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Astrocytes, Synapses and Brain Function: A Computational Approach[1]

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Modulation of synaptic reliability is one of the leading mechanisms involved in long- term potentiation (LTP) and long-term depression (LTD) and therefore has implications in information processing in the brain. A recently discovered mechanism for modulating synaptic reliability critically involves recruitments of astrocytes - star- shaped cells that outnumber the neurons in most parts of the central nervous system. Astrocytes until recently were thought to be subordinate cells merely participating in supporting neuronal functions. New evidence, however, made available by advances in imaging technology has changed the way we envision the role of these cells in synaptic transmission and as modulator of neuronal excitability. We put forward a novel mathematical framework based on the biophysics of the bidirectional neuron-astrocyte interactions that quantitatively accounts for two distinct experimental manifestation of recruitment of astrocytes in synaptic transmission: a) transformation of a low fidelity synapse transforms into a high fidelity synapse and b) enhanced postsynaptic spontaneous currents when astrocytes are activated. Such a framework is not only useful for modeling neuronal dynamics in a realistic environment but also provides a conceptual basis for interpreting experiments. Based on this modeling framework, we explore the role of astrocytes for neuronal network behavior such as synchrony and correlations and compare with experimental data from cultured networks.

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