1

INTRODUCTION

In November of 1990 Richard Ruopp, the former president of Bank Street College in New York City, gave a speech at an education conference sponsored by Columbia University without speaking a word. Ruopp has amyotrophic lateral sclerosis (loss of motor neurons resulting in the progressive loss of motor function), more commonly known as Lou Gehrig's disease. Despite having completely lost the ability to speak, Ruopp, with the help of a laptop computer, a software package called HandiChat Deluxe, and a DECtalk speech synthesizer, was able to give his presentation. Using this system, his speech, which had previously been typed into the computer, was "spoken" by the speech synthesizer. After completing his talk, Ruopp was able to answer questions from the audience by typing his answers into the computer and having them played back through the synthesizer.[1] Ruopp was using what is known as adaptive technology.

Adaptive technology includes a wide range of technologies—technologies which are increasingly computer based. Scanning systems allow an individual who is blind to take a printed text and have it read back to him or her aloud. Individuals who have cerebral palsy can use their head movements to guide an electronic beam across a special keyboard in order to communicate. A gifted student who is also learning disabled, and who has great difficulty reading, can use a talking word processor to write stories and improve her reading.[2] An adult with little or no control over his body movement, but who can still speak, can control his environment by talking into a computer that can recognize spoken commands.[3] An individual who can move only his eyes can type messages on a computer using his eye movements.[4]

In each of the cases described above, an individual has overcome a disability through the use of computer-based adaptive technology. This emerging and innovative technology has become possible because of the widespread proliferation and use of inexpensive computers.

In an earlier work, *Beyond the Gutenberg Galaxy*, one of the authors argues that the introduction of inexpensive personal computers in the late 1970s set in motion an intellectual, technological, and social revolution that parallels to a remarkable degree the invention of moveable type in Europe in the late sixteenth century.[5] Just as printing brought about the creation of a typographic culture, the advent of the microcomputer represents:

> a critical force that is bringing to an end typographic culture and creating in its place a post-typographic culture and consciousness. After 500 years Western society is leaving the Gutenberg Galaxy and entering a new universe. The microcomputer is the key to this universe.[6]

By drawing on the power of the computer, adaptive technology—as we will demonstrate throughout this work—is also part of this new universe.

THE COMPUTER AS A PROSTHETIC DEVICE IN THE COGNITIVE AND PHYSICAL DOMAINS

The idea of the computer as enhancing and extending the capabilities of individuals in the cognitive and physical domains is a relatively new concept for most people. Despite this fact, the literature in computer science includes discussions of this issue dating back to the early 1960s.

In 1963 Douglas C. Engelbart argued in his essay "A Conceptual Framework for the Augmentation of Man's Intellect,"[7] that it would be possible to augment human intelligence through the use of computers. As he explained:

> By "augmenting man's intellect" we mean increasing the capability of a man to approach a complex problem situation, gain comprehension to suit his particular needs, and to derive solutions to problems. Increased capability in this respect is taken to mean a mixture of the following: that comprehension can be gained more quickly; that better comprehension can be gained more quickly; that better comprehension can be gained; that a useful degree of comprehension can be gained where previously the situation was too complex; that solutions can be produced more quickly; that better solutions can be produced; that solutions can be found where previously the human could find none.[8]

Engelbart was talking about the use of computers with normal populations, but his ideas apply equally well to individuals who are cognitively limited or disabled. A child who is dyslexic and has great difficulty reading can have a block of text on a computer screen read aloud to her using adaptive technology. A child who has difficulty learning mathematics can be assisted in solving problems through the presentation of visual representations on the computer.

Engelbart argued that the effect which an individual has on the world is essentially dependent on "what he can communicate to the world through his limited motor channels."[9] The individual's communication, in turn, depends on what information he or she has received through his or her limited sensory channels, his or her personal needs, and how he or she processes that information.[10] Using the computer and adaptive technology, an adult with a disorder like cerebral palsy, who has been severely limited in her ability to communicate, can for the first time convey her thoughts and feelings. While Engelbart refers in his work to the augmentation of human intellect through the use of the computer, we would make the distinction that in the context of the individual with disabilities the computer and adaptive technology have the potential not just to augment the individual's intellect, but also to provide the means to reveal it.

The computer and adaptive technology provide the means for the disabled individual to go beyond the ability to communicate, to allow him or her to actually manipulate and control the environment. Through the use of switches—on/off computer input devices—a physically disabled individual can control a thermostat, answer a phone, direct a robot device to bring food, or activate the motor on an electrically powered wheelchair. Using such applications in adaptive technology, the disabled individual can achieve personal independence by manipulating objects and symbols connected to mechanical devices.

CYBERSPACE, CYBERNETICS, AND CONTROL

Adaptive technology employs several different methods and techniques. Some of these methods and techniques involve the manipulation and control of physical devices, while others involve the manipulation and control of *cyberspace*—a term used by science fiction writers such as William Gibson to describe the "inner space" of the computer.[11] In his novels, and in the stories of authors like Vernor Vinge, individuals using simulations enter into computer-created realities. These realities may or may not be based on the real world. Thus a user may enter into a fantasy world like the one found in J. R. R. Tolkien's novel *The Lord of the Rings* in which sorcerers and magicians have real powers, in which elves and dwarfs can be turned into stone, and in which dragons can fly. In Vinge's novella *True Names*, an elderly woman living in a high-rise apartment in Connecticut uses her computer to assume the role of a powerful sorceress at war with other people in cyberspace.

Cyberspace can also create realties that closely replicate the real world. A flight simulator, for example, can provide a pilot with an experience of flying in a storm with a damaged engine, or any of a wide range of conditions that closely imitate real flying conditions.

The term cyberspace is based on Norbert Wiener's term *cybernetics*. Wiener derived cybernetics from the Greek word *kubernetes* or "steersman." In defining cybernetics, Wiener "classed communication and control together." In doing so, he explains that:

> When I communicate with another person, I impart a message to him, and when he communicates back with me he returns a related message which contains information primarily accessible to him and not to me. When I control the actions of another person, I communicate a message to him, and although this message is in the imperative mood, the technique of communication does not differ from that of a message of fact. Furthermore, if my control is to be effective I must take cognizance of any messages from him which may indicate that the order is understood and has been obeyed.[12]

The use of adaptive technology, by definition, implies both communication and control. When an individual enters a simulation, he or she, is entering not only into a mode of communication, but also into a system of control.

In a simulation, control can be exercised by an individual manipulating a computer within cyberspace, or over an individual. This later case—that of control being exercised over an individual—involves the computer and its programs directing the individual. The question of to what extent the individual controls or is controlled by the computer is a fundamental ethical and moral issue that must be addressed by those interested in the use of adaptive technology and computers.

ON THE NON-NEUTRALITY OF THE COMPUTER

It is widely assumed that computers are a neutral technology; yet neither computers, nor the simulations that they create, are neutral. As Ted Nelson has argued, every simulation has a point of view.[13] C. A. Bowers addresses the same question from a slightly different perspective when he questions

> ...whether the technology is neutral; that is, neutral in terms of accurately representing, at the level of the software program, the domains of the real world in which people live.[14]

Bowers argues that computers must be understood as "part of the much more complex symbolic world that makes up our culture."[15] We must look at them in more than just a procedural context to better understand how they mediate and change our systems of knowledge and ways of interpreting the world around us.[16]

In this context—and more specifically the context of adaptive technology—we must ask what it is that the computer and its software selects for amplification and for reduction.[17]

In the case of a communication board used by individuals unable to produce speech, users are limited by the constraints of the board's program and hardware. If the device can only output messages that have been pre-programmed, then individuals attempting to communicate using the device may find themselves highly constrained. They may want to communicate a desire for a banana or another piece of fruit, while the device only indicates food. They may want to indicate concern, while the machine is only programmed to express anger. Limitations in hardware may mean that a device is incapable of being easily reprogrammed and must be sent to the manufacturer or a lab to be adapted to the specific needs of an individual.

In a software simulation, a physically disabled child may have the opportunity to sense some of the excitement that a fully enabled individual has when playing a game such as football or driving a race car. It should be emphasized, however, that the simulation that is created may have certain aspects of the experience amplified or reduced by what is or is not included in the program. For example, in a race car driving program is the race viewed from the perspective of the driver inside the car or from an overhead view that shows the race cars moving through the track in relationship to one another? In a simulated football game, does the quarterback get feedback from the crowd in the form of boos or cheers?—do weather conditions change and affect the condition of the field? and so on.

In the context of the examples cited, we are not arguing against the use of simulation, but instead are asking not only developers, but also users and enablers, to consider more carefully what it is that a program either emphasizes or de-emphasizes. In doing so, there should be an implicit recognition of the limitations inherent in a simulated environment. This question is particularly relevant with the emergence of new technologies such as virtual reality.

VIRTUAL REALITY AND ADAPTIVE TECHNOLOGY

In the last few years a revolutionary simulation technology has begun to emerge, which has important implications for the field of adaptive technology. While still in its earliest stages of development, this technology, known as virtual reality, promises to rapidly develop in the near future and change in revolutionary ways how we approach and use computers.[18]

Many types of virtual reality systems have been developed. On one level, it could be argued that a sophisticated flight simulator represents a type of virtual reality system. More recently, however, virtual reality equipment has involved the use of sophisticated programs with devices such as eyephones (a tiny pair of video screens that are mounted in front of each eye that provide stereo vision of a computer-created reality), data gloves (in which sensors lining one's hand communicate movement to a graphics computer), and stereo earphones and positional sensing equipment, through which one can enter a simulated computer environment.[19]

Autodesk's Cyberspace program, for example, lets architects and designers stroll through three-dimensional models by putting on stereoscopic goggles. A 3-D model surrounds the user and changes the perspective and point of view as the user turns or tilts his or her head, or walks forward, backwards or sideways. The user also wears a data glove wired with fiber optic sensors. Using the data glove, objects can be manipulated within the simulation that is created by the system. Doors can be opened and shut, objects grasped and a sense of function in "real space" gained in ways that have never been thought possible before.[20]

A preview of the possibilities with virtual reality can be seen in the holodeck device that is included in many of the episodes of the science fiction television program "Star Trek: The Next Generation." Users entering the holodeck are able to participate in virtual simulations that appear completely lifelike. Characters on the program, while moving in their spaceship across the galaxy at enormous speeds, are able to visit a picnic spot and fishing hole on earth, or to assume the role of a historical character in the eighteenth century.

We are convinced that simulations of this type are the logical endpoint in the development of virtual reality systems. How long it will take before it is possible to experience the types of simulations that are available to the members of the crew of the *Enterprise* is of course impossible to precisely predict. However, it seems reasonable that if computers and simulation programs continue to evolve as rapidly as they have in the past decade, Star Trek's holodeck—or something like it—will be part of our future fairly soon.

The implication of technologies such as virtual reality for individuals with disabilities is enormous. Imagine, for example, two individuals whose control over their bodies is limited to eye tracking movement. Connected to virtual reality systems, they have the potential to move through cyberspace in a simulation that could allow them the illusion that they are fully mobile. In its most advanced application, this might involve implanting hardware in the various sectors of the brain that provide feeling and sensation. It is conceivable that individuals who are almost totally paralyzed in the physical world could engage in touching and feeling and even sexual relations in a cyberspace world created with virtual reality techniques.

Of course serious questions arise. What is reality? Where does being a human and being a machine sort itself out? Do we lose something of our humanity by engaging in such techniques? These are serious questions that will have to be addressed in the future, as we advance into progressively more sophisticated applications and use of virtual reality.

ON THE HUMAN USE OF HUMAN BEINGS

Returning to possible futures suggested by science fiction, on "Star Trek: The Next Generation," Jordie, the chief engineering officer for the *Enterprise*, is blind. A sensing device, which he wears like eyeglasses and which is connected directly to his brain, enables him to see. Such devices are in the early stages of development and, while today are only fully realized in science fiction, have the very real likelihood of coming into being in the near future. If such a scenario seems far-fetched, consider the fact that cochlear implants have been used for several years now to transmit sounds via the neural pathways of deaf individuals.

Just how far such technologies might take us is suggested by Hans Moravec, a robotics researcher at Carnegie Mellon University. Moravec predicts, for example, that in the next generation we will have the potential to download a human intelligence onto a computer, where it will be able to direct and control robotic mechanisms.[21] The potential uses of such technology in a field such as adaptive technology are mind-boggling.

Using technology of the type outlined by Moravec, it would be theoretically possible to have the consciousness of a paralyzed individual transferred to a robot, which could allow the individual to function in a day-to-day world. Will such possibilities be liberating or tragically dehumanizing? Would it be morally right to send a human consciousness in a robotic device into the deep reaches of space? What distinctions will be made between being human or being a machine?

Like Prospero in Shakespeare's *Tempest*, we and others interested in adaptive technology are faced with a "brave new world." It is a world fraught with perils and possibilities, which we must carefully consider and reflect upon as we enter into this remarkable new field.