Oscillations Emerge During Conflict in Simulated Subthalamic Nucleus

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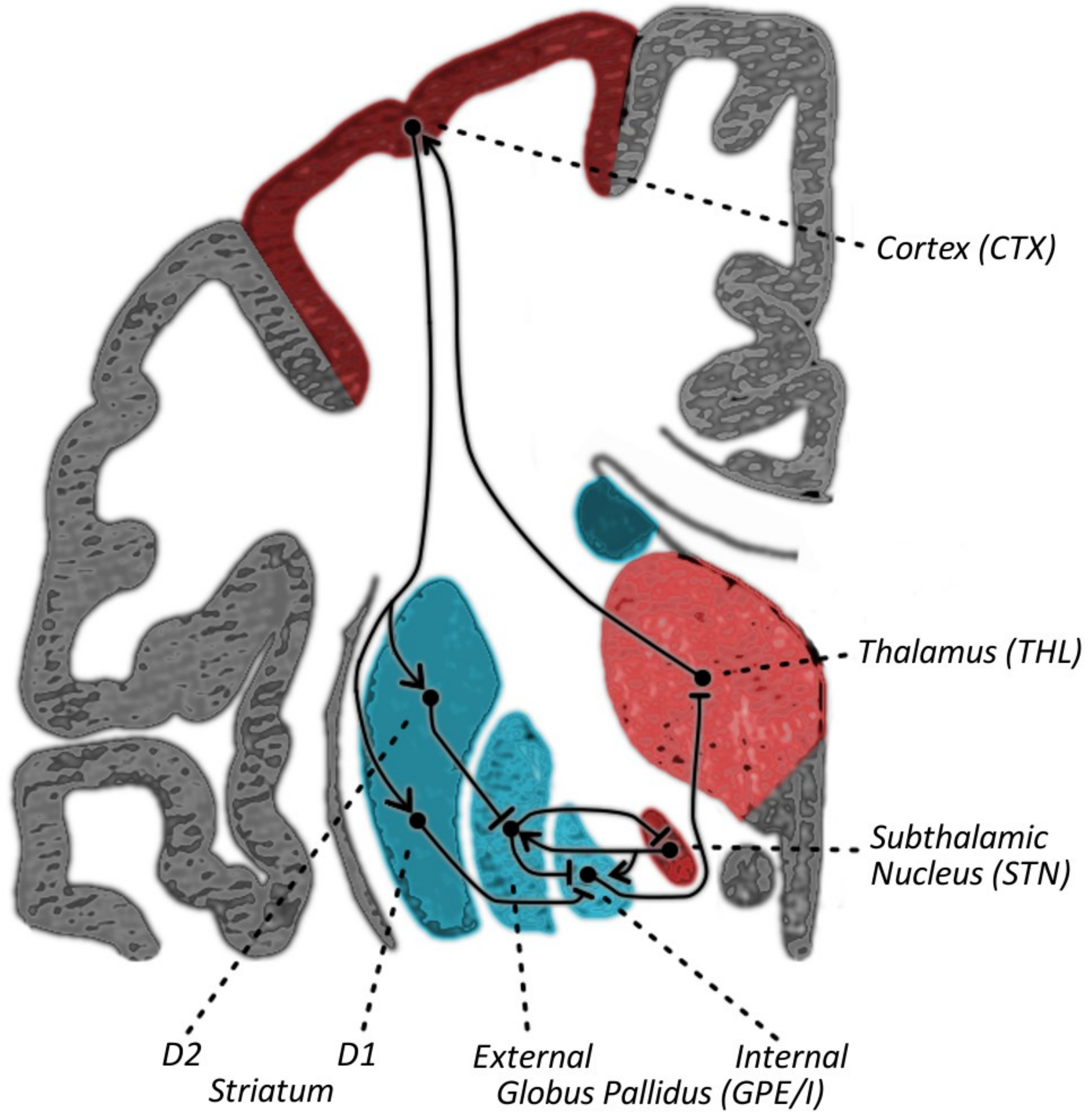
Basal ganglia circuits are implicated in selection and inhibition of responses. Prior work has emphasized static responses and intertrial learning via the corticostriatal and dopaminergic pathways [1].

***In vivo* recordings of human subthalamic nuclei (STN) during DBS surgery suggest involvement in dynamic conflict processing [2]:**

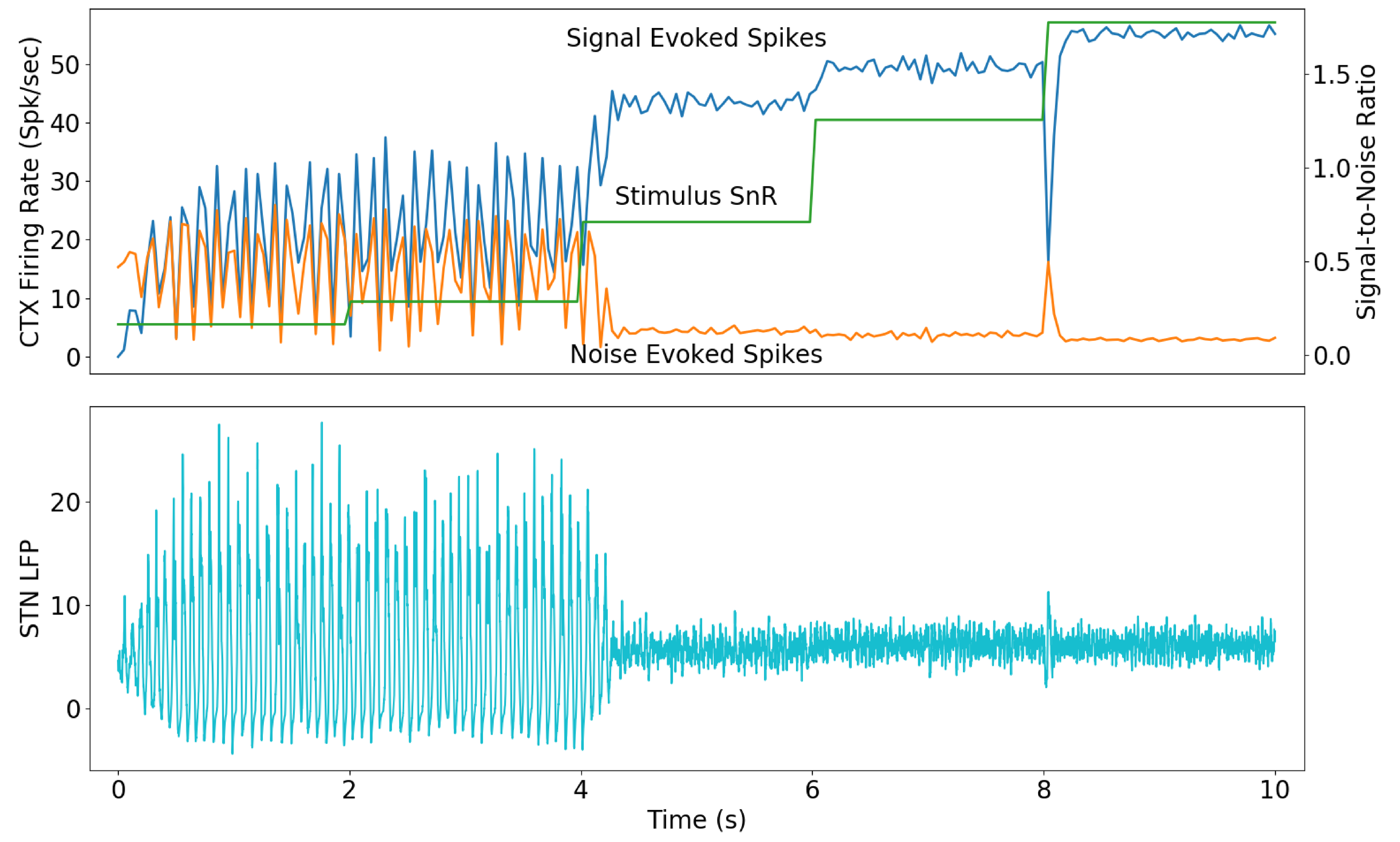


Adapted from "Diseases of the Nervous System" Church (1910), p. 109

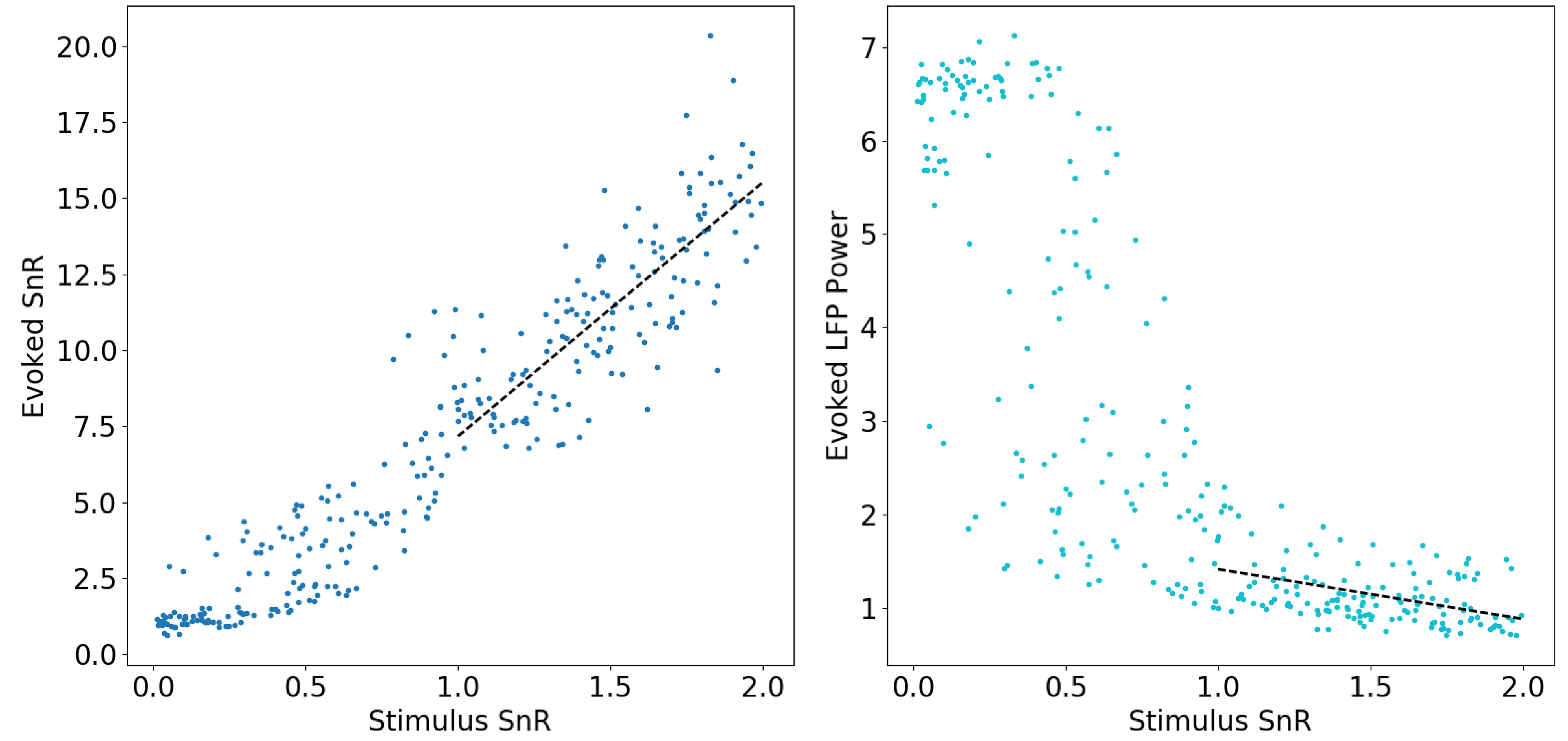
- STN spikes encode decision conflict [3].
- Increased STN theta (4-8 Hz) in LFP during delayed responses to high conflict trials of a flanker task [4].
- Increased STN beta (16-32 Hz) during stop trials of SSRT and incongruent trials of a stroop task [5].
- Theta band coherence may promote neural communication across large scale networks [6].

We developed a spiking neural network model of major regions and pathways of the basal ganglia to investigate the role of STN in dynamic signal selection:

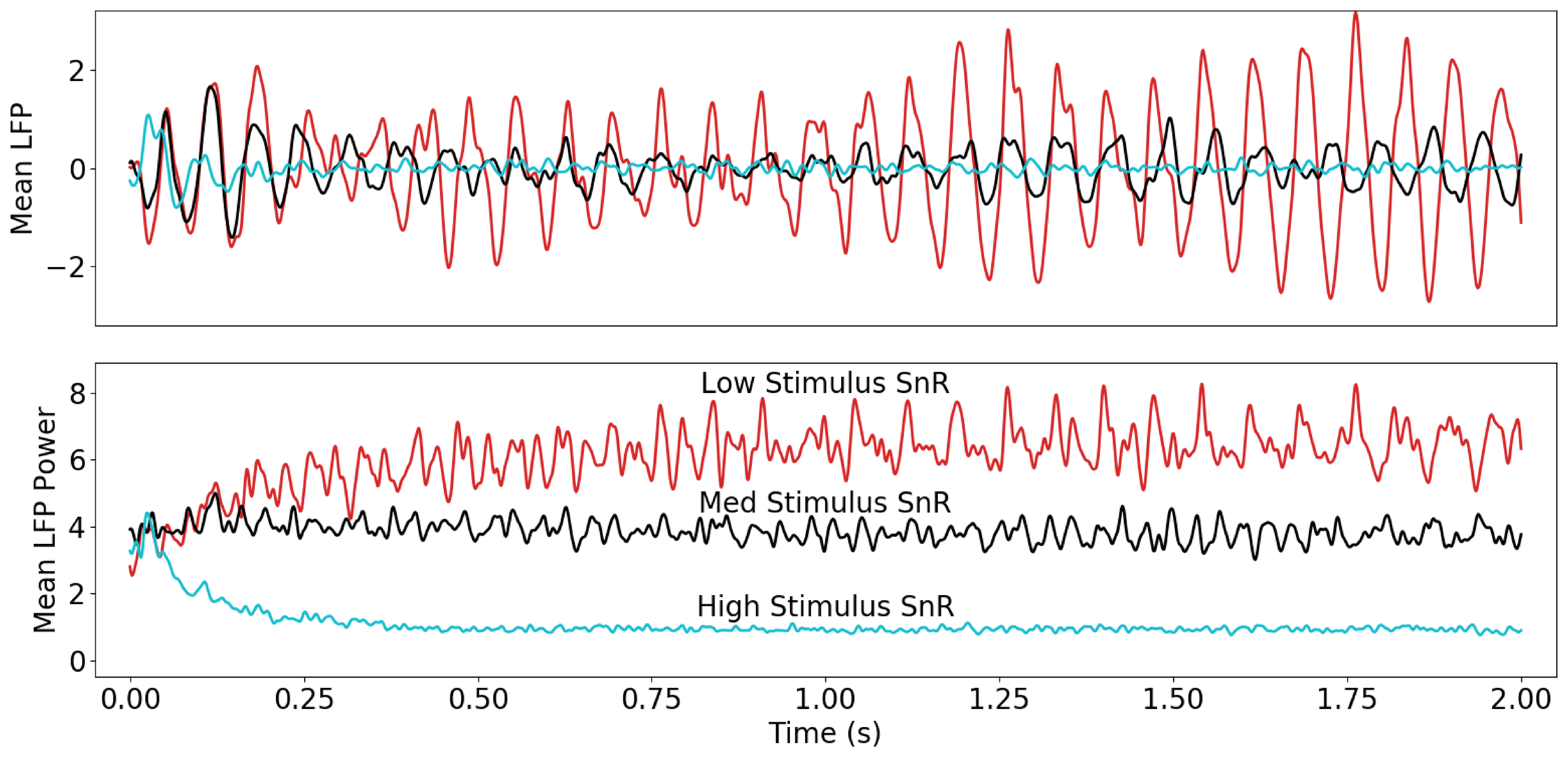
- ***6,000 neurons***
- ***Approx. 500,000 synapses***
- ***Neighborhood connectivity [7]***
- ***Direct (CTX-D1-GPI) and indirect (CTX-D2-GPE) pathways drive on-center off-surround neural computation [8]***
- ***Hyperdirect pathway (CTX-STN-GPI/E) dynamically modulates selection threshold***



Sample Network Responses: *(Top) Evoked firing rates in the model cortex for signal and noise neurons. Stimuli were generated using a gaussian 'bump' with a fixed width and random center position injected at the thalamus (5 stimuli shown). (Bottom) Simulated STN local field potential.*



Signal Selection and Emergent Oscillations: *Evoked SnR and evoked LFP power as a function of stimulus SnR for 300 stimuli.*



Averaged LFP by Stimulus SnR: *Average trial LFP and average LFP power for low, medium, and high stimulus SnR (low < 0.25, high > 1).*

The model exhibits **robust signal selection for high stimulus SnR** by suppressing background firing in the thalamus and cortex. Although this version of the model does not produce responses, we can compare this to rapid responses in low conflict behavioral trials.

Strong oscillations in STN for low stimulus SnR promote broad synchrony (more "*pump your brakes*" than "*hold your horses*").

We propose that the neurocomputational role of the STN in cognitive control is to dynamically modulate the balance between integration of information (via oscillation) and stable signal selection (via noise suppression).

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Acknowledgments

We would like to thank Ben St. Clair for insights on synaptic delays and network stability and Chris Kello for help in understanding complex network dynamics.

This work was supported by National Science Foundation Grant No. 1529127

The authors gratefully acknowledge computing time on the Multi-Environment Computer for Exploration and Discovery (MERCED) cluster at UC Merced, which was funded by National Science Foundation Grant No. ACI-1429783.