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Dynamic Self-Regulation of Neural Impedance

JOSEPH TRANQUILLO[1], DAN MEDANI[2], Bucknell University — One computationally important feature of a neuronal network is the ability of each neuron to dynamically adjust its impedance to external signals. We simulated synaptically coupled Hindmarsh-Rose neurons and found that a bursting neuron can switch a neural oscillator into a temporary period of quiescence, before switching it back to native oscillatory behavior. In quiescent mode, the oscillator did not synchronize to its inputs. In oscillation mode, the neuron did synchronize to its inputs, allowing information transfer. Inhibitory synapses were found to be more effective than excitatory synapses and switching was relatively insensitive to delays, driving frequency or Gaussian noise added to the input. In phase space an unstable limit cycle separates the quiescent and oscillatory modes and the switch is achieve through fold limit cycle and sub-critical Andronov-Hopf bifurcations. While the fast subsystem controls the limit cycle, the size of the unstable limit cycle switch is governed by a slow variable. This separation of time scales allows a neuron to self-regulate input impedance on a slow time scale, while at the same time enabling information to propagate through a larger network on a fast time scale.

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