On the computational role of astrocyte – neuron coupling in brain function
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Research Objective:
- To develop a computational model of astrocyte-neuron interactions and demonstrate how these interactions underpin Learning, Synchrony and Self-Repair.

**Understanding the functional significance of astrocyte-neural interactions**
The triplicate synapse model showing indirect and direct signaling of 2-AG.

**STDP Learning**
Li and Rinzel Calcium model - relates calcium dynamics to IP3, Gating variable f effect probability of transmitter release into the cleft

**Dynamic Coordination (Synchrony)**
Input
N1 Output
N2 Output

- Ca2+ oscillations (black line) and IP3 levels (red line) at a synapse from N1 stimulated by 7 Hz Poisson spike train for 100s.
- Ca2+ oscillations at a synapse from N2 which is only stimulated from 6-40 s and 80-100 s with a 7 Hz Poisson spike train.
- Activity of the gating function f which is activated when the total level of Ca2+ (D) within the astrocyte passes the threshold.
- (D) Black dashed line.
- (E) and (F) The output firing activity of neurons N1 and N2. Note that when the total Ca2+ oscillation crosses the threshold from below both neurons fire with a significantly higher frequency of activity; a result of the global release of glutamate and NMDA.
- SIC activation. These are the only times that the neurons are highly coordinated. Furthermore it can be seen that there are extended periods of silence from both neurons after firing in bursts. This is a result of the negative feedback from f which depresses the release of neurotransmitter from the synapses and remains active until the Ca2+ oscillation crosses the threshold from above.

**Endocannabinoid Mediated Self-Repair**
A system illustrating endocannabinoid mediated self-repair (A) Network before fault. (B) Network after fault. Note 2-Ag is a local signal associated with each synapse connected to either neuron N1 or N2 whereas e-SP is a global signal associated with all synapses connected to the astrocyte A1.

Network with no fault (A) e-SP function of both N1 and N2.
- Since e-SP is a global function and relates to all synapses connected to the astrocyte it is the same for N1 and N2.
- DISE function is different in N1 and N2. Since DISE is only local to all synapses connected to a neuron, DISE is different in N1 and N2 and is driven by the output of each neuron. (C) The probability of a synapse connected to N1 and N2. This probability is the summation of e-SP and DISE presented to the neuron. Note how the probability is reduced by ~50% which results in an overall reduction of the firing rate of N1 and N2 as seen in (D).

Network illustrating endocannabinoid mediated self-repair (A) Network before fault. (B) Network after fault. Note 2-Ag is a local signal associated with each synapse connected to either neuron N1 or N2 whereas e-SP is a global signal associated with all synapses connected to the astrocyte A1.

**References:**