Body Smarts

In an age of pacemakers and microchip implants, the old nightmare vision of man melding into machine no longer seems completely far-fetched. Not to worry, says a noted observer of technology. Surprising things happen when the body interacts with technology.

by Edward Tenner

For more than 50 years, enthusiasts have proclaimed the coming of a new age of technologically augmented humanity, a somewhat unsettling era of bar-coded convicts and chip-implanted children. But technology has been reshaping the body since the very dawn of civilization. The feet of shod people, for example, are physiologically different from those of people who have always walked barefoot. Technologies as various as the thong sandal and the computer mouse have affected how we use our bodies—the *techniques* we employ in our everyday lives—and this coevolution of technology and the body has not always followed the course engineers and other designers imagined. The question now is whether mind, body, and machine will fuse in some radical new way over the next generation.

The enthusiasts themselves are far from agreement on the mechanism that might achieve such a fusion. For some, the new intimacy between humans and machines will simply involve more portable and powerful versions of devices we already take with us—computers, for example, that might be carried as we now carry cell phones and personal digital assistants (PDAs), to be viewed through special eyeglass displays. Spectacles might also transmit the emotional states of their wearers, so that a speaker, for example, could detect an audience's interest or boredom. There are already sneakers that can transmit or record information on a runner's performance, and civilian motorcycle helmets with intercoms and navigational aids built in.

Other enthusiasts scorn mere wearability. They're having sensors and transmitters surgically implanted in their bodies—as, for example, some deaf individuals have been fitted with cochlear implants that restore hearing. The cyborg, or human machine, is an especially powerful and persistent notion, perhaps because it seems a logical next step from technological symbiosis. (Politically, the cyborg idea—which for a few enthusiasts is a movement—spans a continuum from Paul Verhoeven's original *Robocop* film in 1987 to the work of cultural scholars such as Donna Haraway and Chris Hables Gray, who see the connection between human and machine as an emancipatory strategy against rigid economic and gender roles.)

But is the body really becoming more mechanized? Is the interaction of technology and human behavior all that new and frightening? Despite the legend, George Washington never wore wooden teeth, but his last pair of dentures, made of gold plates inset with hippopotamus teeth, human teeth, and elephant and hippo ivory, and hinged with a gold spring, were as good as the craftsmen of his time could produce. Still, he suffered great discomfort, and ate and spoke with difficulty (perhaps the enforced reserve enhanced his dignity). At any rate, if the nation's first president was a cyborg, it's not surprising that one in 10 Americans had some nondental implant—from pacemakers to artificial joints—by 2002. Nor was Washington an isolated case: Benjamin Franklin's bifocals and Thomas Jefferson's semireclining work chair were giant steps in human-mechanical hybridization. One might even say that John F. Kennedy was continuing the cyborg tradition when he

became one of the first politicians to adopt the robotic signature machine, a giant and distinctively American step in the cloning of gesture.

The many amputations wounded soldiers suffered during the U.S. Civil War led to the creation of an innovative artificial-limb industry. Today, responsive advanced prosthetics, wheelchairs, vision implants, and other assistive devices exceed the 19th century's wildest dreams. (There has even been litigation in the United States over whether a teenage swimmer with an artificial leg was unfairly barred from wearing a flipper on it.) But the first choice of medicine is still the conservation of natural materials and abilities. Thus, the trend in eye care has been from spectacles to contact lenses to laser surgery, and dentistry has moved steadily from dentures to prophylaxis and the conservation of endangered natural teeth. Some dental researchers believe that adults may be able to grow replacement teeth naturally. Other forms of regeneration, including the recovery of function by paraplegics and quadriplegics, may follow.

The body remains surprisingly and reassuringly conservative, and humanity has stayed steadfastly loyal to objects that connect us with our environment. The traditional zori design—the sandal with a v-shaped thong separating the big toe from the others—is still used for some of the most stylish sandals. Athletic shoes with the most technically advanced uppers and soles still use a system of lacing at least 200 years old. For all their additional adjustments, most advanced new office chairs still rely on the 100-year-old principle of a spring-mounted lumbar support, and recliners still place the body in the same contours that library chairs did in the 19th century; according to industry sources, interest is fading in data ports built into recliners and in other technological enhancements. The QWERTY arrangement of the keyboard has resisted all reform, and alternatives to the flat conventional keyboard are expensive niche products, partly because, in the absence of discomfort, so few users are willing to learn new typing techniques. A century after the piano began to lose prestige and markets, it remains the master instrument, with a familiar keyboard.

Computers now allow the production of advanced progressive eyeglasses without the visible seam of bifocals, but wearers still hold them on their heads with the folding temples introduced in the 18th century. The latest NATO helmet still reflects the outlines of the medieval sallet. But then, our skulls—like our foot bones, vertebrae, fingers, eyes, and ears—have not changed much. Even the automatic transmissions in our cars rely on a familiar tactile principle, a knob or handle and

lever; the seemingly more efficient push-button shifter was largely abandoned after the Edsel. And the 21st century's automobiles are still directed and controlled by wheels and pedals—familiar from early modern sailing ships and wagons—rather than by the alternative interfaces that appear in patents and experimental cars. Meanwhile, many technological professionals study body techniques that need few or no external devices: yoga, martial arts, and the Alexander technique (a series of practices developed by a 19th-century Australian actor to promote more natural posture, motion, and speech).

Even Steve Mann, the Christopher Columbus of wearable computing, has misgivings about integrating himself with today's "smart" technology. Mann, who holds a Ph.D. in computer science from the Massachusetts Institute of Technology, was photographed as early as 1980 wearing a helmet equipped with a video camera and a rabbit-ears antenna. But in his book *Cyborg* (2001), he acknowledges being "increasingly uncomfortable with the idea of a cyborg future," where privacy is sacrificed for pleasure and convenience to a degree he compares to drug addiction.

Today's advanced cyborg technology is a harbinger of neither a utopian nor an apocalyptic future. Virtual reality helmets, often featured in scare scenarios of the future, are still not playthings; they're professional tools demanding rigorous training in physical and mental techniques if wearers are to avoid disorientation and lapses in judgment. At the other extreme of complexity, the miniature keyboards of cell phones and other devices are exerting a surprising influence at the level of everyday life. They're shifting the balance of power of the human hand from the index finger to the thumb. C. P. E. Bach elevated the role of the thumb in musical keyboarding 250 years ago, but touch-typing pioneers of the 20th century rediscovered the fourth and fifth fingers and banished the thumb to space bar duty. Now the thumb is enjoying a renaissance. It has returned to computing with the introduction of pen- and pencil-like devices such as the styluses used with PDAs. The latest computer mouse, developed by the Swedish physician and ergonomist Johan Ullman, is gripped and moved around the desk with a pen-shaped stick that uses the precision muscles of the thumb and fingers and doesn't twist the hand and tire the forearm. Even thumb-dependent pencils are resurgent, their unit sales having increased by more than 50 percent in the United States in the 1990s.

The biggest surprise is the thumb's role in electronics. In Japan today, so many new data-entry devices rely on it that young people are called *oyayubi sedai*, the Thumb Generation. In Asia and Europe, users have turned technology on its head: Instead of using the voice recognition features of their phones, they're sending short text messages to friends, thumbs jumping around their cellular keyboards in a telegraphic imitation of casual speech. By spring 2002, there were more than 1.4 billion of these transmissions each month in the United Kingdom alone.

One British researcher, Sadie Plant, has found that thumbs all around the world are becoming stronger and more skillful. Some young Japanese are now even pointing and ringing doorbells with them. As Plant told *The Wall Street Journal*, "The relationship between technology and the users of technology is mutual. We are changing each other." Always attuned to social nuance, the "Style" section of *The Washington Post* also noted the ascent of the formerly humble digit. The major laboratories did not predestine the thumb to be the successor to the index finger, though they did help make the change possible; its full capacities were discovered through collaborative experimentation by users, designers, and manufacturers. The ascendancy of the thumb is an expression of the intimate relationship between head and hand described by the neurologist and hand injury specialist Frank Wilson, who speaks of the "24-karat thumb" in his book *The Hand*

> Edward Tenner, *a former Wilson Center fellow, is the author of* Why Things Bite Back: Technology and the Revenge of Unintended Consequences *(1996) and the forthcoming* Our Own Devices: The Past and Future of Body Technology *(2003), from which this essay is adapted. He is a senior research associate of the Lemelson Center for the History of Invention and Innovation at the National Museum of American History.*

(1998): "The brain keeps giving the hand new things to do and new ways of doing what it already knows how to do. In turn, the hand affords the brain new ways of approaching old tasks and the possibility of understanding and mastering new tasks."

But change is not without cost. We learn new body skills to the neglect of others, and humanity has been losing not only languages but body techniques. Scores of resting positions known to anthropologists are being replaced by a single style of sitting. Countless variations of the infant-feeding bottle compete with the emotional and physiological rewards of nursing. The reclining chair, originally sold partly as a health device, has become an emblem of sedentary living. The piano's advanced development in the late 19th century prepared the way for the player piano, and ultimately for recorded music. Typewriter and computer keyboards eliminated much of the grind of learning penmanship, along with the pleasure of a personal hand (today's children may still grumble, but rarely must they learn the full, demanding systems of the 19th-century master penmen). The helmet wards off danger even as it encourages overconfident wearers to engage in new and dangerous activities. All these devices augment our powers, but in doing so they also gain a power over us.

The challenge within advanced industrial societies is to cope with a degree of standardization that threatens to choke off both new technologies and new techniques. We need a return to the collaboration between user and maker that marked so many of the great technological innovations, whether the shaping of the classic American fire helmet or the development of the touch method by expert typists and typing teachers. Research in even the most advanced technical processes confirms the importance of users. In the 1980s, for example, the economist Eric von Hippel studied change in high-technology industries such as those that manufacture scientific instruments, semiconductors, and printed circuit boards. Von Hippel found that up to 77 percent of the innovations in the industries were initiated by users. He therefore recommended that manufacturers identify and work with a vanguard of "lead users"—as was done in the past, for example, when 19th-century musicians worked with piano manufacturers, or when the typewriter entrepreneur James Densmore tested his ideas with the court reporter James O. Clephane in developing the QWERTY layout, an efficient arrangement for the four-finger typing technique that prevailed until the victory of the touch method in the 1890s. Today's cognitive psychologists of work are rejecting the older model of a single best set of procedures and learning from the experience of workers and rank-and-file operators how equipment and systems can be modified to promote greater safety and productivity. As one psychologist, Kim J. Vicente, has written, "Workers finish the design."

Design should be user friendly, of course, but it should also be user challenging. The piano keyboard is rightly celebrated as an interface that's at once manageable for the novice and inexhaustible for the expert. Information interfaces should similarly invite the beginner even as they offer the experienced user an opportunity to develop new techniques; they should not attempt to anticipate a user's every desire or need. The practice of participatory design, introduced in the 1970s by the mathematician and computer scientist Kristen Nygaard, began with Norwegian workers who wanted a say in the development of technology in their industries and was ultimately embraced by corporations worldwide.

The keyboard that's negotiated with a thumb is a threat to handwriting traditions, whether Asian or Western, and that's regrettable. But adapting to its use is a mark of human resourcefulness and ingenuity. The thumb, a proletarian digit ennobled in the digital age, is an apt symbol for a new technological optimism based on the self-reliance of users. The index finger—locating regulations and warnings in texts, wagging and lecturing in person—signifies authority, the rules. The thumb, by contrast, connotes the practical knowledge men and women have worked out for themselves, the "rules of thumb." It represents tacit knowledge, too, the skills we can't always explain, as with a "green thumb." And when extended during the almost lost art of hitchhiking, the thumb displays the right attitude toward the future: open and collaborative, but with a firm sense of direction. ❑