brain
SUMMER 2002 BRIEFINGS

**EVEN SIMPLE MOVEMENTS, SUCH AS PICKING UP FOOD TO EAT, CAN DISAPPEAR WHEN AN ACCIDENT OR INJURY CAUSES THE LOSS OF A LIMB OR DAMAGE TO THE SPINAL CORD. NOW, FOLLOWING YEARS OF RESEARCH, SCIENTISTS HAVE DEVELOPED SYSTEMS THAT CAN BYPASS THE LOSS OR DAMAGE BY DIRECTLY INTERPRETING AN ANIMAL'S BRAIN SIGNALS AND LAUNCHING MOVEMENT IN ROBOTIC LIMBS. THE ADVANCES MAY LEAD TO NEW WAYS TO HELP DISABLED PEOPLE REGAIN MOBILITY.**

## ROBOTIC LIMBS

Zip, zap, zing. Pure mental power propels a robotic arm to reach out and clutch an apple.

This scenario once seemed more relevant to a science fiction movie script than a scientific study. But over the past three decades a better understanding of how the brain controls movement urged many scientists to seriously scrutinize the notion of thought-driven artificial limbs. Most recently researchers translated their knowledge into the development of systems that can interpret an animal's brain signals and launch movement in robotic devices. The new advances are leading to:

- Creative methods to provide movement in disabled people who have lost a limb or are paralyzed from a spinal cord injury.
- Insights into how technology can boost medical progress.

In healthy animals and humans, the brain constantly computes and sends complex signals in order to move an arm, hand, leg or foot. Much of today's research in the robotic limb field comes from earlier studies that decoded this special language. For example, back in 1970, researchers discovered that a specific pattern of activity in a small set of brain cells could predict the force changes in wrist movements of a monkey. Several other animal studies revealed additional aspects of the movement language, such as the type of cell activity required to propel the arm in a certain direction.

Armed with this information, researchers began to develop computer programs that could read and decode the language and then set off an intended movement in a robotic limb.

So far researchers have had success with the programs in monkeys, rats and

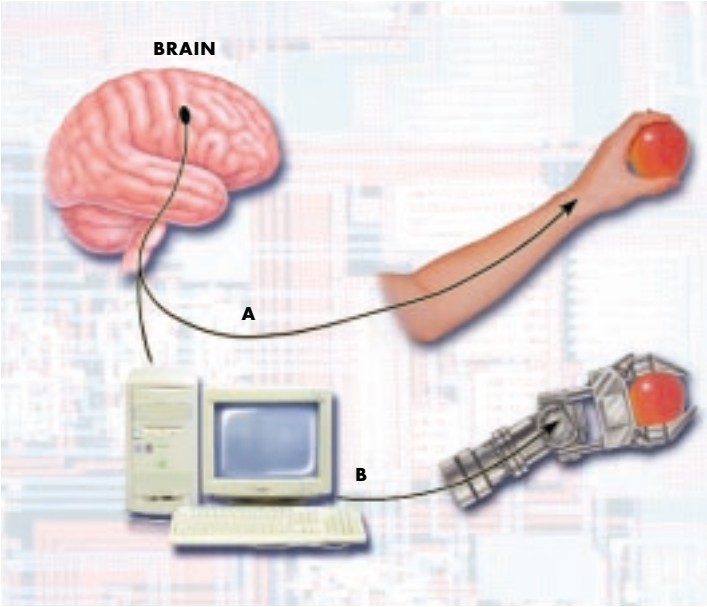


ILLUSTRATION BY LYDIA KIBIUK

▲ A) THE BRAIN EMITS A BARRAGE OF SIGNALS THAT FORM A PLAN ON HOW THE MUSCLES AND JOINTS OF THE ARM, FINGERS AND WRIST NEED TO MOVE TO ACCOMPLISH A DESIRED TASK. SENT DOWN THE SPINAL CORD TO THE ARM, THESE SIGNALS ALLOW YOU TO GRASP AN APPLE FOR LUNCH. AN ACCIDENT OR INJURY THAT CAUSES THE LOSS OF A LIMB OR DAMAGE TO THE SPINAL CORD, HOWEVER, CAN SEVER THIS COMMUNICATION LINE AND PREVENT A DESIRED MOVEMENT. B) IN AN EFFORT TO COUNTER THE PROBLEM, SEVERAL GROUPS OF RESEARCHERS ARE TESTING SYSTEMS IN ANIMALS THAT CAN INTERPRET BRAIN SIGNALS AND LAUNCH MOVEMENT IN ROBOTIC LIMBS. WITH FURTHER ADVANCES, THEY HOPE THAT DISABLED PEOPLE WILL BE ABLE TO INCORPORATE THE ROBOTIC DEVICES INTO PART OF A REPRESENTATION OF THEIR BODY AND REGAIN LOST MOVEMENT ABILITIES.

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even lamprey, eel-like creatures. For example, in recent work scientists implanted electrodes that detect cell activity into the brains of two monkeys. Computer programs analyzed the activity, predicted the monkey's planned movement and sent the command to a robotic arm. When a monkey extended its arm, the robotic arm would move simultaneously in a similar fashion.

Early work also shows that a variation of the brain-reading systems, designed for people who can barely move or speak, helped one person use their thoughts to move a computer cursor and spell words.

Researchers believe that in the future the more complex robotic limb system also could help disabled humans replace their lost movements. But first they need to work on several areas, including feedback components. For real-world use of a robotic limb, the brain needs to exchange signals to and from the appendage, creating a loop of interaction. Already, rat and lamprey studies showed that the brain could detect and react to feedback. Currently, researchers are providing feedback components, such as visual cues, to monkeys. For example, in early work, one group trained monkeys that had both arms restrained to use their brain power to make a cursor, a sort of animated arm, reach toward a target in a virtual reality environment. The monkeys can see how their thoughts move the cursor, which allows them to adjust their reactions and improve their performance. Next they want to replace the cursor with a robotic limb.

Researchers also are trying to find the best areas to insert the electrodes. Many focus on the motor cortex, a brain area known to control movement. Another group is investigating the nearby posterior parietal cortex. They believe this area processes sensory information, such as signs of touch and visual cues, to make the earliest plans of a movement.

In addition, more work is needed on the technical side. Today's electrodes are not extremely stable. Researchers are working to create systems that stay rooted in their intended area and provide long-term, high-quality signals.

With continued advances, however, the zip, zap, zing may soon help human brains launch movements in robotic limbs, putting apples and life back in reach.

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