Neurons found to be similar to Electoral College

September 14 2009

A tiny neuron is a very complicated structure. Its complex network of dendrites, axons and synapses is constantly dealing with information, deciding whether or not to send a nerve impulse, to drive a certain action.

It turns out that neurons, at one level, operate like another complicated structure -- the United States, particularly its system of electing a president, through the Electoral College.

A new Northwestern University study provides evidence that supports the "two-layer integration model," one of several competing models attempting to explain how neurons integrate synaptic inputs. The findings are published in the journal *Neuron*.

In this model, each dendritic branch of a neuron receives and integrates thousands of electrical inputs, deciding on just one signal to send to the axon. The axon then receives signals from all the dendrites, much like electoral votes coming in from state elections, and a final decision is made. The result could be an output in the form of an impulse, or action potential, or no action at all.

"There are more than 100 billion neurons in the human brain, so detailed knowledge of individual neurons will lead to a better understanding of how the brain works, including the processes of learning and memory," said Nelson Spruston, who led the research team. He is professor of neurobiology and physiology in the Weinberg College of Arts and

Sciences at Northwestern.

Using electron microscopy, the researchers made a three-dimensional reconstruction of individual dendritic branches of mammalian hippocampal neurons with all their synapses. They found that the synapses get progressively smaller, or weaker, between the origin of the dendrite's branch and its end. This distribution supports the two-layer integration model.

Output from each branch, rather than each synapse, is sent to the axon. This design of the neuron implies that local integration is very important to the cell. After information is integrated locally within a branch, there is a global integration within the axon.

"Each of these neurons is a complicated network in and of itself," said William Kath, an author of the study. He is professor of engineering and applied science in the McCormick School of Engineering and Applied Science and is co-director of the Northwestern Institute on Complex Systems.

More information: The paper is titled "Synapse Distribution Suggests a Two-Stage Model of Dendritic Integration in CA1 Pyramidal Neurons." In addition to Spruston and Kath, other authors of the paper are Yael Katz, Vilas Menon, Daniel A. Nicholson and Yuri Geinisman, all from Northwestern.

Source: Northwestern University (news : web)