BIOMEDICINE

An Ultrathin Brain Implant Monitors Seizures

The device can conform to the shape of the brain, enabling better recording of electrical activity.

FRIDAY, NOVEMBER 18, 2011 | BY LAUREN GRAVITZ

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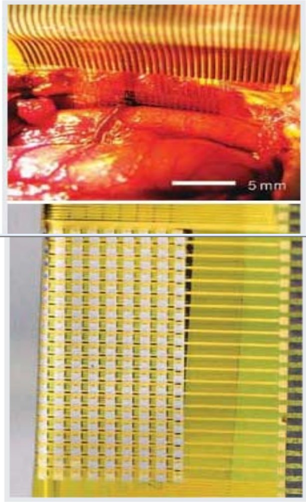

Brain map: An ultrathin array of electrodes, shown at top being inserted into the brain of a cat, allows for data acquisition far greater than ever before possible. At bottom, the electrode array is so flexible that it can fold around even the slimmest objects, allowing for easy insertion and good coverage of uneven surfaces.
Nature Neuroscience

A new, ultrathin, ultraflexible implant loaded with sensors can record the electrical storm that erupts in the brain during a seizure with nearly 50-fold greater resolution than was previously possible. The level of detail could revolutionize epilepsy treatment by allowing for less invasive procedures to detect and treat seizures. It could also lead to a deeper understanding of brain function and result in brain-computer interfaces with unprecedented capacity.

For epilepsy patients who don't respond to medication, neurologists will often try to map where in the brain the seizure originated so that region can be surgically removed. The doctor removes a section of skull and places a bulky sensor array on the surface of the patient's frontal cortex.

"These clinical devices haven't changed much since the '50s or '60s," says Brian Litt, an epilepsy specialist and bioengineer at the University of Pennsylvania and one of the scientists who led the new research. Because the device has to accommodate wires for each electrode, it only has space for fewer than 100 electrodes and gives a poor resolution picture of the electrical activity. "It's like trying to understand what's going on in a crowd in Manhattan with a single microphone suspended from a helicopter," Litt says.

Current technology has stalled out at a sensor array with about eight sensors per square centimeter; the new array—built in collaboration with John Rogers, a professor of materials science and engineering at the University of Illinois Urbana-Champaign—can fit 360 sensors in the same amount of space. To create a small device so densely packed with sensors, Rogers integrated electronics and silicon transistors into the array itself, drastically reducing the amount of wiring.

"This is more like an array of 360 microphones, lowered closer to the surface and recorded from much smaller regions: a couple of people at the street corner, a couple by the mailbox," Litt says. "This new technique could be the key to understanding functional networks in the brain, and could even be the key to treating and potentially curing some diseases."

In their first test of the device, on a cat with epilepsy, Litt, Rogers, and graduate student Jonathan Viventi (now an assistant professor studying translational neuroengineering at New York University), saw something striking: a storm of activity that looked like a self-propagating spiral wave. The pattern, only apparent with incredibly high-resolution recording, is remarkably similar to one seen in cardiac muscle during a life-threatening condition called ventricular fibrillation.

Rather than large sections of the brain being responsible for seizures, something Litt says has traditionally been thought to occur, it appears to instead stem from multiple clusters of very small areas, or "microdomains," in the cortex. The research was published online last week in *Nature Neuroscience*.

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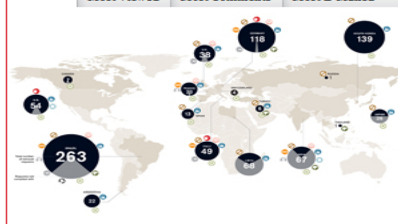

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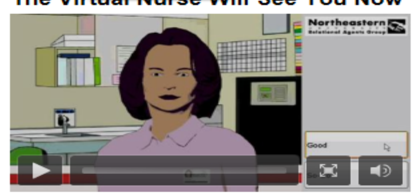

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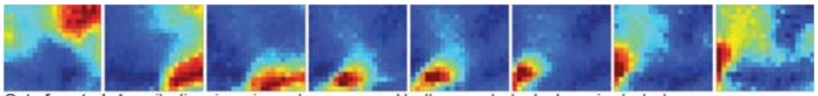

Out of control: An epileptic seizure in a cat, as measured by the new electrode-dense implant, shows a never-before-seen spiral wave of electrical activity.
Nature Neuroscience

the Wadsworth Center in Albany, New York. Schalk was not involved in the research. "It will be of tremendous value for basic neuroscience and for translational research." Schalk notes that if the technology proves itself in humans, it could open up substantial opportunities for everything from diagnostics to brain-computer interface devices.

The device could also enable less-invasive testing and treatment. Rather than cutting open a large section of skull to place a monitoring device, Litt says, the new implant could allow surgeons to drill just a small hole through which to slip the slim, rolled-up sensor array, and unfurl it onto the brain's surface once it's inside. And instead of removing areas of brain the size of a golf ball, it might be possible to just remove the microdomains and leave the rest of the cortex intact.

The current version of the device is one square centimeter; for human use, researchers need to expand it to about eight square centimeters. A startup called MC10 will work on making it larger and production-ready.

Litt and Rogers are now working to create an implant with stimulators embedded next to the sensors. If they can build a device that not only detects the onset of a seizure but can just as quickly provide electrical stimulation to quash it, the research could have great clinical impact. "This isn't just a research tool. It has a clearly defined mode of use in the clinical setting," Rogers says. "This is a piece of biointegrated electronics that is unmatched in its functionality, and the proof is in the pudding."

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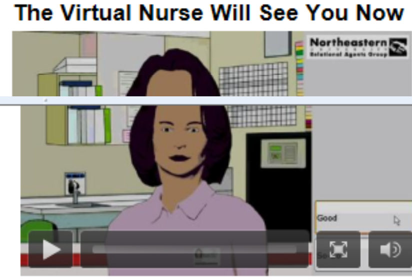

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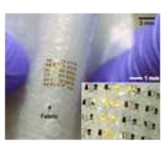

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