Rewiring the Brain
By Jeffrey Kluger / Cleveland

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It's harder than you think to say hello to your mother--at least in terms of the work your brain has to do. A glimpse of Mom must first register on your occipital lobes as a pattern of light and shadow. From there it is relayed to your memory center, where it is identified by comparison with every other face you've ever seen. You must then summon the speech centers in your frontal lobes, which recruit your breath and muscles and at last allow you to utter the words Hi, Mom.

The fact that recognizing and acknowledging a familiar person is such a complex thing made it all the more remarkable in early August when scientists announced that a 38-year-old man had managed to pull it off. The man, whose identity was withheld, had suffered severe brain damage in a 1999 mugging and spent the past eight years in the dark cognitive well that neuroscientists call a minimally conscious state. Improbably, however, he can now greet both his parents. He can identify objects, hold very brief conversations and watch movies, and he recently recited the first 16 words of the Pledge of Allegiance. "I told him to say the pledge, and he did," says neuropsychologist Joseph Giacino of the JFK Johnson Rehabilitation Institute and the New Jersey Neuroscience Institute. "I didn't have to cue him."

None of this is the stuff of functioning adulthood, but all of it is huge for a person who was never supposed to manage anything like it again. And all of it is a result of the growing therapeutic science of deep-brain stimulation (DBS). Doctors at the Cleveland Clinic inserted a pair of fine wires into the mugging victim's brain last year, threading them down to the thalamus, a deep, intact structure that could, in theory, jump-start the surviving circuits in the damaged cerebral cortex above. Very low current was sent through the wires, stimulating the thalamus, which indeed awakened the higher brain.

Using DBS in severely brain-damaged patients may be a brand-new breakthrough, but the technology has already proved itself as a treatment for the tremors of Parkinson's disease, is nearing Food and Drug
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Administration (FDA) approval for obsessive-compulsive disorder (OCD) and is in clinical trials as a therapy for depression. Studies suggest it could also help control symptoms of Alzheimer's disease, dystonia—or paralytic muscle rigidity—epilepsy and even some addictions. "DBS is like a pacemaker for the brain," says Cleveland Clinic neurosurgeon Ali Rezai, who performed the operation on the brain-damaged man. "We pinpoint the part that needs stimulation and provide it."

For something that counts as brain surgery, a DBS procedure can be a surprisingly relaxed thing. On a recent morning in Cleveland, Scott Stipp, 55, a businessman and Parkinson's patient, lies lightly sedated on an operating table while Rezai and a team of surgeons drill a hole about as large as a dime in the crown of his head. Rezai then threads a wire just 4 microns thick—or four-thousandths of a millimeter—into Stipp's brain. Guided in part by CT scans and in part by real-time readings of electrical activity that the probe encounters as it passes different neural structures, surgeons aim for the subthalamic nucleus (STN), an olive-size clump of tissue deep in the basal ganglia that helps govern motor control. For much of the morning, Stipp's right arm has been shaking violently enough to rock the table.

"Go ahead, tremor away," says Rezai. "We want to see where the STN is."

"No problem there," Stipp says, laughing.

When the probe hits home, Rezai asks Stipp to perform a few tasks. Can he touch his index fingers together? Raise a cup to his lips? Sign his name? Stipp can do none of it. Then Rezai sends a few volts through the wire. Stipp's tremors calm. His index fingers meet. He signs the paper. "It's been a long time since I did that," he says wonderingly.

It will be a bit of time before he's able to do it routinely. In a week he'll come back, and wires will be tunneled beneath his scalp, over his shoulder and to his chest, where a small pacemaker will be implanted. Three weeks later—after all possible brain swelling subsides—the power will be switched on, and the precise voltage needed to control his symptoms will be determined. Then it will simply be a matter of returning every few years for a battery change.

The Cleveland Clinic is one of 250 places in the U.S. that perform DBS for Parkinson's, and worldwide, close to 40,000 people have undergone the procedure. But the operation is by no means a cure. For one thing, it doesn't do much for end-stage Parkinson's symptoms like cripplingly bad posture and difficulty swallowing. More important, Parkinson's is a degenerative condition, which means that while DBS neutralizes tremors, the brain continues to deteriorate beneath the mask of the treatment. After a decade or so, electrical stimulation is not enough to contain the disease. Still, that's 10 relatively symptom-free years during which other treatments may become available.
The benefits of DBS would have a similar expiration date for a degenerative disease like Alzheimer’s, but in the case of anxiety or mood disorders like OCD or depression, it could effectively serve as a cure. "People with OCD don’t typically have a degenerative course of illness," says Dr. Ben Greenberg, a professor of psychiatry at the Brown University Medical School and the leader of the OCD work that led to the application for FDA approval. "They should thus get more disability-free years."

While OCD and depression patients would be required to exhaust all other remedies before opting for something as extreme as DBS, those suffering from traumatic brain injury have few such options. Right now, from 100,000 to 300,000 Americans have suffered sufficient brain trauma to be classified as minimally conscious—a number that is growing as soldiers wounded by shrapnel come home from Iraq. Twenty percent of minimally conscious patients recover well enough to return to the community and resume their lives. Others never do. Still others drift at the functional margins, needing just a boost to cross the line into self-sufficiency.

The 38-year-old mugging victim is nowhere near able to resume the life he had, but he has gone from minimal consciousness into what’s known as a post-traumatic confusional state. What’s more, he continues to improve even after the electrical stimulation is turned off, suggesting that the brain is recovering abilities on its own. "He’ll potentially be able to perform self-care such as eating and brushing his hair," says Giacino, who, along with neurologist Nicholas Schiff of the Weill Cornell Medical College in New York City, was part of the team that conducted the surgery.

DBS does present ethical issues. Volunteers who receive the treatment for depression smile on the operating table as the voltage is turned up and frown as it’s turned down, raising questions about just whose mind it is anyway. Advocates argue that when your life has come to ruin as a result of disability, you’re concerned less with such philosophical questions than with simply feeling better. Trickier are the cases of brain-damaged patients on whom the operation is, by definition, performed without consent. Dr. Joseph Fins, medical ethicist at Weill Cornell and a principal researcher on the recent study, is untroubled by that, arguing that the very condition that eliminates the ability to consent is the one the surgery seeks to correct. His position is hard to challenge. A patient for whom the neural lights go on for the first time in eight years may react in a lot of ways, but he’s unlikely to insist he should have been left in the dark.