# Zeroing in on Epilepsy

BY VIC KY WALTZ

Mark Kramer always had an interest in public health. His father was a doctor, and his mother and grandmother were nurses. While his aversion to blood dashed any aspirations of attending medical school, he did not let it deter him from seeking a career in medicine.

"You don't have to be a physician to have a clinical impact," Kramer says. "You can be a biologist, engineer, mathematician."

Or, in Kramer's case, a physicist.

As a doctoral student in the University of California, Berkeley's program in Applied Science and Technology, Kramer helped develop a mathematical model that describes what happens in the brain during an epileptic seizure. The purpose of the study, published in the March 2005 issue of the Journal of the Royal Society of London Interface, was to help neurologists better understand and treat epilepsy.

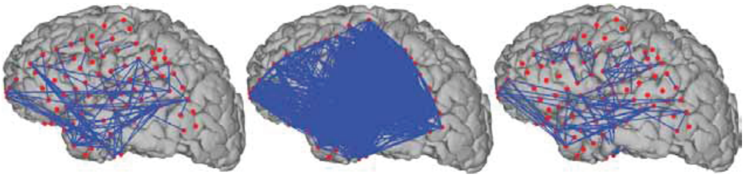
When epilepsy patients fail to respond to various drug treatments, Kramer explains, doctors may take an alternative course of action. "They remove the part of the brain that causes the seizure," he says.

While numerous measures are undertaken to ensure patient safety, the surgery is nonetheless invasive, and it is not always accurate. According to a 2007 Cleveland Clinic study, 60 percent of patients who have the surgery continue to have seizures.

Now an assistant professor of mathematics and statistics, Kramer wants to reverse those numbers. To that end, he is using his background in math and physics to help doctors at Massachusetts General Hospital determine which parts of the brain to target.

"Up until now," he says, "the primary way to analyze data retrieved from the brains of epilepsy patients has been through a painstaking visual inspection. Epileptologists stare at complicated traces of brain activity and try to determine where in the brain the seizure is starting."

Before surgery, neurologists must map the region where the patient's seizure originates to ensure that they remove only what is necessary. This involves lifting a section of the skull and putting electrodes directly on the surface of the brain.



Representative networks, in blue, constructed from the brain activity of a human patient during a seizure. As the seizure evolves, the number of connections in the network changes.

"The patients stay in the hospital for about a week," Kramer says, "during which time they may experience a number of seizures."

Kramer and his collaborators study the voltage data collected from the electrodes using sophisticated mathematical techniques. "Rather than looking at individual voltage traces," he says, "we're examining them collectively. Are there any relationships between those traces? Is there any sort of pattern?"

While the recordings reveal the consequences of abnormal brain activity, he continues, they do not identify the cause. "If we understand why and how seizures progress over the surface of the brain," he says, "eventually we may be able to prevent the seizure by disrupting the activity preemptively with medication or stimulation."

To date, Kramer's team has analyzed only a handful of seizures from a small group of patients. It is a minuscule percentage of the 50 million people worldwide who suffer from the disease, but still a strong start. "The scientific process is filled with wrong turns," Kramer says, "but I truly believe we're on our way." R