Role of network topology in the generation of coordinated neuronal activity

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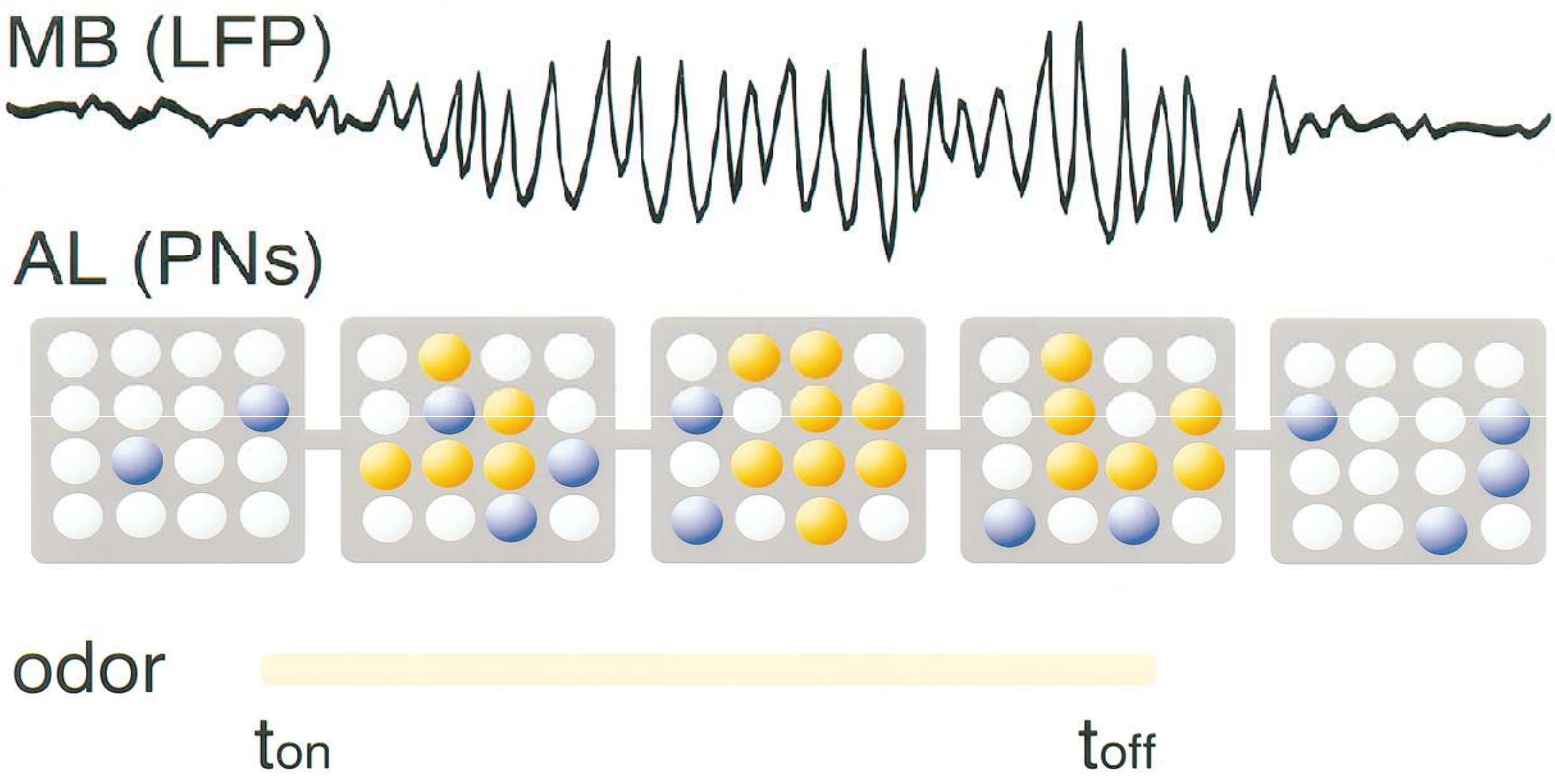
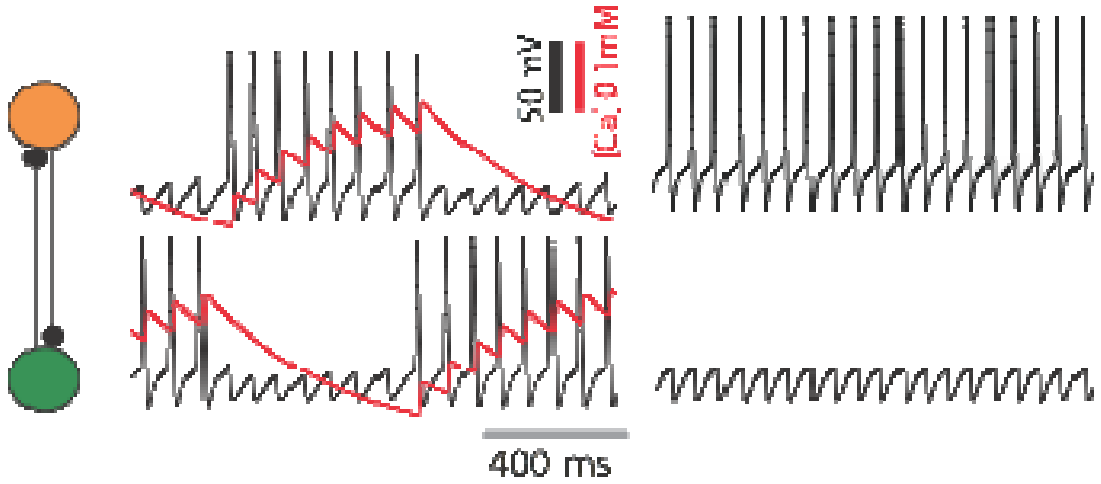
Antennal lobe dynamics



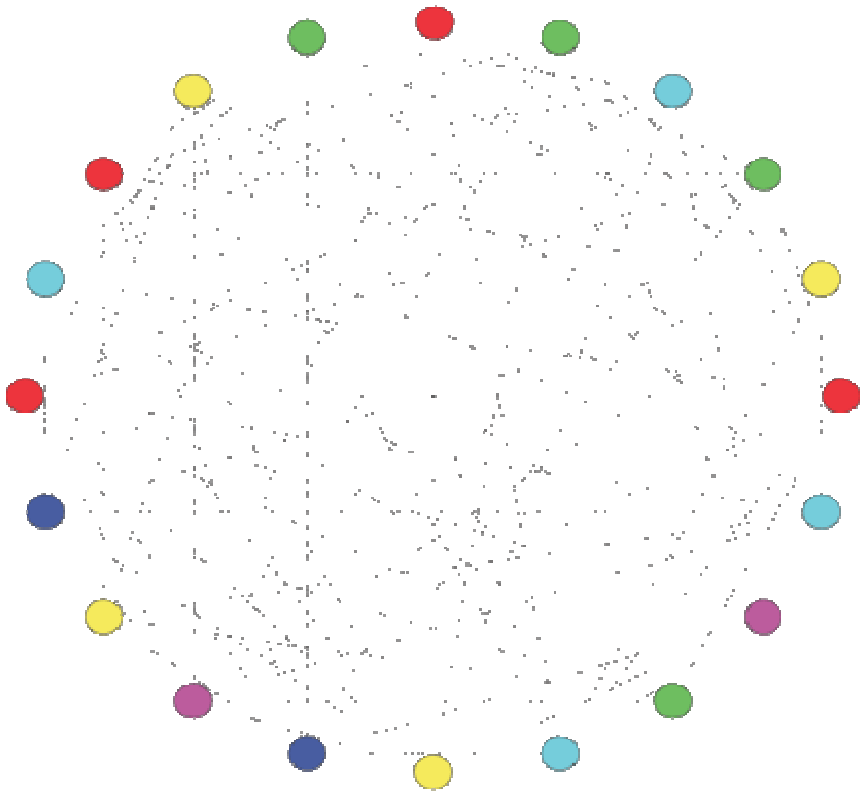
Overlapping groups of PNs transiently synchronize with each other to generate a ~20Hz oscillation.

Reciprocal inhibition



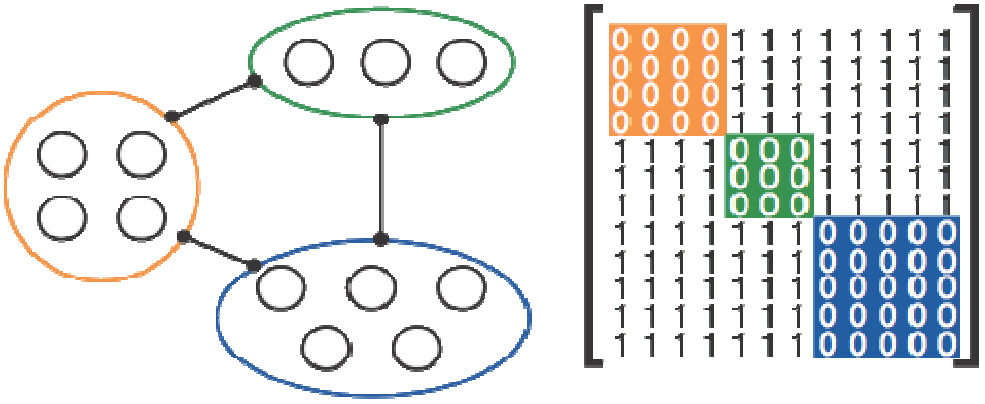
- Hodgkin-Huxley neurons with fast Na and K channels and a slow Ca^{2+} dependent K current I_{KCa}.
- I_{KCa} causes spike frequency adaptation. As the distance between consecutive spikes increases one neurons inhibitory influence on the other decreases allowing the inhibited neuron to switch from quiescence to spiking.
- In the absence of I_{KCa}, one neuron produces a train of spikes while the other remains silent.
- Coloring reflects the dynamics. Can this be extrapolated to larger networks?

Graph coloring



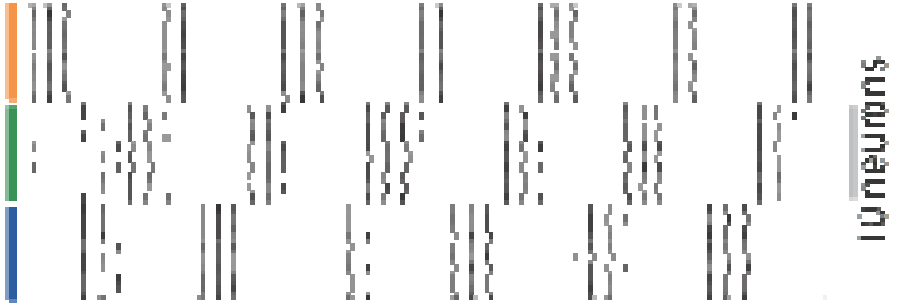
- We wish to control a number of coloring based properties of the graph. For example, the number of colors, the number of neurons associated with a particular color etc.
- This is not possible in an arbitrary random graph.

Construction.

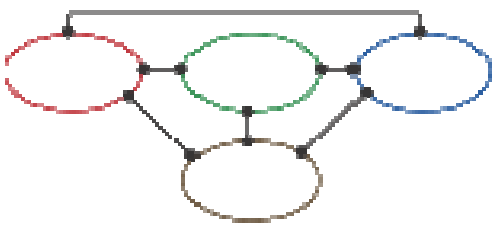


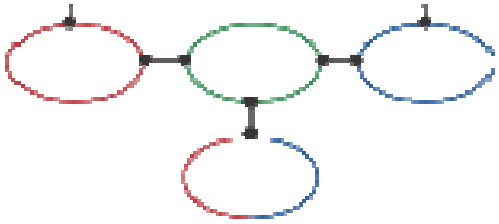
- Construct a pre-colored graph with the required properties.

- Neurons associated with the same color tend to spike together

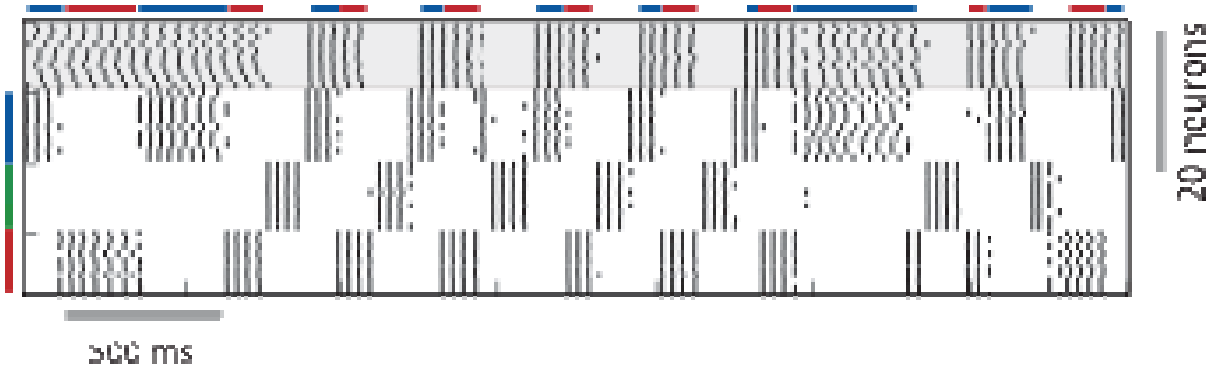


Transient overlapping synchrony

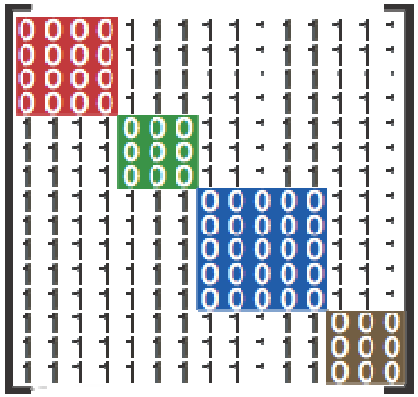


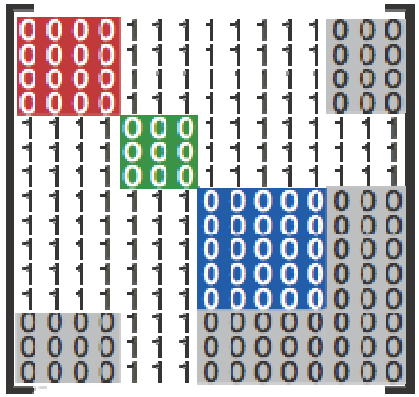


- In general graphs possess more than one coloring.

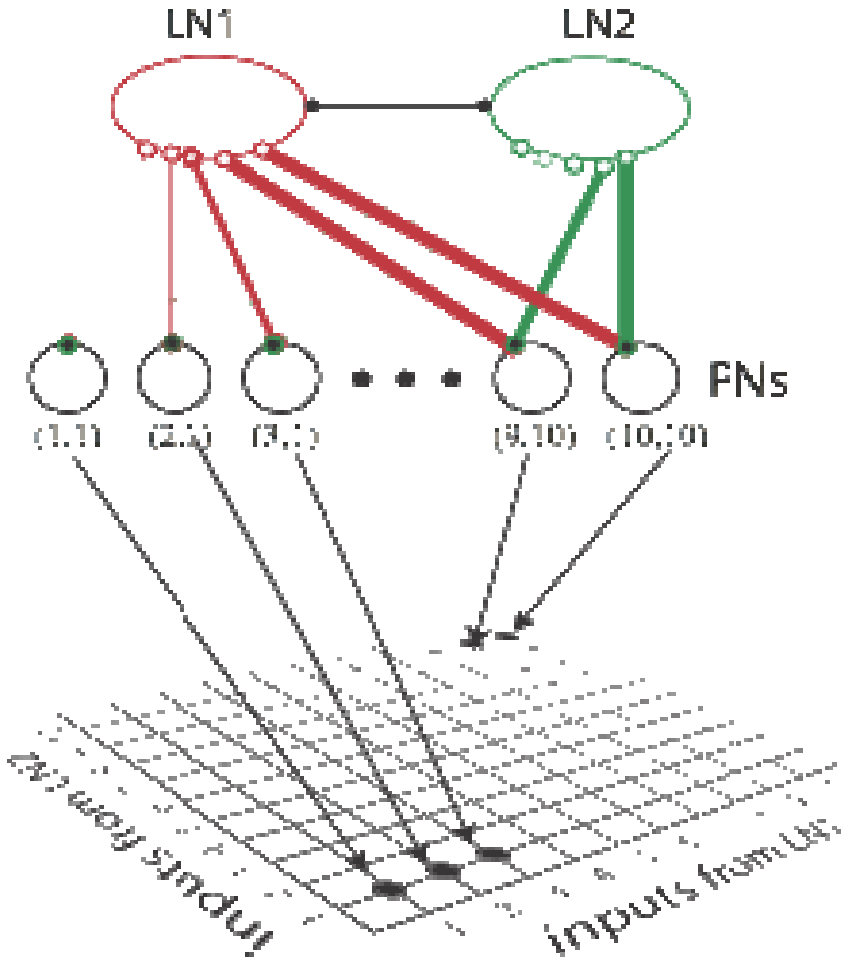


- Dynamical consequence of multiple colorings.



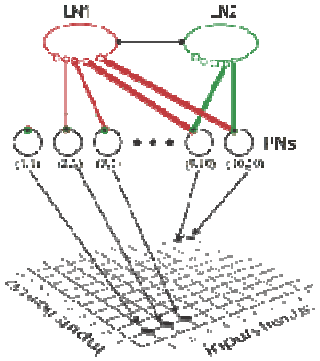


Coloring-based space for PNs.



- Reorganize PNs based on input it receives from LNs associated with a given color.
- The dimensions of the space in which the PNs are embedded is equal to the number of unique colors of the network

PN dynamics



QuickTime™ and a
YUV420 codec decompressor
are needed to see this picture.

Inputs from LN2

Inputs from LN1

Key points

- The coloring of the inhibitory sub–network can be a useful predictor of the collective dynamics.
- Using the coloring we defined a space in which the distance between excitatory neurons is defined not by the length of the synaptic path connecting those neurons, but by the similarity of the inhibitory input they receive.
- Dynamics on networks is inherently high–dimensional and difficult to analyze. A metric that provides a low–dimensional description can uncover surprising relationships between network elements.

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