UCSD team connects electronic circuit to brain cells enabling repair of damaged neurons

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UCSD TEAM CONNECTS ELECTRONIC CIRCUIT TO BRAIN CELLS ENABLING REPAIR OF DAMAGED NEURONS

First time artificial and biological neurons function together in a network family.

An interdisciplinary group of scientists at the University of California, San Diego has teamed up in a unique experiment that may eventually lead to restoring brain function in patients suffering from stroke, Alzheimer's and other neurological disfunctions.

The team of researchers at UCSD's Institute for Nonlinear Science (INLS) led by Henry Abarbanel, professor of physics, Misha Rabinovich at INLS and Allen Selverston, professor emeritus of biology, has successfully integrated an electronic neuron within a group of 14 biological neurons from the California spiny lobster. The artificial neuron was accepted by the real ones and its signaling rhythm fell into place with the other cells.

"We built an electronic neuron that is able to work as a member of a neural framework," said Abarbanel, director of INLS. "It's science fiction, except that we did it."

The finding comes after two years of research, using $7.50 worth of circuit parts from a Radio Shack store and dozens of spiny lobsters from La Jolla Cove purchased from a local fisherman.

It is the first time that researchers have been able to get artificial and biological neurons to function together in a network family. In their normal function, the 14 neurons control the rhythmic way food is passed from the stomach to the lobster's digestive system.

The researchers said the key finding was in the mathematical modeling that preceded the actual experiment. They discovered that they only need to control three variables that affect a neuron's overall function, rather than the hundreds of variables involved in the detailed biological functioning of each cell. This finding radically simplified the mathematical algorithm used to construct the circuit.

"We found a way to replace the neuron without getting lost in the details," said neuroscience researcher Rob Elson. "It's a higher level of modeling where you capture the performance according to a model involving a few variables, and you're not concerned directly with all the small cogs working behind the scenes."

The model used to describe the neuron's function was so simple that it was done on a desktop personal computer, and was then used to construct an inexpensive circuit built from mail-order parts.

The researchers chose the California spiny lobster because it is a well-studied animal model. The 14 neurons are highly interconnected and capable of complex control processes. Like other neurons, they oscillate in both a slow and a fast way using the fast oscillations to send signals between neurons through their axons.

The group of lobster neurons, called the central pattern generator, performs regular oscillations so the lobster's food is passed efficiently to its digestive system.

By removing crucial biological neurons from the natural circuit, the UCSD researchers created an unhealthy state of oscillations in the neurons, added the electronic one, and were able to get the entire network to return to its normal state.

"We've created lobster 'epilepsy' and then cured it," Abarbanel said.

The next step is to gradually replace each of the neurons with electronic ones. If the entire network still functions properly, the researchers will be closer to replacing diseased or damaged neurons in human tissue. The UCSD researchers see their work as having important impacts on spinal cord research, for example.

The team working on the two-year project includes Abarbanel, Rabinovich, Selverston, Elson, and postdoctoral fellows Pablo Varona, Alexander Volkovskii and Atilla Szucs.

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