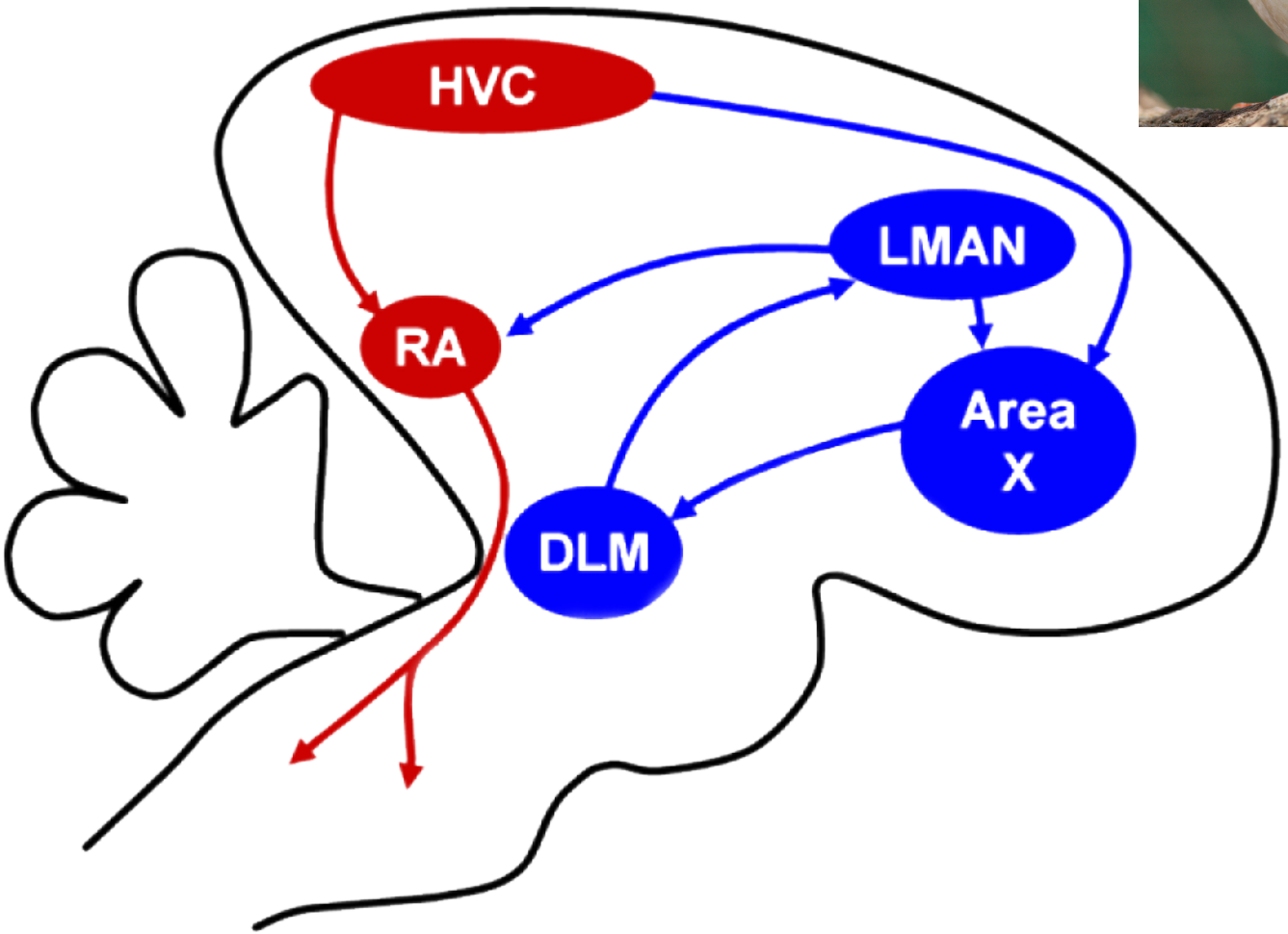
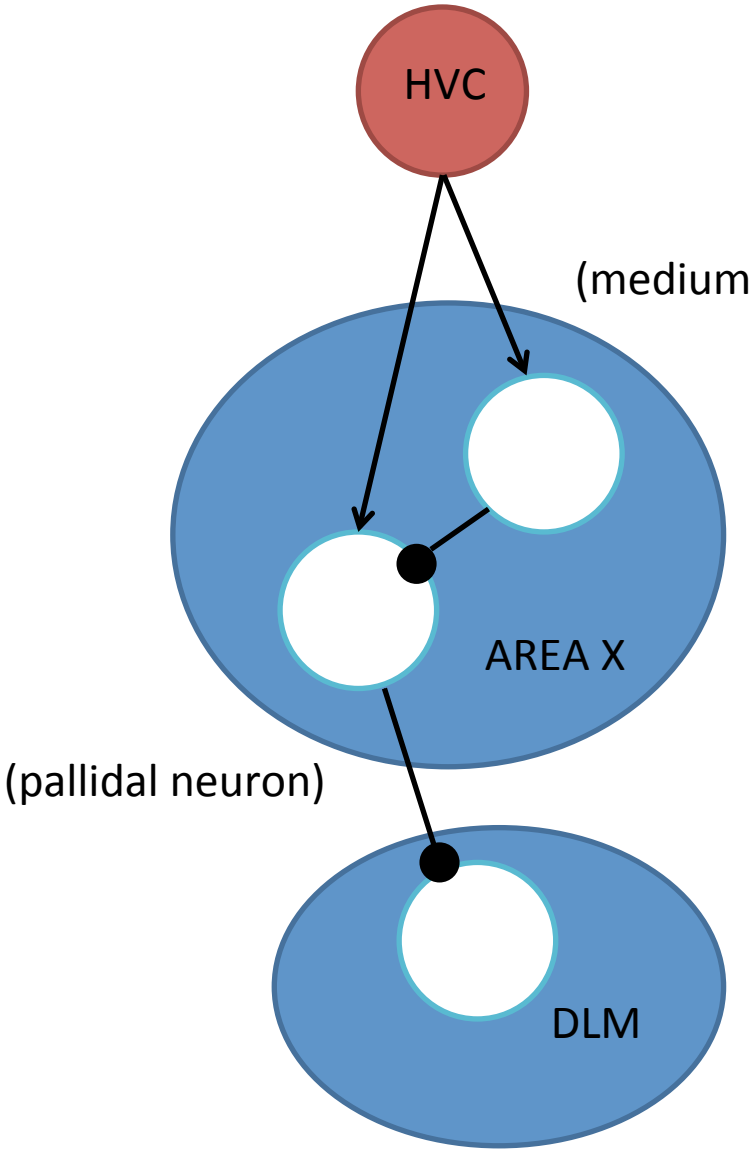
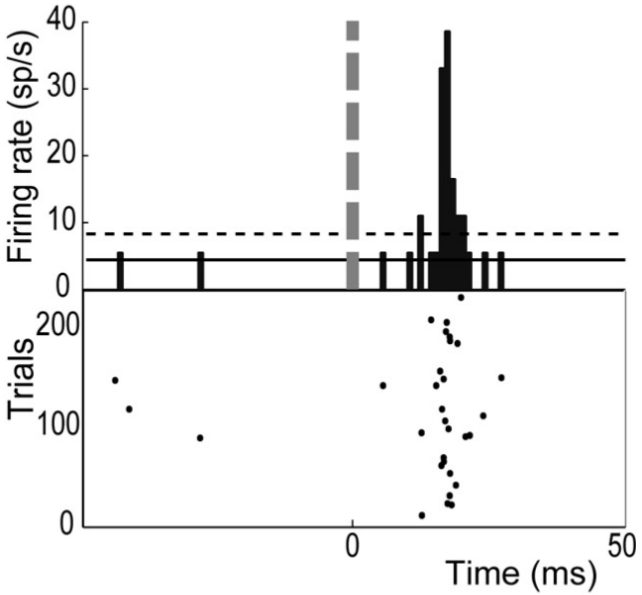
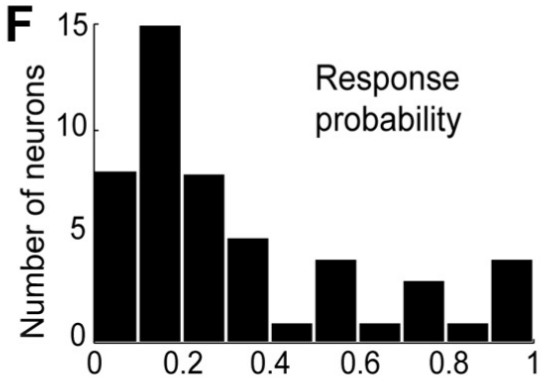
Songbird Vocal Circuitry – Anterior Forebrain Pathway



AFP Basal Ganglia Connectivity







Leblois et al, 2009

How might variability in spiking be produced within this circuit?

- Started by writing differential equations to represent these connections in a firing rate model
- Ended up using Integrate-and-Fire model with injected synaptic conductances

Passive Integrate and Fire

$$cdV/dt = dQ/dt = -i_{mem} + (I_{ext}/A)$$

$$i_{mem} = g_m(V_m - E_{rest})$$

$$CdV/dt = -g_m(V_m - E_{rest}) + I_{ext}$$

$$C\frac{dV_m(t)}{dt} = -\frac{1}{R_m}[V_m(t) - V_{rest}] + I_{ext}(t)$$

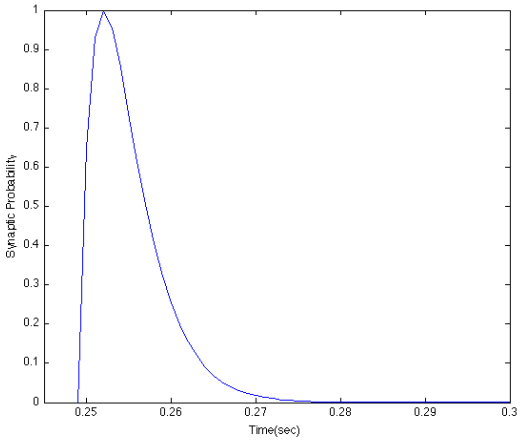
if $V > V_{thr}$ then Spike and $V = V_{reset}$

(+ absolute refractory period)

Dayan P and Abbot LF, *Theoretical Neuroscience*, 2001

Synaptic Current

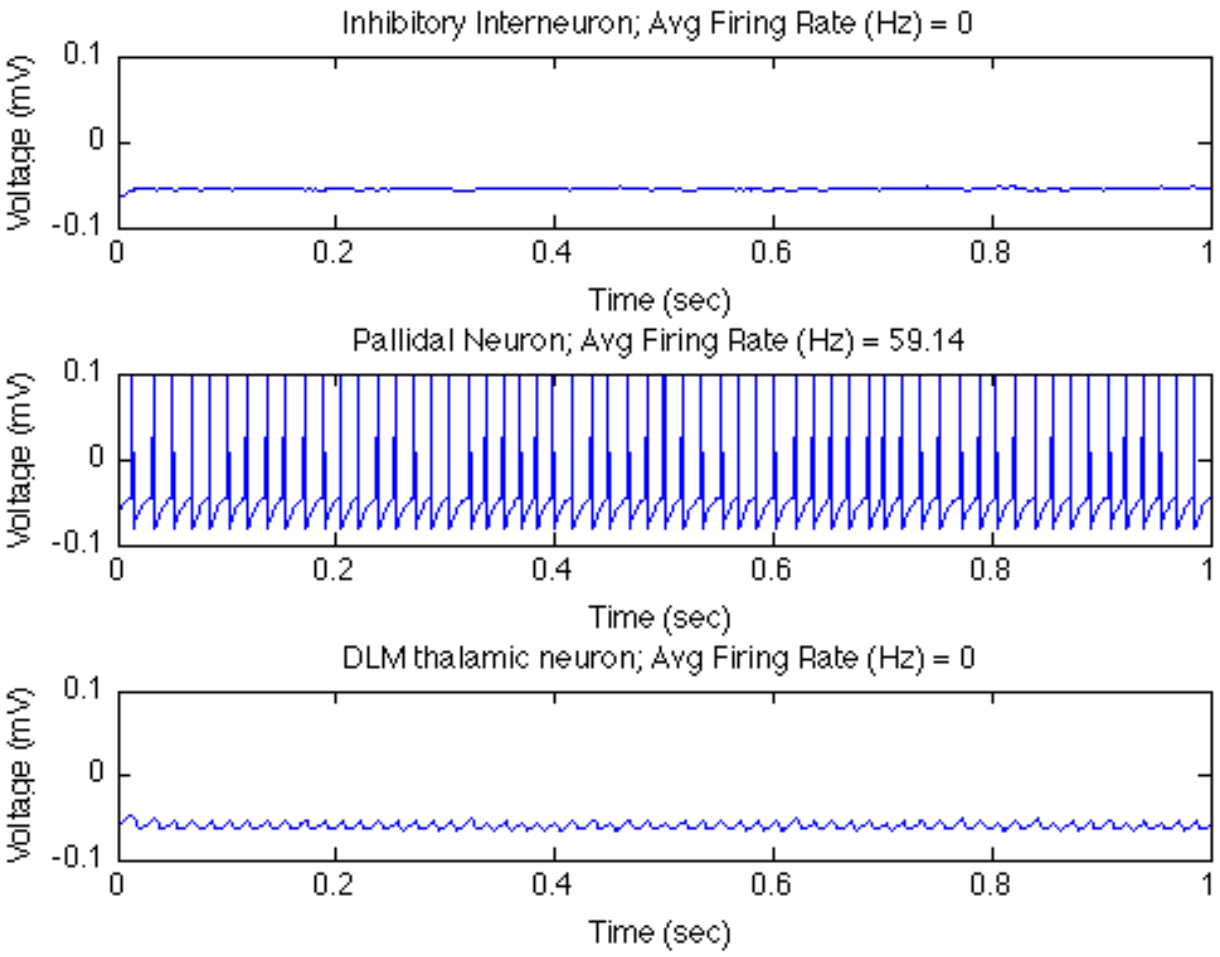
$$\tau_m \, dV/dt = E_l - V + R_m I_e$$



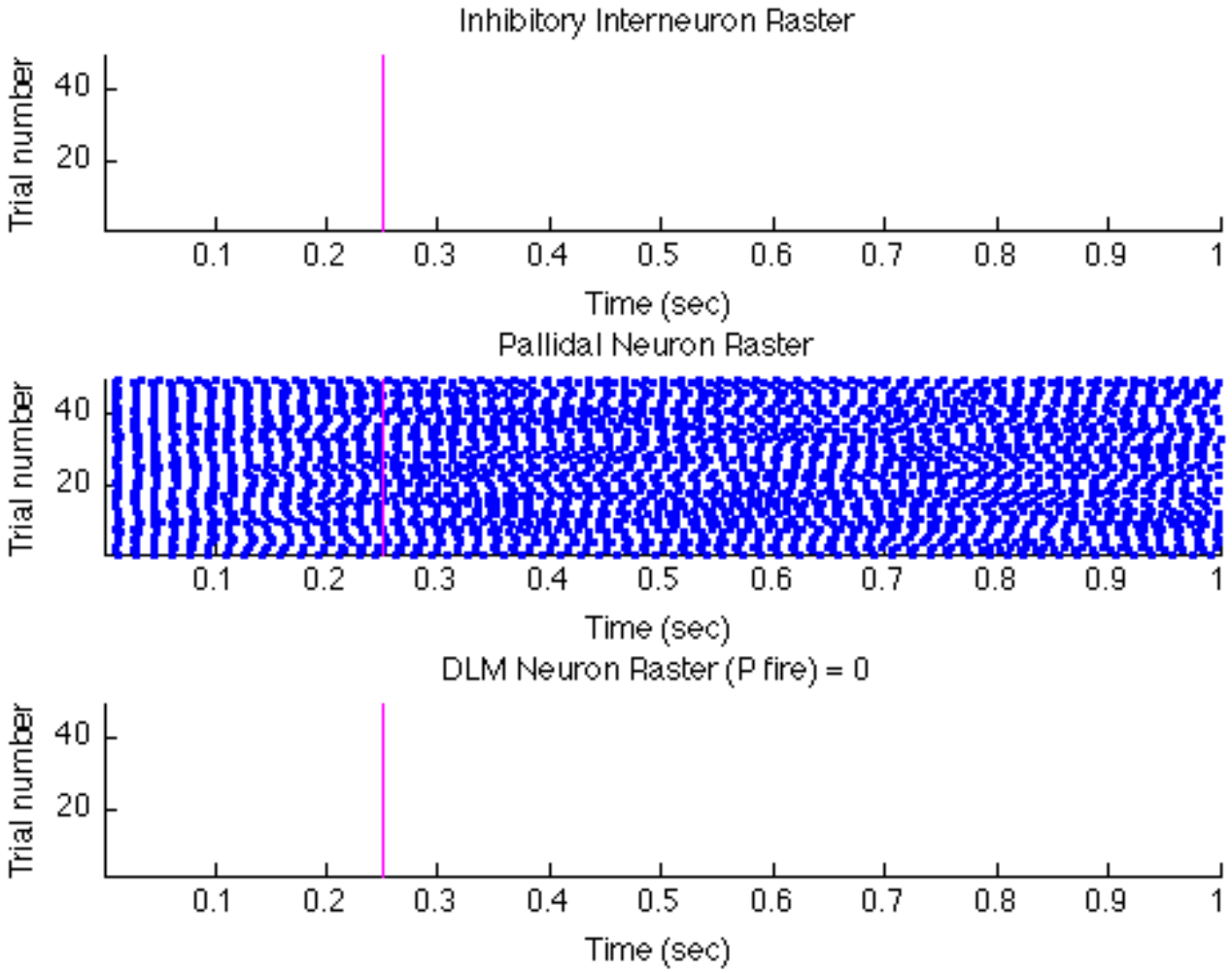
$$P_s = P_{max} * t * e^{1-(t/\tau)}/\tau$$

$$\tau_m \, dV/dt = E_l - V - r_m g_s P_s (V - E_s) + R_m I_e$$

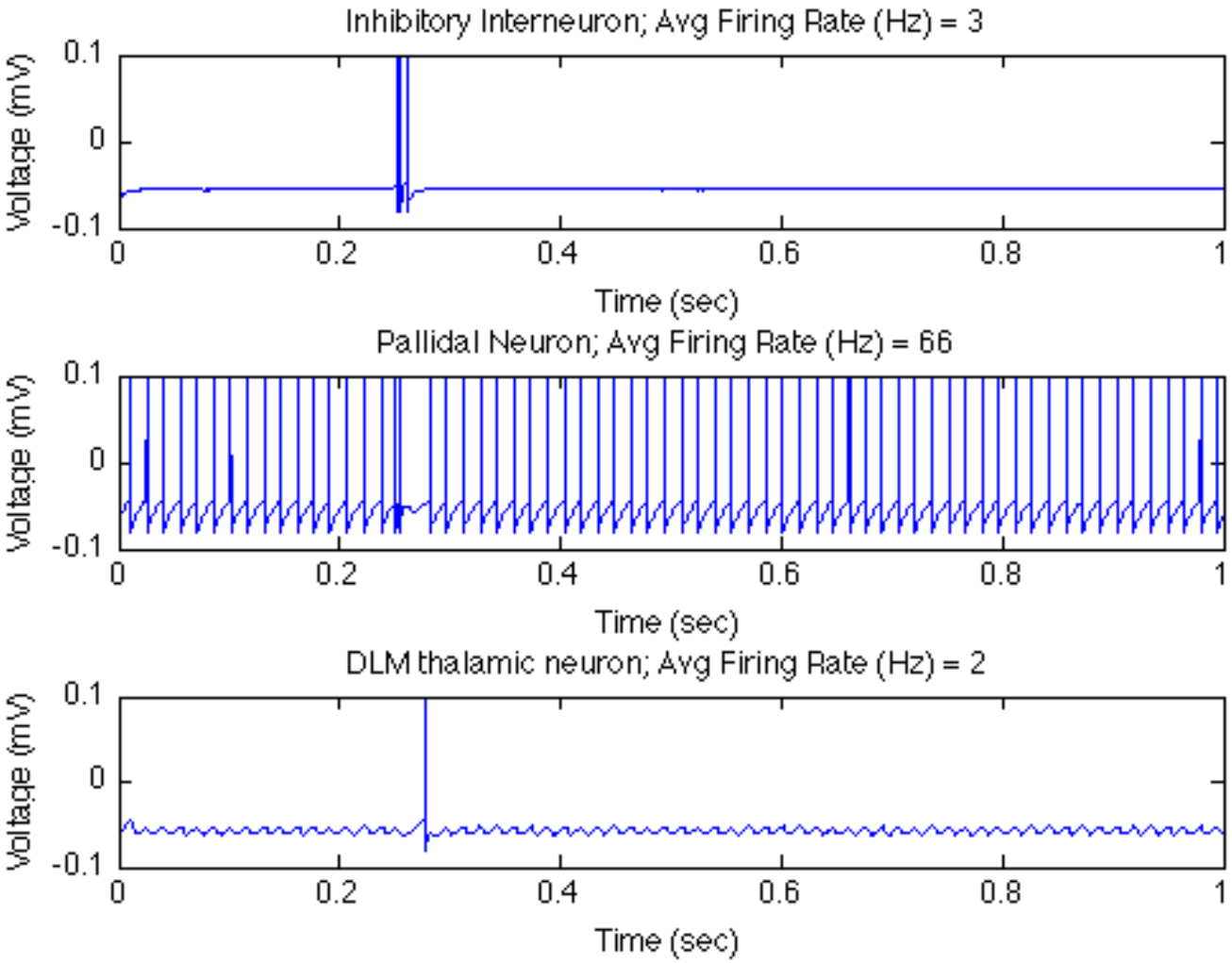
Spontaneous Activity

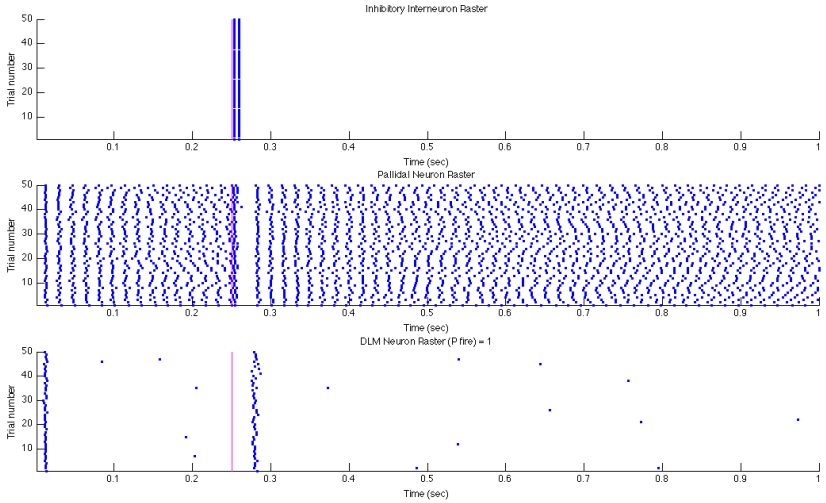


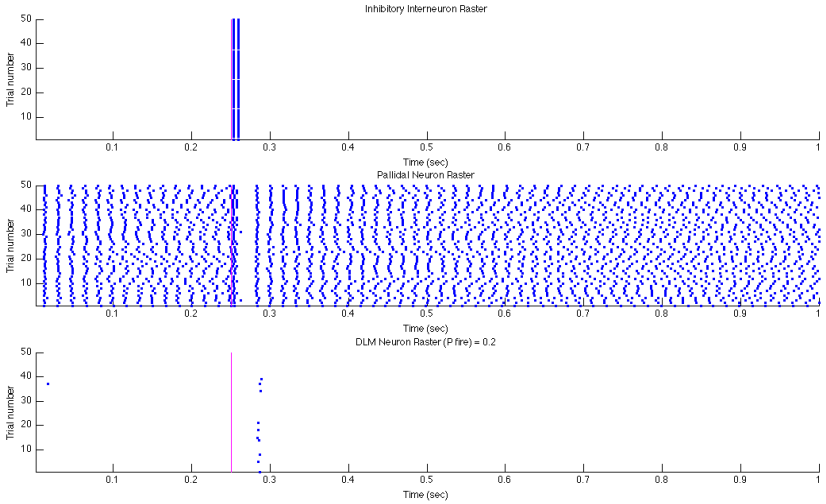
Spontaneous Activity

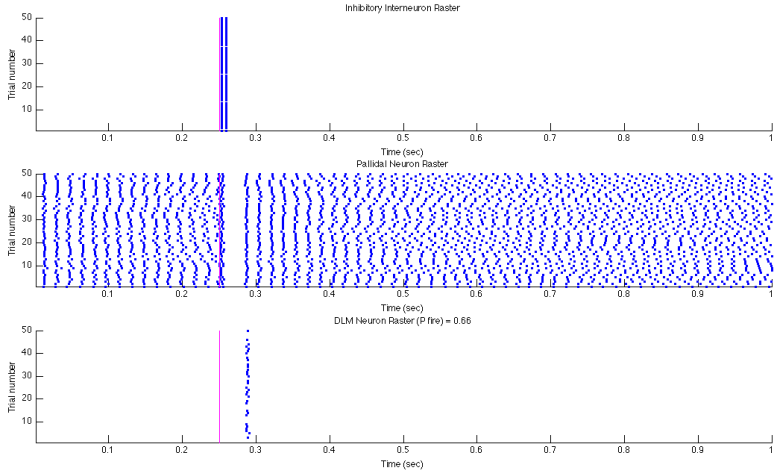


Stimulating excitatory afferents




Inhibitory Interneuron Raster
Trial number
Time (sec)
Pallidal Neuron Raster
Trial number
Time (sec)
DLM Neuron Raster (P fire) = 1
Trial number
Time (sec)


Inhibitory Interneuron Raster
Trial number
Time (sec)
Pallidal Neuron Raster
Trial number
Time (sec)
DLM Neuron Raster (P fire) = 0.2
Trial number
Time (sec)


Inhibitory Interneuron Raster
Trial number
Time (sec)
Pallidal Neuron Raster
Trial number
Time (sec)
DLM Neuron Raster (P fire) = 0.66
Trial number
Time (sec)

- Changing strength of excitatory input
- Changing strength of inhibitory feedback onto pallidal cell
- Variability in the noise being injected into the pallidal cell
- Time constants
- Need to make the model more robust!
- Phase – trigger cortical input during different phases of pallidal cell's ISI

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