

## NeuroStar: Firing Up Neurons To Treat Depression

Emory University



The introduction of the antidepressant Prozac in the late '80s not only marked a new era in modern psychiatry, it launched a cultural revolution: As millions of Americans began taking the drug, depression and its treatment became one of the nation's hottest topics.

Prozac did not, however, prove to be a wonder drug for everyone. Researchers say nearly 30 percent of patients with depression do not benefit from or cannot tolerate antidepressant therapy. Until now, these patients have had too few treatment options: electroconvulsive (shock) therapy or complex and often unproven combinations of medications.

Neuronetics Inc., the makers of the NeuroStar Transcranial Magnetic Stimulation Therapy System, are hoping to spark its own psychiatric revolution by offering an alternative therapy to the millions of patients with treatment-resistant depression.

"Drugs to treat depression are all variations on a similar theme: They change brain chemistry," says Neuronetics founder and CEO Bruce Shook. "Transcranial magnetic stimulation advances the field by offering a different mechanism

for getting patients well.”

## A Treatment Like No Other

The NeuroStar system is so unlike most psychiatric treatments, its therapeutic concept can be difficult to wrap one’s brain around. In fact, the therapy is based on 100-year-old science that simply took the right pairing of scientists to human-size the technology.

“We’ve known for a century that if we had a powerful enough electromagnetic field we could fire brain cells without opening the skull,” says Charles (Chip) M. Epstein, M.D., a professor of neurology at Emory University.

In the late ‘80s, scientists were beginning to achieve their goal, perfecting a process now known as transcranial magnetic stimulation (TMS), in which short electromagnetic pulses are sent through the skull where they create electrical currents that stimulate nerve cells.

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An amateur electronics buff, Epstein was experimenting with his own coil design for TMS when he ran into a power problem.

“A compact camera flash with 100 times the brightness of an ordinary light bulb has just a fraction of the energy needed for TMS,” says Epstein. “TMS requires the power of hundreds of flashes all at once, which requires a lot of physical space and generates a lot of heat.”

## Finding the Right Rock

High-voltage parts are dangerous and prone to failure—to say nothing of the issue of generating heat so close to the patient’s head. Epstein knew these obstacles could only be overcome by embedding the right magnetic material into his wire coil, and he knew just who to call for help: an expert in electromagnetism at the Georgia Institute of Technology named Kent Davey, Ph.D. (Davey is now at the University of Texas, Austin.)

The two collaborated on the device, settling on a variant of iron that reduced the energy and heat requirements by factors of four and eight, respectively.

“Very few people could have picked the appropriate magnetic materials,” says Epstein of Davey. “It took the right materials and the right coil design for this to work.”

With help from Emory University’s Office of Technology Transfer, patents for the invention were obtained and originally licensed for another medical purpose to an incubator in Atlanta. Stan Miller, now vice president of business development at Neuronetics, was employed at the incubator and recognized the potential for a neurological application. When Shook met Miller, they worked together with other founding members of the Neuronetics team to obtain a license from Emory in return for royalties on future sales and to pull together a consortium of venture capital investors to finance the new company. Neuronetics was born.

“*This is a variation of magnetic resonance imaging, or MRI. Instead of a playing a diagnostic role,*

*we've turned it into therapeutic modality for a very targeted part of the brain."*

**Bruce Shook**

In 2003, Shook went to work developing Epstein's technology into a product. A company-conducted research study of 301 patients demonstrated the safety and efficacy of the Neurostar system, paving the way for its clearance by the United States Food and Drug Administration in late 2008.

Neuronetics conducted a second study of more than 300 patients receiving TMS in routine clinical practice and that found that 58 percent of patients achieved a meaningful improvement in their depression, and 37 percent became symptom-free after receiving TMS therapy.

"Six months after their therapy ended, the vast majority of patients were still symptom-free, with about 37 percent of those receiving at least one re-treatment during that time," said Shook.

### **Firing up Neurons**

Why did those patients find relief? In the brains of depressed patients, the left prefrontal cortex is underactivated. To jumpstart the brain circuitry in that area of the brain, the Neurostar system places the electromagnetic coil, called the treatment link, on the top left side of the head. Then the system sends 3,000 highly targeted pulses directly into the brain throughout a 37.5-minute treatment session. The treatment is repeated five days a week for four to six weeks.

"We're firing up neurons in the part of the brain known to be the source of depression," explains Shook. "We get blood flowing and glucose metabolism up. By continually causing the neurons to activate with the repeat pulsing, we exercise that part of the brain back into shape."

Patients, who relax in a reclined chair during the treatment sessions, experience light tapping on their skull, but none of the side effects common among antidepressant therapy, such as weight gain and sexual dysfunction.

"Antidepressants are a systemic treatment," explains Shook. "As you treat the brain you also treat the rest of the body. Because TMS is limited to the brain, the risk of systemic side effects is greatly diminished."

### **Expanding Domestically and Around the Globe**

Today, there are more than 430 Neurostar TMS therapy systems operating across the United States in private clinics, academic centers and military hospitals—and more being installed every month. The price tag for the system, which includes physician training, is \$74,900.

"We've barely scratched the surface in the U.S.," says Shook. "Of the 14 to 20 million Americans who suffer from depression, at least 4 million remain ill or can't tolerate the side effects of antidepressants. There's plenty of opportunity to help make people well."

This year, the Malvern, Penn.-based company—which now has 120 employees—is also expanding internationally to Asia and the Middle East and has recently received the CE Mark, which will allow for marketing in European Union countries.

According to J. Cale Lennon III, director of licensing at Emory, the family of patents licensed to Neuronetics is providing substantial licensing revenue that can be reinvested to fund new research at the university. But he added the product's impact on society has an even higher value.

"We measure our success by the number of products [based on Emory inventions] that make it to market," says Lennon. "TMS addressed a significant unmet need in the marketplace. To be a part of that solution, and one that has profoundly affected so many lives, is very satisfying."

### **Early Adopting Physicians**

Shook says that like any new technology, it's the forward-thinking clinicians who have initially embraced TMS, which can only be administered with a doctor's prescription. Patients with major depressive disorder who have not responded to at least one antidepressant medication are eligible for the treatment.

"There are more than 40,000 psychiatrists in the United States, and they are a very heterogeneous group," says Shook. "They don't necessarily treat people in the same way."

### **Lifting the Veil of Depression**

Insurance companies have started accepting the therapy as a reimbursable service, but coverage is not yet universal. This sometimes leaves patients on their own to pay the \$7,000-plus price tag for the treatment. While convincing insurers and psychiatrists of the merits of TMS is an ongoing effort, Shook says the patient experience is what gets him up in the morning.

"The most gratifying thing about this business is the reaction from patients who experience a dramatic turnaround in their lives," says Shook. "It makes going to work every day easy."

To date, more than 250,000 treatments have been administered with Neurostar systems and former patients—many of whom credit TMS with saving them from a life of chronic despair—are happily sharing their experiences on a website created by Neuronetics called The Depression Hope Center. One patient, a successful New York advertising executive, has even written a book entitled *3,000 Pulses*.

For a doctor who enjoys tinkering with gadgets in the basement, inventing something that is making thousands of people better has been a profound experience.

"I'm a doctor, my job is to help people feel better," says Epstein. "But in 10 careers I couldn't help as many people as TMS already has."

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