MedicalXpress

Scientists create first realistic 3D reconstruction of a brain circuit

December 7 2011

Researchers from the lab of Nobel laureate Bert Sakmann, MD, PhD at the Max Planck Florida Institute (MPFI) are reporting that, using a conceptually new approach and state-of-the-art research tools, they have created the first realistic three-dimensional diagram of a thalamocortical column in the rodent brain. A vertically organized series of connected neurons that form a brain circuit, the cortical column is considered the elementary building block of the cortex, the part of the brain that is responsible for many of its higher functions.

This achievement is the first step toward creating a complete computer model of the brain, and may ultimately lead to an understanding of how the brain computes and how it goes awry in neurological, neurodevelopmental and psychiatric disorders. The study is published online in the journal Cerebral Cortex.

"This is the first complete 3D reconstruction of a realistic model of a cortical column," said Marcel Oberlaender, PhD, first author on the paper. "This is the first time that we have been able to relate the structure and function of individual neurons in a live, awake animal, using complete 3D reconstructions of axons and dendrites. By creating this model, we hope to begin understanding how the brain processes sensory information and how this leads to specific behaviors."

The electrically excitable axon extends from the body of the neuron (brain cell) and often gives rise to many smaller branches before ending at nerve terminals. Dendrites extend from the neuron cell body and

receive messages from other neurons.

In addition to recreating the structure of the cortical column, the study also sheds significant light on the function of its constituent neurons, and the relationship between their functionality and structure. In looking at neurons' response to sensory stimulation, the researchers discovered that sensory-evoked activity in some of the cells can be directly correlated with their structure and connectivity, which marks a first step toward understanding basic organizational principles of the brain.

Working with both awake and anesthetized rats, and also examining stained brain slices, the neuroscientists used sophisticated new light microscopy as well as custom designed tools to examine 15,000 neurons of nine identified cell types. Using a painstaking, six-step process, the researchers identified and reconstructed the column's constituent parts using sophisticated software and a range of other new state-of-the-art tools and processes.

Described in a related paper co-authored by Drs. Sakmann and Oberlaender, these new methods, which were developed in part at the Max Planck Florida Institute, allow researchers, for the first time, to simulate electrical signaling in a computer model at subcellular and millisecond resolution.

"We can now quantify the number of neurons of each cell type, their three-dimensional structure, connectivity within these networks, and response to sensory stimulation, in both an anesthetized and awake animal," said Dr. Oberlaender. "Such a quantitative assessment of cortical structure and function is unprecedented and marks a milestone for future studies on mechanistic principles that may underlie signal flow in the brain, during such functions as decision making."

Provided by Max Planck Florida Institute