

FIG. 5.3. A simulation of a user viewing images inside a virtual dome. From Hirose, Yokoyama, & Sato (1993). Copyright by IEEE. Reprinted by permission.

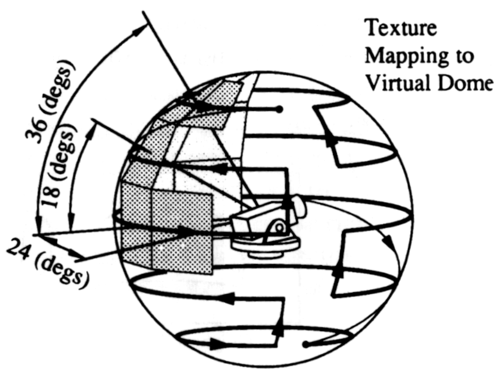

FIG. 5.4. The figure displays the rotation pattern of the remote camera and how the images are pasted (texture mapped) onto the virtual dome. From Hirose, Yokoyama, & Sato (1993). Copyright by IEEE. Reprinted by permission.

and have the illusion of the 3-D scene that would surround them. Going back to our White House lawn example, multiple remote 3-D modeling cameras might be located there. Viewers could be free to "jump" from camera to camera, viewing the scene from a variety of vantage points and from a variety of angles. Pre-positioned telerobotic sensing systems could take us to the streets of Peking, the halls of Congress, or to a joint U.S.-Russian space station. Although the virtual dome demonstrates a number of interesting design concepts, there are many engineering obstacles to overcome before it can be turned into a mass telepresence system.[8] It is only one possible model among many of a mass telepresence system.

Now consider some of the questions the virtual dome scenario raises. Who, for instance, would own the telerobotic sensors? Who would pre-position them and based on what notions of newsworthiness? How does one edit a 3-D news story? Would reporters use some device to direct the attention of viewers to some part of the dome image? Is news from cyberspace the ultimate news from nowhere? At a later stage of development, could telerobotic sensor systems (or simstim decks for that matter) allow VR audiences to engage in virtual role-playing games, entering virtual environments for limited periods of time to see and hear and taste and feel what it's like to be a refugee in the sub-Sahara or a basketball star in the NBA finals? How would audiences judge the truthfulness or veridicality of the images and sound? (See Shapiro & McDonald, this volume.) What does it mean to say that viewers engage in a "negotiated" or "oppositional" decoding (Hall,1973) in a virtual news environment?

What if we up the ante just a bit and include a higher level of interactive capability in this projected telerobotic system. Instead of passively receiving 3-D images and sound or interacting with simulations, what if audiences could interact with the people "in" the news, the journalists reporting the news and the social actors being "covered"? What would viewers do with this new capability? Does this become little more than a 3-D "call-in" show or something more? Would they, for example, seize the opportunity to engage in an even more intense kind of parasocial interaction (Horton & Wohl, 1956) with media personae? If they really are interacting—albeit through a mediated channel—is it parasocial or is it truly social interaction? The question of parasocial interaction of course is just one of many which come to mind when we consider the consequences of virtual news environ-

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[8]The system is not presently designed for multiple users, but that is one of the next steps (Michitaka Hirose, personal communication). The image update rate for the dome is still too slow.

Camera rotation speed and image processing speed would need to be increased. At present, this is overcome by updating the image more frequently in the direction of the viewer. This is a good solution when there is only one viewer; it becomes less efficient as the number of viewers climb, although it is unlikely that even thousands of viewers would distribute their view randomly around a dome—they would likely follow the "action." The dome deformation takes time and is still somewhat inaccurate.

Because a news system could not allow that the viewers interact with the environment (e.g., interrupt the president's speech), signal delays can be introduced into live events to allow the computer more time to build the images. Pre-recorded events would also give the computer more time to construct the dome images and deform the dome for relief-like 3-D cues.

ments. There is no more important set of questions to ask than to inquire how virtual news environments might affect what its audiences know, think, and believe. As students of communication, we have always searched for communication effects, but with mixed success. If virtual news environments vividly engage many, perhaps all, of the human senses, then we might well hypothesize that its effects too will be heightened.

Just as virtual news environments will affect audiences, they will, we believe, also have substantial impact on the work of journalists. How, for example, will professional norms of "objectivity" be affected? What journalistic routines will be used when virtual news workers seek to demonstrate their lack of bias? And how will libel law be applied to news from virtual environments? Will "viewers" who interact virtually with people in the news be subject to libel action? (For one line of speculation, see chapter 14 by Harvey.) The questions of "objectivity" and "bias" bring us to the more troubling issue of simulation and its relation to the "reality" news seeks to represent.

VR News as Simulation

> Behind the baroque of images hides the gray eminence of politics.
> Thus perhaps at stake has always been the murderous capacity of images, murderers of the real, murderers of their own model as the Byzantine icons could murder the divine entity. To this murderous capacity is opposed the dialectical capacity of representations as a visible and intelligible mediation of the Real. . . . But what if . . . the whole system becomes weightless, it is no longer anything but a giant simulacrum—not unreal, but a simulacrum, never again exchanging for what is real, but exchanging for itself, in an uninterrupted circuit without reference or circumference
> So it is with simulation, insofar as it is opposed to representation. Whereas representation tries to absorb simulation by interpreting it as false representation, simulation envelopes the whole edifice of representation as itself a simulacrum.
> These would be the successive phases of the image:
> —it is a reflection of basic reality
> —it masks and perverts a basic reality
> —it masks the absence of a basic reality
> —it bears no relation to any reality whatsoever: it is its own pure simulacrum.
> (Baudrillard, 1983, pp. 10–11).

After the fact, all news is a kind of simulation. Computer scientists Alan Kay and Adele Goldberg (1977) even argued that "Every message is, in one sense or another, a simulation of some idea. It may be representational or abstract" (p. 254). A newspaper journalist recreates an event using vivid language. A TV news crew "edits" a view of a demonstration. Sometimes the editing is pure fiction. For example, in 1910 a news reel crew completely simulated the coronation of Britain's King George V using actors and elaborate sets.

In television news, the modern version of pure simulation lives on in the current trend toward "reenactment" of new events. Sometimes, the reenactments attempt to deepen the ambiguity of the simulation by using the "real people" as actors. But this form of simulation violates "accepted" journalistic norms to a community of media workers uncomfortable with any practice that will loosen its claim to "real" representations. Even the innocuous "amelioration" of photographs is frowned upon in the journalistic community. Many journalists fear that any overt manipulation of iconic media like pictures or film casts into question the authenticity of all photographic news evidence.

Concern with the real is a concern with the authority of journalistic representations. Journalism's authority lies in the appearance of the presentation of reality, or at least of the earnest effort to recover reality. In a statement that seems quaint in the age of virtual reality, many journalists wonder: How will the audience know when something is real and when it's not? It's as if the community of journalists seeks desperately to an authentic claim to the real as Baudrillard's vision quoted earlier threatens to engulf them in the "gigantic simulacrum."

As a practical matter, virtual reality offers a means of providing richer interaction with news events through simulations. In a primitive way, simulations creep into many news reports. Consider the UN–Iraq war. All major news networks used graphic models that represented the movement of tank forces over a terrain. The model represented the "real" movement on the battlefield. News does not just carry information, it carries models of social events and processes.

Computer simulation is increasingly a valid way to present news. A number of news outlets are considering the use of computer simulations as a way of deepening knowledge about news. One simulation produced for Newsweek Interactive[9] models the natural environment. This would be a more news-oriented simulation than, for example, SimEarth. At the University of North Carolina a simulation of the federal budget and the economy was created for the *Baltimore Sun* newspaper.[10] Users made choices about budgetary allocations and the simulation responded with social outcomes. These simulations offer only limited interaction over a small, somewhat abstract domain. But they are a quite visible step in the direction toward richer computer simulation. Virtual reality offers only a

[9]Vernon Church, Newsweek Interactive (personal communication).

[10]A study is under way by Gary Rosenweig, graduate student at the University of North Carolina, involving an economic simulation created for the *Baltimore Sun* newspaper.

further point on the simulation continuum. But it is a point where the computer simulation may take on the added cognitive effect of sensory realism. It is news you can touch; it is news you can shape. Therefore, it becomes news you can create. The simulacrum of news reaches out and embraces the senses.

Vivid computer simulations present a number of problems in news environments. For example, there may be no such thing as an "objective" computer simulation—just as there may be no such thing as "objective" news. But the bias of the computer simulation is less visible that other forms of news bias; it sits deep inside the machinery of the illusion. The assumptions of a simulation lie buried in the guts of the program.[11] The face seems so real, but the heart is false. In advanced VR environments, a vivid—potentially seamless—realism might be displayed. A hundred hidden assumptions about time, motivation, causality, and sequence may lie largely unnoted in the unfolding simulation. The VR simulation's very transparency and apparent reality is the mechanism for its falsehoods.

On the other hand, it could be argued that simulations change little basically about news. Like news stories today, simulations will be suspect, ideologically marked. But symbolic interactionists (e.g., Blumer, 1969) might ask today's news reader: How many of you have set foot in Somalia? With no direct experience of the objects of news, how can you even be sure they exist? Is this not all a construction of sorts? Gross fabrications, of course, are unlikely now or in future news reports. The issue is not pure fabrication; the issue for decades has been the social construction of news events, people, and problems. As Baudrillard suggested, it is more rational to assume that a news report is not necessarily unreal, but a *simulation of the real*—with all the *incompleteness* that this suggests. Virtual reality further extends the power of our semiotic systems to filter and construct our views of the world around us.

Some suggest that some form of objectivity can be rescued with the use of multiple "points of view" and multiple scenarii that can be built into the simulation, just as different points of view are imported in the form of quotes from "opposing" sources. In this narrow sense, virtual reality offers the news organization opportunities for more varied representations, rich ways to extend existing professional practices.

But with "multiple simulations" the user of a VR news interface potentially enters a confusing news environment. The battle of the "film clip" becomes a battle of simulations. Multiple "realities" compete for his or her favor. The group that can stage the most experientially convincing simulation may conquer the hearts and minds of millions. Simulation gives rise to

[11]This issue already poses problems in legal cases where computer simulations are presented as "evidence."

more advanced semiotic forms of persuasion, a new *rhetoric of the senses.* Rather than creating a capacity for "mass persuasion" the power of this rhetoric of the senses is likely to be buried by the chaos of competing realities. In the age of virtual reality the "sound byte" will get replaced by the "experience byte," and users will be swallowed byte-by-byte into Baudrillard's "gigantic simulacrum."

News Space as Database

The cybersurfing digital journalist is a new, information-devouring creature in the age of virtual reality. Increasingly journalists need to be adept organizers of information and data, technical wizards filtering the nets and extruding patterns of human activity. Journalists access and manipulate government and private text and databases (e.g., Nexus–Lexis) or surf the Net in search of virtual sources of news. Sometimes called "data-based journalism," this kind of information spade work is an important part of modern news work.

The telling of news is also an act of database organization, and as such it requires the construction of categories—economic news, human interest, and so forth. News has a structure. Take, for example, the average daily newspaper, a seemingly "primitive" interface by comparison to the possible VR interface under discussion. But in many ways the newspaper is a user-friendly, print-based database. Information is organized in a 2-D space; certain categories of information—business, weather, sports—always appear in the same physical location, in a specific section or a page. Important information appears up front and higher on the page. Index words—headlines—are made big for easy user searches.

Like the newspaper, the virtual news environment is also a database. But unlike the newspaper it may have bottomless depth—a string of articles, pictures, and video receding backward in time and out to the infinite horizon. The cyberspatial news environment is a place of information richness—but also information confusion and overload. As we suggested in chapter 2, virtual reality interfaces offer a way to tame the likely information management crisis threatening cyberspace. The "globe-trotting journalist" becomes a "cyber-trotting" agent navigating cognitive space, seeing, editing, and even listening to vast data arrays (e.g., Kramer, this volume; Nilan, 1992). Returning from cyberspace with a rich trove of data, the journalist will have to decide what to share with his or her "readers," and how to display this news. Indeed, the routinization of news production forces the creation of simplified (i.e., edited) news spaces into which audiences could enter by using VR technologies.

Although some (see Hallin, 1992; Katz, 1992) have speculated about "the end of journalism," particularly in an age of virtual reality, we do not share that concern. Even though journalists are likely to be only one competing group among various savvy "information packagers," they are likely to endure the transition to this medium as they have the transition to radio, television, and multimedia. Conceptually, VR journalism may be no different than present-day journalism. Certainly the tools will change. But constructing a news space will increase the level of complexity of the news tasks by a power of 10. The added complexity of "deep" news environments is already being felt by journalists in the multimedia area. Creating links and structure among text, pictures, video, and simulation models will require new news routines and some form of increased news automation.

Undoubtedly, the art and science of journalism will change, as will its effect on public discourse. But even in cyberspace, there will be a need for good journalists—someone better skilled at "tweaking" and "riding" the nets. More than ever before, the information depth of cyberspace brings the editing function to the fore. Most audience members will have neither the time, nor the inclination. nor the experience to steer through the traffic jam of "news" which could gridlock the information superhighway. As today, journalists and editors will be at work, choosing and shaping the news. In the giant virtual simulacrum, there will still be some—maybe only a few—earnestly looking for the "real story."

"THE NEXT BEST THING TO BEING THERE"

The most interactive medium is the interpersonal medium—the fully interactive human being. The most interesting experience in virtual environments is likely to be other people.[12] Virtual reality technology is likely to build on the popularity of existing interpersonal communication media. It is the pleasure of interpersonal communication that breathes life into many other "cyberspaces" such as computer bulletin boards (CBBs), multiuser dimensional spaces (MUDS), teleconferencing systems, and multimedia (virtual) rooms and work spaces. France's teletext system, Minitel, would have died like many others were it not for the French intuitive sense for the pleasure of the "other."

"How Should We Talk: Natural or Augmented? "

> "In a few years, men will be able to communicate more effectively through a machine than face to face" (Licklider & Taylor, 1968, p. 24).

[12]A moment of reflection reveals that all computer-based interactivity is a form of interaction with other humans, even when none are present. The human presence of the programmers and designers remains resident in the *logic and structure* of the artificial interaction.

This technoprediction was written in 1968, and it sets up one of the most critical questions for interpersonal communication in virtual reality: Can computer-mediated communication be more effective than interpersonal communication? If the answer to this question is yes—sometimes—then under what conditions and for what kind of interpersonal messages is it more effective? Both authors of this prediction, J. C. R Licklider and Robert Taylor, were at one time the heads of ARPA's Information Processing Techniques Office, a major force in development of technologies and concepts that led directly to development of virtual reality. Both men were instrumental in trying to make good on the promise of their prediction. Their promise of "more effective" interpersonal communication was written in the early years of "man-machine symbiosis" of the process of immersing the movement of human bodies into the computer (Bardini, Horvath, & Lyman, in press; Englebart, 1988).

In discussions of teleconferencing and cooperative work in virtual environments, one sees three competing design themes:

1. *Reproduction of interpersonal communication.* A design theme that emphasizes the desire to collapse space and reproduce in detail unmediated face-to-face communication.
2. *Augmentation of interpersonal communication.* A design theme that seeks to enhance or extend through artificial means the range of interpersonal communication (with an assumption that these can be more effective than unmediated interpersonal communication).
3. *Regulation of presence in interpersonal communication.* A design theme that acknowledges and tries to accommodate cultural rules that informally channel and regulate interpersonal communication behaviors.

A number of interesting and perplexing issues are likely to emerge as researchers seek to simultaneously simulate face-to-face communication and artificially augment interpersonal communication (in chapter 10 some of these issues are taken up by Mark Palmer). Is face-to-face communication the best way to understand someone's thoughts and intentions? Can mood-signaling behaviors like facial expressions be amplified? How?

This issue, natural versus augmented, is likely to focus on how we use interpersonal communication codes, whether a code is present (e.g., expressive hand gestures), absent (e.g., the direction of the other's eye gaze), or augmented (e.g., extreme close-up on the other's eyes). The more sensory channels are supported by the more advanced virtual reality systems the more possibilities are open to both naturalism and the augmentation. For example, consider the smile—natural or augmented? Is there some value of having smiling muscles change the color of virtual environment—red for smiles, blue for frowns? This simple example only begins to suggest the possibilities.

Less Is More: Interpersonal Regulation of Presence

Robert Lucky, former head of Bell Labs and later Bellcore, presents us with an interesting scenario. Reflecting on the checkered history of the picture phone in a TV interview, he suggested that maybe we may not necessarily want more presence in mediated interpersonal communication. In a television interview, he half-jokingly suggested that he wanted a "presence dial" on a future medium (Moyers, 1990). Each individual would determine the level of presence at which he or she experiences the other. For example, irritating salespeople would be dialed down to "reduced presence." Someone very close or important might be dialed up to "augmented presence."

Maybe, for certain kinds of interactions, "less is more." For example, the telephone highlights a set of audio codes but at the loss of all others.[13] This might serve the user better by buffering certain kinds of interaction like home shopping, registering a complaint, or lurking in some virtual environment. In certain interaction it is likely that users might find it helpful to restrict visual information. This might have cognitive benefits as when the audio channel carries most of the critical information (e.g., speeches or verbal instructions).

Communication might benefit from limited sensory stimuli, for example undivided attention to the audio channel. You might have noticed how individuals restrict their eye movements when they are attentively trying to decipher a distant or muffled sound or close their eyes when listening to a particularly pleasing passage in a symphony. In this case, blocking the visual sensory channel allows the individual to allocate more sensory resources to the aural channel.

There is a social dimension to how we use sensory channels. Obviously, access to sensory channels and codes is likely to be related to the intimacy of the relationship of two people meeting in cyberspace. As communication systems become capable of replicating and extending more of the sensorimotor channels and codes of face-to-face communication—including touch—conventions will emerge for establishing the "level" of code access each person has when communicating with another. These are likely to be extensions of our present interpersonal communication rules. For example, think of a crowded elevator and the unstated eye contact and touching rules that operate there. These social rules are likely to invisibly regulate interpersonal interaction in a mediated virtual environment as well.

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[13]In some ways, the other codes are not "lost," they are "simulated" in the minds of the listeners.

But interpersonal communication rules involve assumptions about group membership and, inevitably, hierarchy. What will happen when individuals of unequal power meet in code-augmented cyberspace? By *code-augmented* we mean virtual environments where interpersonal codes are enhanced or amplified or where there may be more codes than are present in unaugumented interpersonal communication. Will the more powerful individual demand more access than the other (e.g., the ability to "see" the lower status individual while presenting only a "mask" to that person)? There is ample precedent for these kinds of rules in interpersonal communication. For example, the bowing greeting rituals found in some cultures are in part motivated by rules as to who is "allowed" to have full view of the other, and whether eye contact between a high-status and low-status individual is "permitted."

Interpersonal communication rules in the new medium are likely to be negotiated and constructed. Take for example, the experience of the telephone. When the telephone first made its appearance, it was considered "rude" to call people you didn't know. And, in the same context, some claim that the meaning of the word "phony" emerged from the tendency for some people to fake their identity or to be pretentious and falsely familiar when talking to others on the telephone.[14] One can only wonder how the meaning of words like "cyber" might change in the age of virtual reality.

The rituals of interpersonal communication are culturally derived. Work on multimedia teleconferencing systems has highlighted the importance of different codes and rituals that facilitate interpersonal communication in various task environments (Brittan, 1992). Teleconferencing system designs that fail to appreciate the rules and cultural nuances of interpersonal communication are likely to distort communication or fail to gain social acceptance and adoption. It is also likely that different tasks and contexts—for example, discussion of engineering specs versus hard business negotiation—will require different interface configurations and codes.

No matter which rules and rituals emerge, it is unlikely that the absolute reproduction of face-to-face communication will always be the best or most desired mode of interpersonal interaction. In some ways, the social or technological equivalent of Lucky's presence dial may emerge to regulate the intensity of interpersonal communication in virtual environments.

Reproducing Interpersonal Communication

If the goal in communication media is to completely reproduce interpersonal communication, as some theorists believe (see Ciampa, 1989), then virtual reality faces a number of major technological hurdles. The full

[14]Webster's dictionary notes that the origins of the word are unknown, but most early references to the term are American and appear to date from the early part of this century.

transmission of personal presence is not within the means of the present technology. But this technology is likely to communicate a greater sense of presence than any before it.

Transmitting 2-D representations of human expressions, for example, is now relatively easy—picture phones and teleconferencing systems do this daily. But mutual presentation of 3-D representations of facial expression is likely to be more difficult—maybe a lot more difficult. Real-time 3-D digitizers do not yet exist, therefore, 3-D "movies" of a face cannot be captured.

MIT's Media Lab demonstrated one possible solution. The solution involved the projection of a 2-D moving image of a face on a 3-D form. One early attempt to do this used cathode ray tubes molded to the contours of a human face (Brand, 1988). These molded TV tubes were to be mounted on dummies sitting around a conference table. But this was not a practical system; the small benefit was clearly outweighed by the cost and cumbersome design of the system. Yet, the effort to produce such a system clearly demonstrated the desire to generate interpersonal presence across mediated channels.

A similar concept has been carried over into the more malleable world of virtual reality. In virtual environments, the costs and feasibility restrictions are eased. In some visions of an interpersonal communication system 2-D images of a human face are bit-mapped onto 3-D wire-mesh models. In some cases the wire-mesh models are generic; in others, the models are digitized wire-mesh models of the actual face of the individual. These animated masks painted with realistic faces can be used to represent the individual.

A critical challenge occurs when we attempt to animate these models. Why not just show a 2-D video image of someone's face on a mannequin face in a 3-D world? In the present generation of immersive VR systems it is not even possible to easily video facial expressions. The most immersive environments use head-mounted displays. These cover the face, especially the expressive eyes. Therefore, it is not possible to video the face of the individual. Because the person's face is covered, a real-time video image of his or her facial expressions is not available to be mapped onto a wire-mesh model of the individual inside the virtual world. Even if it were available, it might not be satisfactory to see an animated, video-projected face on a motionless 3-D mannequin.

One solution is to fully animate the wire-mesh model using some electronic measure of facial movement and a digitized model of appropriate facial expressions. Facial muscle movement could be measured electronically using electromyographic sensors. Based on this measure, the 3-D wire-mesh model could be animated. Moroishima and Harashima (1993) displayed an example of a facial animation system that could be used for teleconferencing and facial animation of virtual actors. In this system, a 2-D image of a face is stretched (bit-mapped) over a 3-D digitized wire-mesh model of the individual's head. Using Ekman's (1974) work on facial expressions, the movement of facial muscles is simulated to create facial expressions. These can be timed to audio tracks of phrases, and the structure of speech itself can be used as a cue to facial expression. The resulting animations can display a rather impressive, convincing range of facial expressions with only slight but noticeable cues of the inauthenticity of the expressions. These are highly realistic, animated masks.

Unfortunately, animated masks—even highly realistic ones—face obstacles. We have evolved a very discriminating ability to read faces. The perception of inauthenticity is likely to be very high, and potentially off-putting in instances where the viewing individual knows the person intimately. In such cases, it is unlikely that the generic algorithms for animating the face will capture the nuances of the individual's own natural expressions. In real-time animations of interactions, it is also likely that the simulated facial expressions may not accurately express the emotion of the individuals and could contribute to the miscommunication of intention or emotion.

On the other hand, individuals may adapt and compensate for imperfections in such a system. For example, the miscommunication of emotion is common in telephone conversations where facial expressions are not visible and must be imagined. Vocal cues of emotion become more important. In sensory-impoverished environments like electronic mail, codes such as ":-)" have been constructed to communicate the irony and humor cued in conversation by facial expression, voice pitch, and rhythm. These examples show that users use other cues to compensate for the communication system's inadequacies. It is likely that the additional layer of expressiveness presented by emerging facial animation systems may add a highly satisfactory and feasible communication of presence. The slight miscoordination of facial codes and meanings may be compensated for—as they are on the telephone—by more explicit aural statements of intent and emotion. As in all interfaces, people's usage of codes interacts with the bandwidth and flexibility of the physical media.

There is one additional advantage to having a facial animation system based on measures of facial muscle movement rather than just simple video images of facial expression. The facial animation system described above makes use of a highly realistic *mask* of the individual's real face. If the data from the sensors can be used to animate one mask, it can be used to animate *all manner of masks*. For humor, ritual, or other forms of social expression, individuals may prefer to tie their facial movements to fantastic masks, masks of the faces of famous people, or other forms of visual display. This kind of behavior has already been observed in teleconferencing systems. In one prototype system developed at Xerox Parc individuals were supposed to place still images of themselves in boxes on a computer screen. These were used to represent them in their office. Soon users replaced the dull images with creative cartoons or animated pictures. In one case, a programmer put up an animated clip of Elvis' face instead of his own. In interpersonal communication within VR environments, such forms of expressive play may be given full vent.

Transmitting Kinesthetics, Proxemics, and Touch

A significant amount of communication is transmitted through the movement of the body (*kinesthetics*) and the location of the body relative to others (*proxemics:* see Hall, 1966). Multiuser VR environments can and do make use of such codes. At their crudest, VR war games express intent by movement to and away from enemies and by raised arms pointing weapons. At the moment, the most common models of physical movements in VR environments are somewhat wooden. This is due to the fact that individuals are often presented by only two position points, usually the head and the hand. A wooden, and largely inexpressive graphic puppet is attached to these points and represents the individual in the environment. When a data glove is used, most finger motion is captured and the hand can potentially communicate a modest range of expression. For example, gestural languages are used to communicate commands to the computer and with other users.

More complete exoskeletal devices (see chapter 4 by Biocca & Delaney) can capture and communicate a full range of kinesthetic and proxemic messages. Here more nuanced 3-D motions of the extremities and torso can transmit meaning. But, at present, most exoskeletal devices are cumbersome, especially those that are also used to provide force feedback. On the other hand, lighter exoskeletons like data suits, which use fiber optic sensors, are light and flexible enough to allow body motion as expressive as dance (but not yet precise enough to register dance). But as a practical matter, there is some question as to whether individuals will be willing to wear special clothing for common teleconferencing, a point frequently made by Myron Krueger (1991) who advocates his less intrusive, but also less immersive "mirror worlds." Full body motion is desirable for full interpersonal expression, but it is clear that common teleconferencing requires highly unobtrusive means of capturing this information.

Transmitting Touch. Touch is the mark of intimacy. But most VR work on the transmission of touch is concerned with transmitting the sensation of distant or virtual objects like tools, rather than the touch of virtual humans (Shimoga, 1993a, 1993b). But it should be obvious that a technology developed for touching metal might also be used for touching skin. Touch is a very important part of intimate interpersonal communication, but only a small part of the more formal interpersonal communication of business and work communication. Most teleconferencing systems are designed for business and work communication—the likely markets for such expensive systems. Nonetheless collaborative work in such environments requires the joint handling of objects. Little is known about how users would accept and use mediated touch systems for interpersonal communication. Anyone who has spoken publicly on the topic of virtual reality knows that discussion of tactile feedback often leads VR enthusiasts to fantasize and joke about the possibility of "teledildonics," a term apparently coined by Ted Nelson for the remote, computer simulation of sexual contact (see Rheingold, 1991). But touch is more active in the imagination of virtual reality, than in the hardware and software.

Sometimes More is Better

"Perhaps the reason present-day two-way telecommunication falls so far short of face-to-face communication is simply that it fails to provide facilities for externalizing models. Is it really seeing the expression in the other's eyes that makes the face-to-face conference so much more productive that the telephone conference call, or is it being able to create and modify external models?" (Licklider & Taylor, 1968, p. 23).

Most intriguing is the potential expressive power of the development of flexible, augmented, interpersonal communication codes that exceed and enhance the range of codes available for personal expression, communication of intent, or interpersonal play (see Lanier & Biocca, 1992). These might help individuals communicate and construct more elaborate mental models[15] of interpersonal messages. In everyday communication, humans use artifacts to augment interpersonal communication codes. For example, women's makeup such as rich, red lipstick and striking eyeliner increase the salience and expressiveness of major communication "media," the lips and eyes. Clothing is often used to increase or decrease the salience of body shape or motion. In most cases, this is done to communicate aspects of sexuality, physicality, group membership, power, or status.

In virtual environments, the use of artifacts to augment interpersonal communication codes may be greatly enhanced. Artists often invent or explore these codes. McLuhan argued that "The artist is the person who invents the means to bridge between biological inheritance and the environments created by technological innovation" (McLuhan & McLuhan, 1988,

[15]Although many agree that mental models influence communication, not everyone agrees as to the structures of mental models. See Johnson-Laird (1984) for a seminal work on mental models. See Biocca (1991) for a theory of mental models of communication messages.

p. 98). This may be true of the development of augmented interpersonal communication codes. The exploration of augmented interpersonal communication is still unsystematic and largely the domain of VR artists like Krueger (1991). In Krueger's work we see some of the possibilities of interpersonal play using augmented codes. In one Krueger demo, giant hands nudge small bodies. In Krueger's "Tickle" the vibrating edges of a body radiate sound when touched. In another a moving body leaves behind visual "echoes" undulating in brilliant color. In such "experiments" we see possibilities for new ways to use the human body for expressive interpersonal communication.

The pursuit of augmented interpersonal communication strikes at some fundamental concepts of communication. As Licklider and Taylor suggested, all communication is about the construction, externalization, and reception of mental models (Biocca, 1991; Johnson-Laird, 1983). This is especially true of cooperative work. In cooperative work group actions must be based on some common communicated goals (e.g., agreement to construct a house) and some code-based model of the objects of collective action—the relevant things, actions, and world (e.g., the architectural plans for a house). Virtual reality can provide the tools to more easily express and share these models. The communication associated with architecture and construction is a good example because work at the University of North Carolina and elsewhere has already shown the value of virtual reality for the expression and communication of models of future living spaces.

Exploration of augmented interpersonal communication by interdisciplinary teams that include interpersonal communication researchers might provide more systematic insight into fruitful directions for human-to-human interaction and how VR interfaces might be designed to augment human communication.[16] But like the ill-fated attempts to design universal languages like Esperanto, it is unclear whether augmented human communication codes can be created by designers, labs, or committees. It is likely that the inventive imagination of artists and users will generate infinite variations of codes from specific needs of free play. In some ways, interpersonal communication in the age of virtual reality is likely to remain improvised and creative, as users define VR's communication norms (e.g., observe the emerging codes and norms in virtual communities such as the use of emoticons, e.g., (:-), see Rheingold, 1993).

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[16]To some degree, this kind of work goes on in teams that explore cooperative work in various virtual environments at research centers like Xerox Parc, Bellcore, Media Lab, and others. While these are indeed creative centers, there is the possibility that the product development focus of the research might inhibit the exploration of apparently "frivolous," but ultimately more rewarding directions.

IF WE BUILD IT, WILL THEY COMMUNICATE?

We have touched upon only a few of the communication issues related to the development of VR applications. We hope we have given the reader a flavor of some of the creative possibilities potentially unleashed by this emerging medium. Experience of the more engaging forms of these applications remains at some point in the future. But the tapping of computer keys—the hammers and anvils of the computer industry—is busily stringing together the lines of code that will drive new communication applications. This creative tapping may start to sound like a deafening industrial clanging as more institutions and more individuals turn their talents to the crafting of VR communication applications. In the end we can only judge these applications by what they yield in our minds and for our society. It remains to be seen if virtual reality and its new communication applications will increase our understanding of human communication or human understanding of each other. Optimism usually greets the dawn of a new medium.

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