Medical Xpress

How brain pacemakers erase diseased messages

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DURHAM, N.C. -- Brain "pacemakers" that have helped ease symptoms in people with Parkinson's disease and other movement disorders seem to work by drowning out the electrical signals of their diseased brains.

Despite the clinical success of the devices, which have been approved by the Food and Drug Administration and can be found in the heads of about 30,000 Americans, the mechanisms by which deep brain stimulation alleviates disease symptoms aren't well understood.

Biomedical engineers at Duke University's Pratt School of Engineering have found that stimulation administered by rapid-fire electrical pulses deep in the brain produces what they call an "informational lesion." By relaying a repetitious and therefore meaningless message, constant pulses overwhelm the erratic bursts of brain activity characteristic of disease.

"Periodic bursts in the brains of people with tremor -- which might follow a pattern such as 'pop-pop-pop, silence, pop-pop-pop, silence' -- propagate pathological information within brain circuits," said Warren Grill, the study's lead investigator and an associate professor of biomedical engineering. "If you replace that instead with a constant 'pop-pop-pop-pop-pop-pop,' you've erased that pathological information."

Grill said the high-frequency deep brain stimulation acts like a surgical lesion, another acceptable treatment for severe tremor disorders and epilepsies. But the electronic device has the advantage of being adjustable or reversible.

The researchers' report appears in a special June 2007 issue of the journal IEEE Transactions on Neural Systems and Rehabilitation Engineering, edited in part by Grill. The study was conducted by a team that included Alexis Kuncel, a doctoral student in biomedical engineering at Duke, and Scott Cooper, a neurologist at the Cleveland Clinic, with support from the National Institutes of Health.

The FDA approved the use of deep brain stimulation for Parkinson's disease in 1997. The electrical implants are also an approved therapy for other movement disorders and are at various stages of testing for the treatment of epilepsy, depression, obsessive-compulsive disorder and pain, according to Grill.

The complexity of the brain -- in which nerves project in all directions and connect with one another to form multiple, looping networks -- makes studying how deep brain stimulation works a challenge, Grill said.

Grill's team created a mathematical model of a normally functioning brain cell. The researchers then gave the model neuron the pathological pattern of activity seen in people with tremors, assembled a group of these model cells and watched what would happen when the cells were electrically stimulated at various rates and intensities.

In addition to showing how the therapy works, their model of neurons in action also revealed that stimulation delivered at too slow a pace fails to keep bad information at bay. Indeed, slower pulses can actually add to problematic bursts, they showed.

The model's findings closely parallel the clinical responses of patients, who typically experience the greatest relief from symptoms when their devices are tuned by physicians to deliver rapid pulses, Grill said. Patients' symptoms can actually worsen when the devices are dialed to a slower setting.

The intensity of stimulation also plays an important role, the study suggests, by determining the number of brain cells affected by a particular series of pulses.

A better understanding of the processes underlying deep brain stimulation could enable physicians to better fine-tune electrical implants, Grill said. That could be particularly useful for zeroing in on effective settings for implants used to treat diseases, such as epilepsy, in which seizures occur only sporadically, as well as conditions, such as depression, in which symptoms can vary widely from day to day.

"In the case of tremor, physicians can alter the setting until they see the symptoms stop," Grill said. "You don't have to know how it's really working.

"In a condition like epilepsy, however, it's extremely unlikely that a person would have a seizure in the doctor's office," he said. "Therefore, it might take months of trial and error to find the optimal setting." Grill's new model promises to streamline the process.

Source: Duke University