Investigating the ability of astrocytes to drive neural network synchrony

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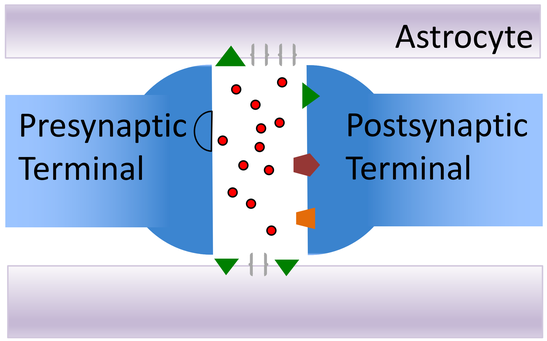
BACKGROUND:

Astrocytes are glial cells that e.g., buffer and recycle neurotransmitters, and exhibit calcium transients



The level of astrocyte ensheathment can influence the duration of receptor activation on the postsynaptic terminal

METHODS:

We considered two layer spiking networks

Synaptic input currents: $I_j(t) = R_j(t) + F_j(t)$

Recurrent input:

$$R_j(t) = \frac{1}{\sqrt{N}} \sum_{k=1}^{N} \sum_{spikes} J^{jk} \cdot \eta^{jk}(t - t_i)$$

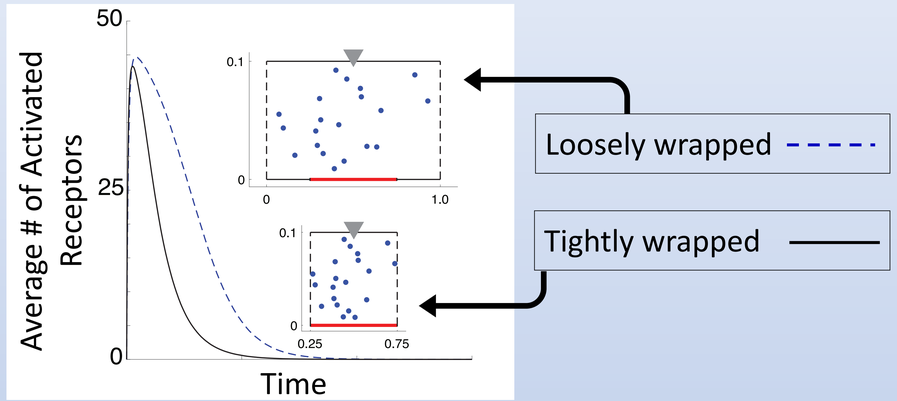
$$\eta^{jk}(t) = \frac{1}{\tau^{jk}} \exp(-t/\tau^{jk}) \cdot H(t)$$

Known result: allowing for fast excitatory synaptic currents can lead to excessive synchrony

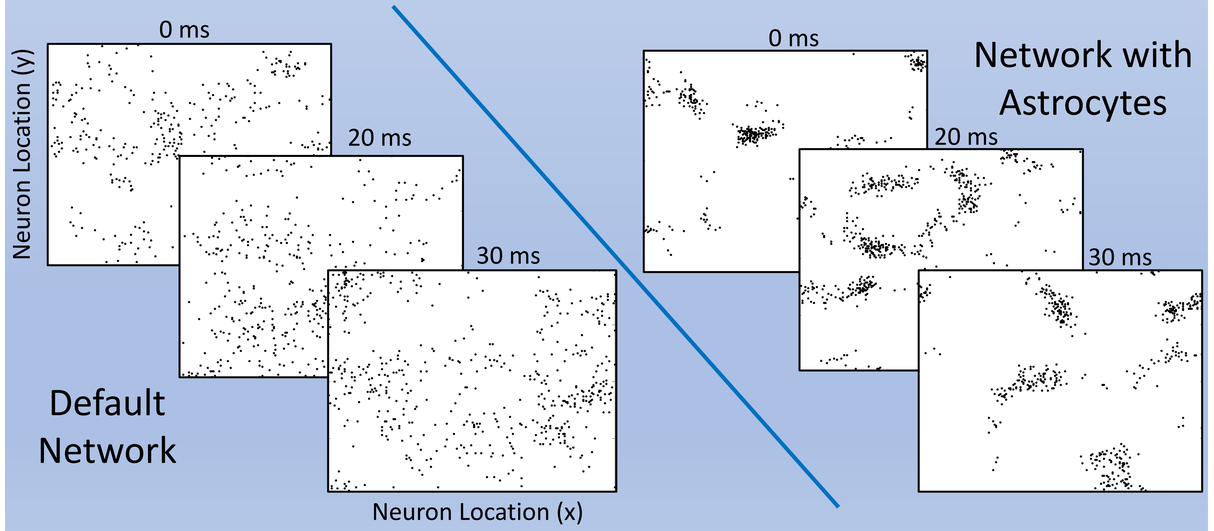
Question: How will the network behave in the presence of strong heterogeneity introduced by astrocytes that decreases both J^{jk} and τ^{jk}?

Two key parameters: Probability of ensheathment and strength of ensheathment

Astrocytes can make **individual synapses** weaker and faster,



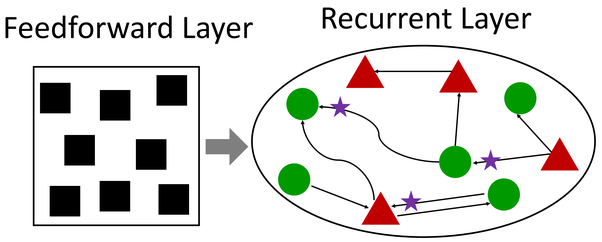
increasing the tendency of **correlated behavior** in networks



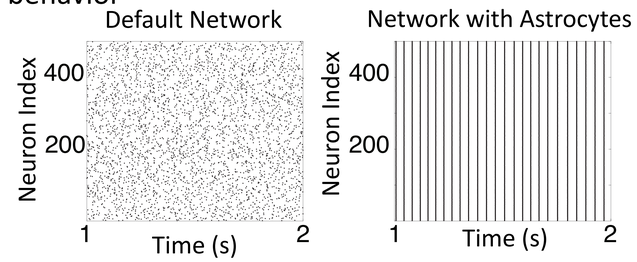
Want to see these networks in action? Scan here!

Photography encouraged

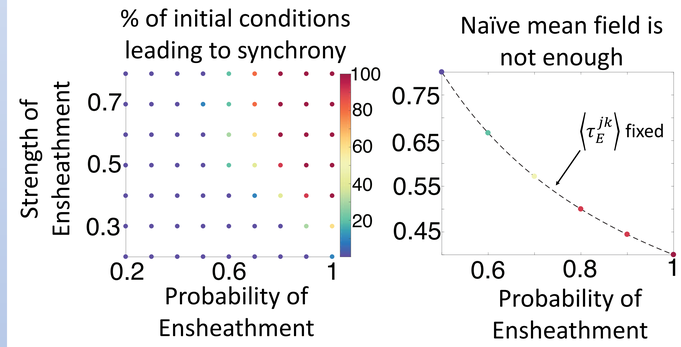
Non-spatial Network



Astrocytes can push networks into synchronous behavior

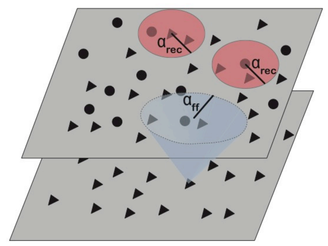


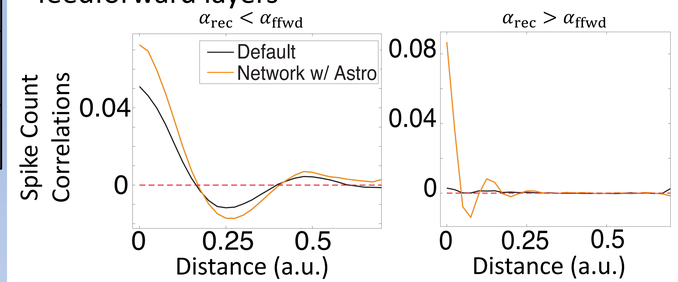
Parameter sweep reveals **bistability**: same network, different initial conditions, different results



Spatial Network

Astrocytes can modulate spatial correlations created by differences in the spatial projection widths of recurrent and feedforward layers





[1] G Handy, SD Lawley, A Borisyuk 2019, Phys Rev E, 99.
[2] C Börgers, N Kopell 2005, Neural Comp., 17
[3] R Rosenbaum et al. 2017, Nat. Neurosci, 20(1).
[4] Huang et al. 2019, Neuron, 101.
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