Network Model (6):

Decision Making Network

Neuron models	HH neuron model
	LIF neuron model
	Exponential IF model
Synapse models	Exponential/Alpha synapse
	AMPA/GABA/NMDA synapse
Network Models	E/I balance network
	Continuous attractor network
	Working memory model
	Decision making model

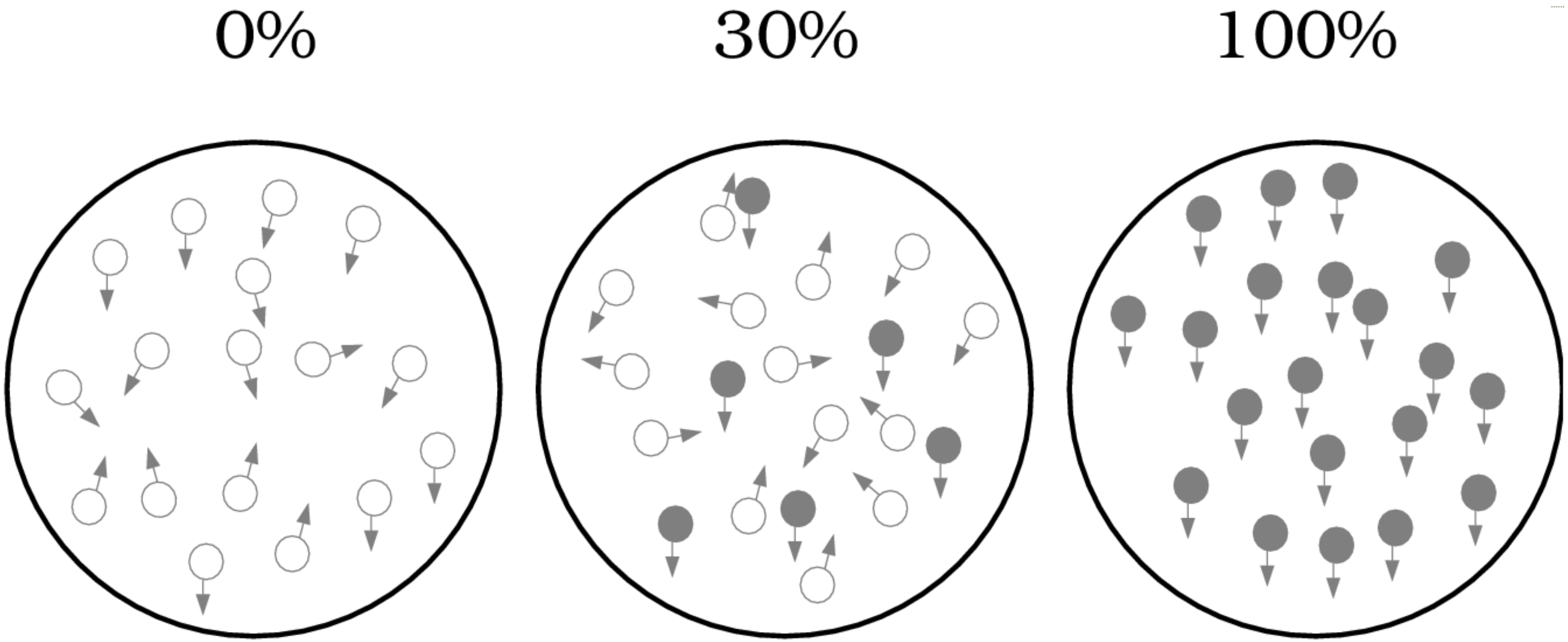
Problems of DDM

- Abstract: neural correlates of model variables are unclear

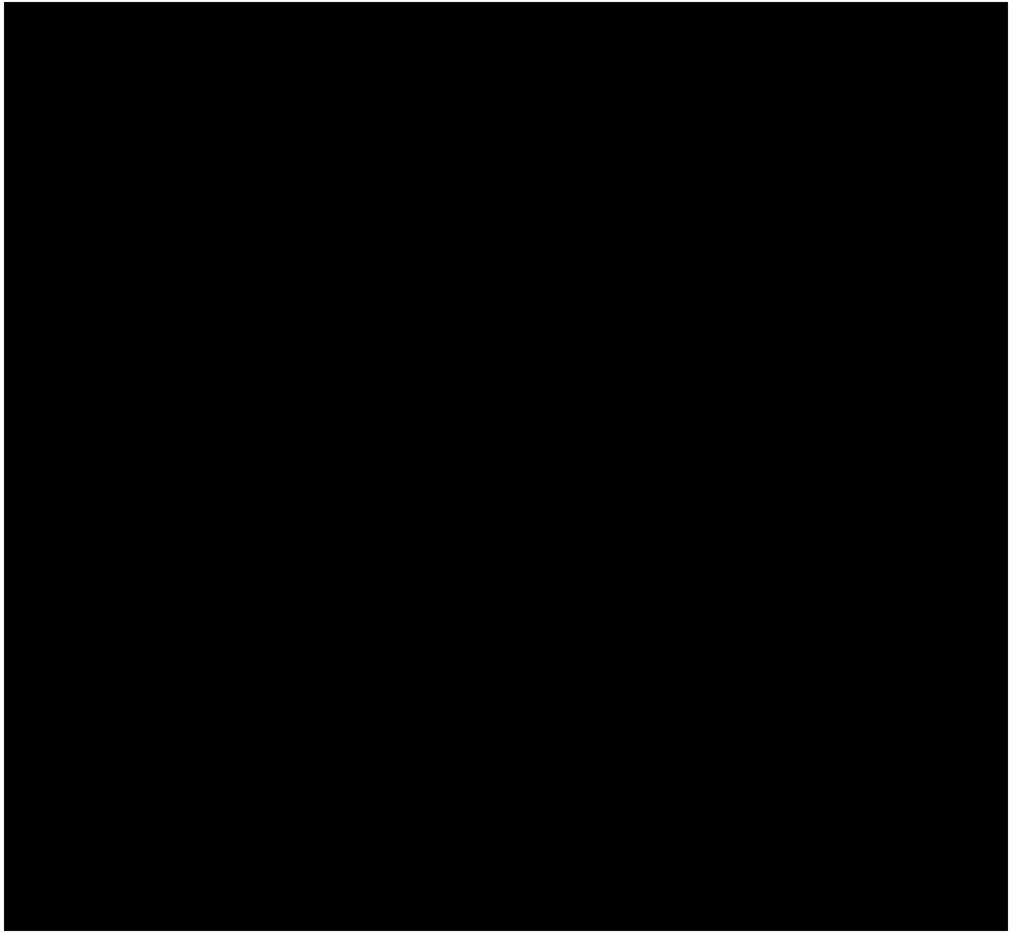
- Unrealistic: leak of information is missing, etc

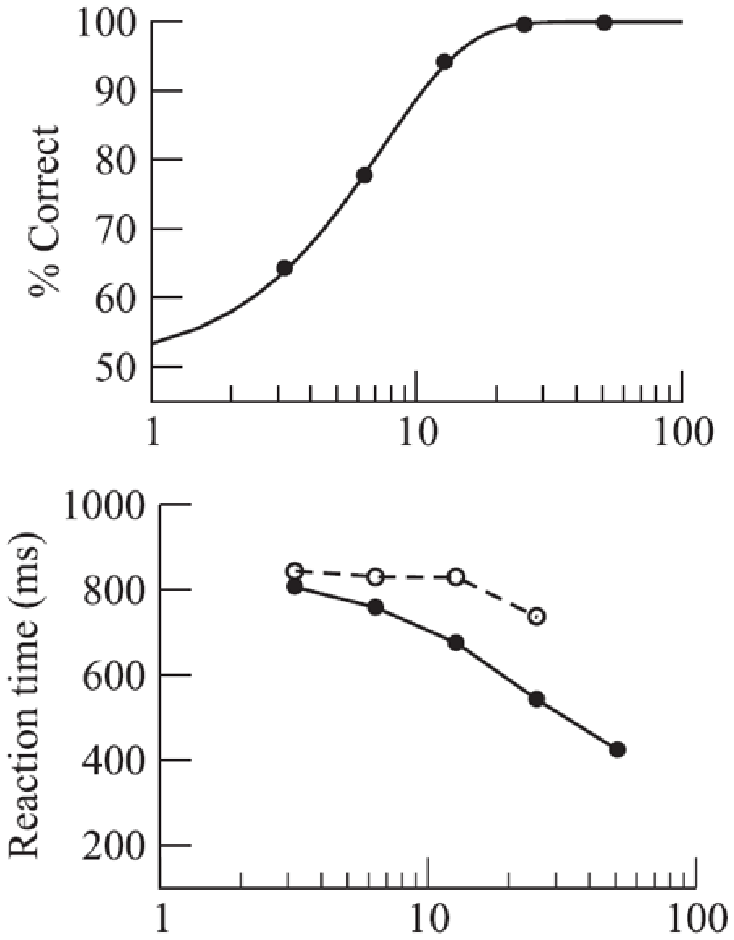
- Limited: cannot capture the reaction time difference between correct and incorrect trials

Random moving dot with varies coherence level

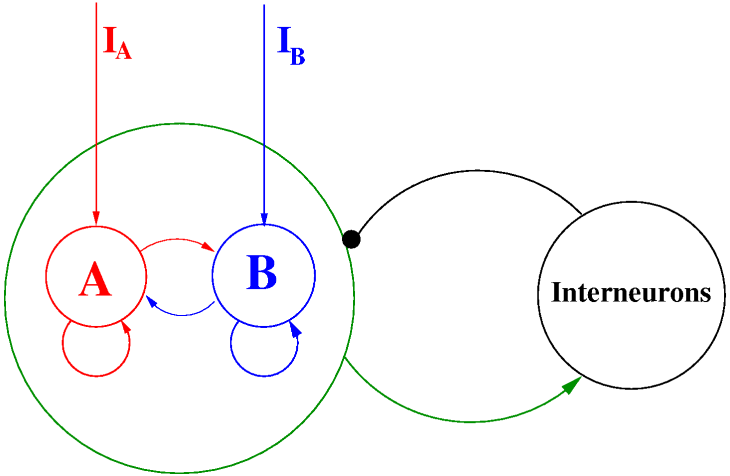


Random moving dot with varies coherence level





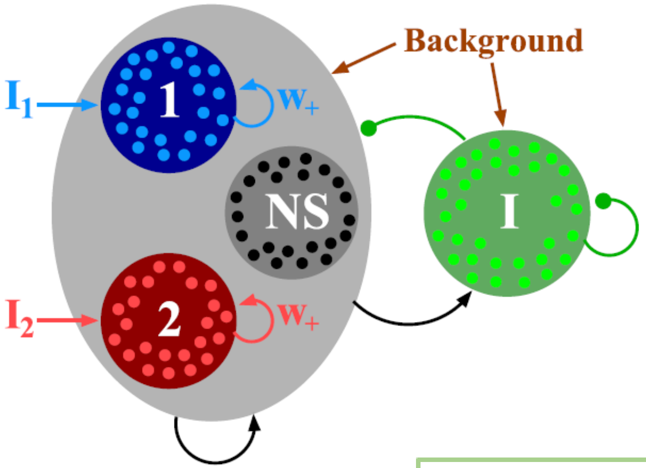
A cortical circuit model for decision making



Wang, Neuron 2002
Wong and Wang J Neurosci 2006

- 2-population excitatory neurons (integrate-and-fire neurons driven by Poisson input)
- Slow reverberatory excitation mediated by the NMDA receptors at recurrent synapses
- Winner-take-all competition by feedback inhibition

Spiking neuronal network model



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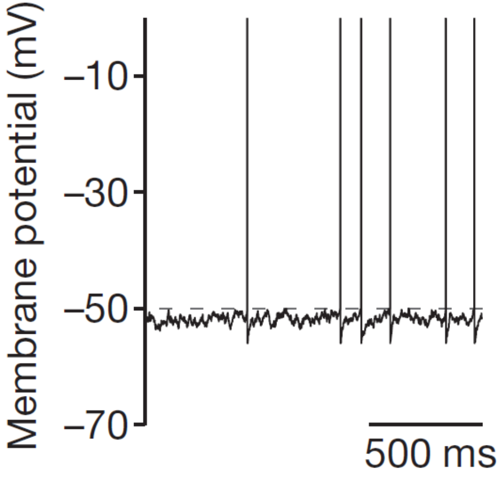


$$C_m \frac{dV(t)}{dt} = -g_L(V(t) - V_L) - I_{syn}(t) \qquad I_{syn}(t) = I_{ext,AMPA}(t) + I_{rec,AMPA}(t) + I_{rec,NMDA}(t) + I_{rec,GABA}(t)$$

$$I_{\text{ext,AMPA}}(t) = g_{\text{ext,AMPA}}\,(V(t) - V_E)\, s^{\text{ext,AMPA}}(t)$$

$$I_{\text{rec,AMPA}}(t) = g_{\text{rec,AMPA}}\,(V(t) - V_E) \sum_{j=1}^{C_E} w_j s_j^{\text{AMPA}}(t)$$

$$I_{\text{rec,NMDA}}(t) = \frac{g_{\text{NMDA}}(V(t) - V_E)}{(1 + [\text{Mg}^{2+}]\exp(-0.062V(t))/3.57)} \sum_{j=1}^{C_E} w_j s_j^{\text{NMDA}}(t)$$

$$I_{\text{rec,GABA}}(t) = g_{\text{GABA}}\,(V(t) - V_I) \sum_{j=1}^{C_I} s_j^{\text{GABA}}(t)$$

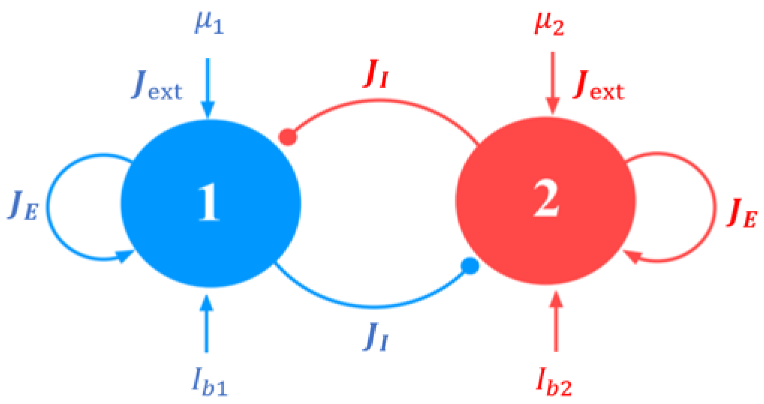
$$\frac{ds_j^{\text{AMPA}}(t)}{dt} = -\frac{s_j^{\text{AMPA}}(t)}{\tau_{\text{AMPA}}} + \sum_k \delta(t - t_j^k)$$

$$\frac{ds_j^{\text{GABA}}(t)}{dt} = -\frac{s_j^{\text{GABA}}(t)}{\tau_{\text{GABA}}} + \sum_k \delta(t - t_j^k)$$

$$\frac{ds_j^{\text{NMDA}}(t)}{dt} = -\frac{s_j^{\text{NMDA}}(t)}{\tau_{\text{NMDA,decay}}} + \alpha x_j(t)(1 - s_j^{\text{NMDA}}(t))$$

$$\frac{dx_j(t)}{dt} = -\frac{x_j(t)}{\tau_{\text{NMDA,rise}}} + \sum_k \delta(t - t_j^k)$$

Model Reduction



Synaptic variables

$$\frac{dS_1}{dt} = F(I_1)\,\gamma(1 - S_1) - S_1/\tau_s$$
$$\frac{dS_2}{dt} = F(I_2)\,\gamma(1 - S_2) - S_2/\tau_s$$

Coherence-dependent inputs

$$\mu_1 = \mu_0(1 + c')$$
$$\mu_2 = \mu_0(1 - c')$$

Input Current to each population

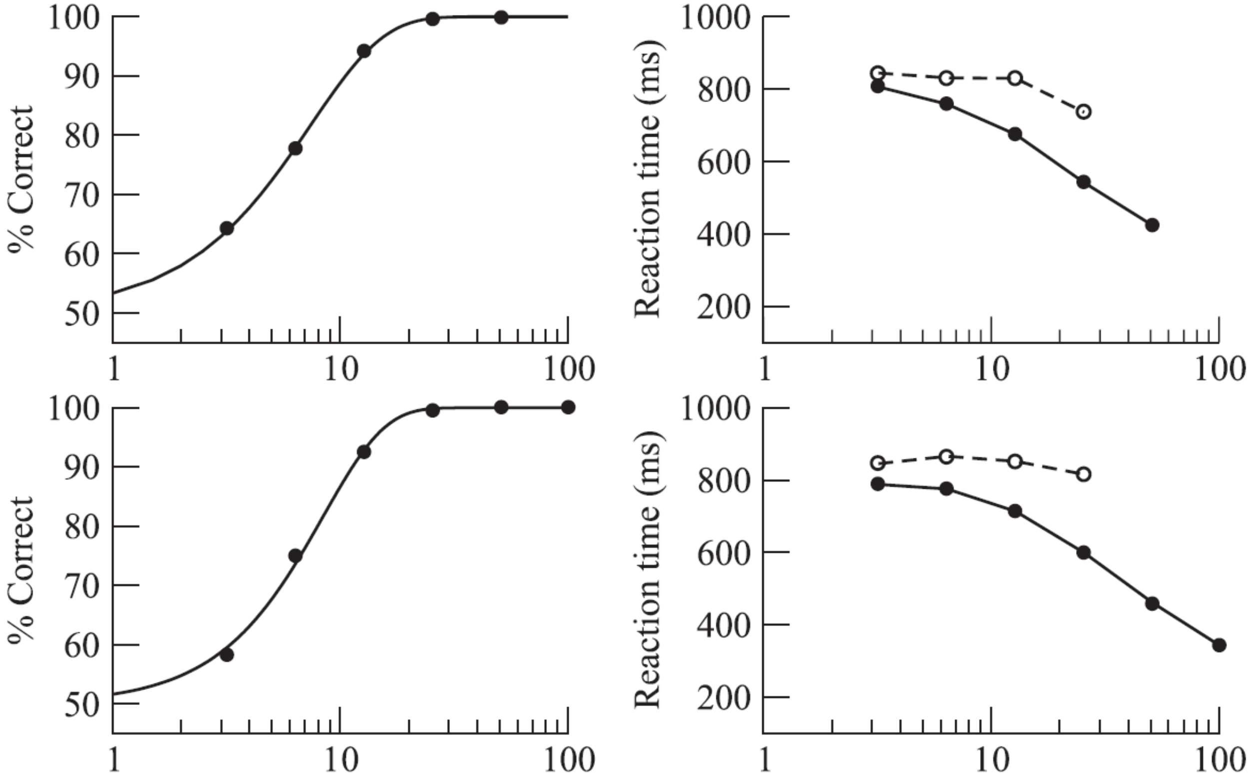
$$I_1 = J_E S_1 + J_I S_2 + I_{b1} + J_{ext}\mu_1$$
$$I_2 = J_E S_2 + J_I S_1 + I_{b2} + J_{ext}\mu_2.$$

Firing rates

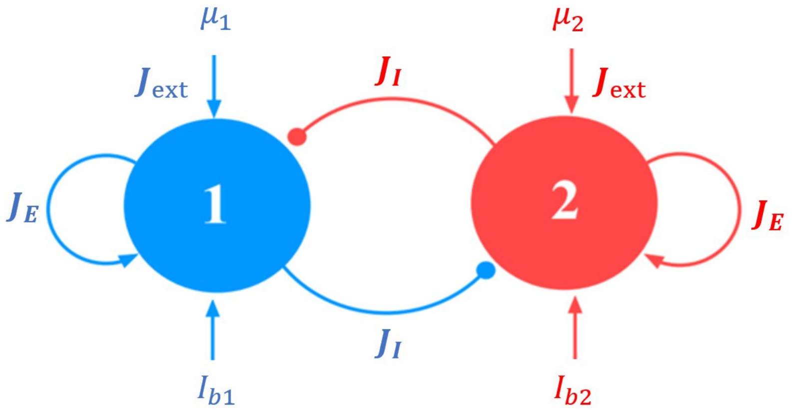
$$r_i = F(I_i) = \frac{aI_i - b}{1 - \exp(-d(aI_i - b))}$$

Experimental data

Spiking neuronal network model

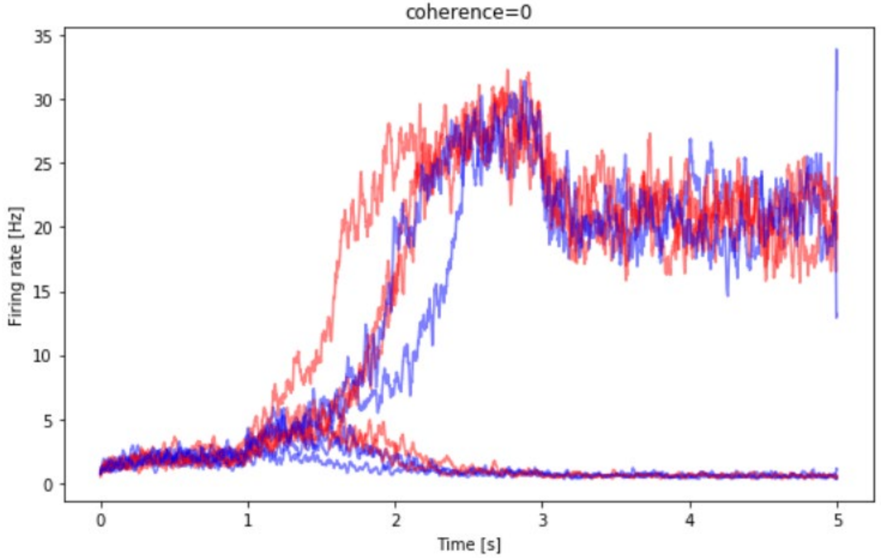


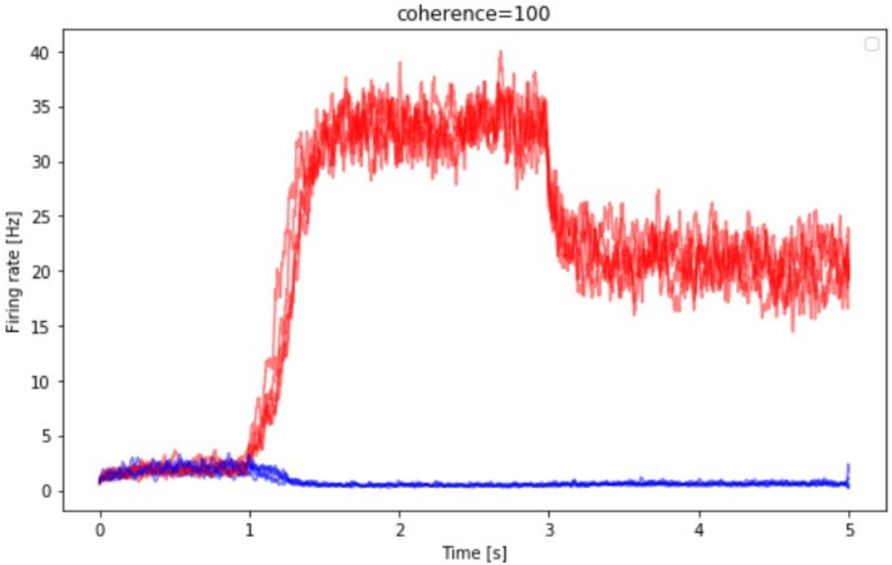
Wong and Wang J Neurosci 2006



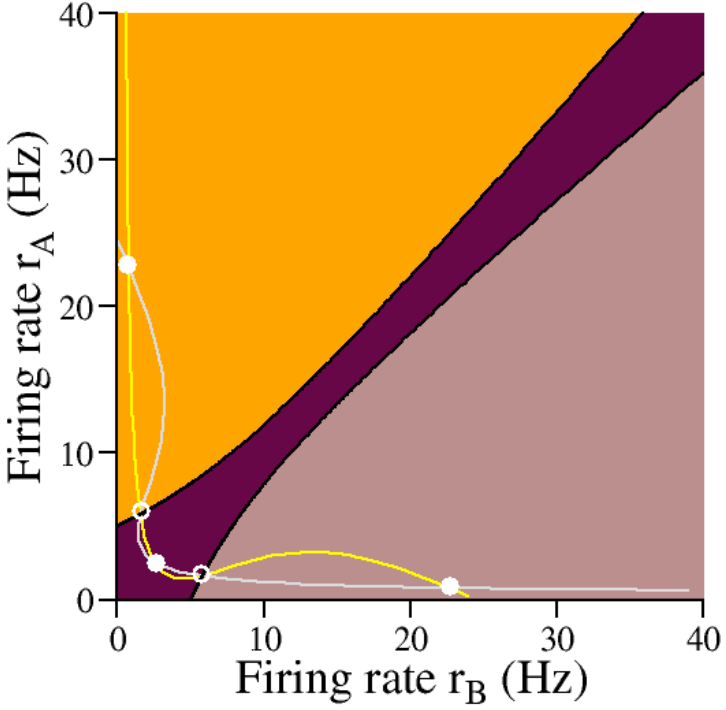
Coherence-dependent inputs

$$\mu_1 = \mu_0(1 + c')$$
$$\mu_2 = \mu_0(1 - c')$$

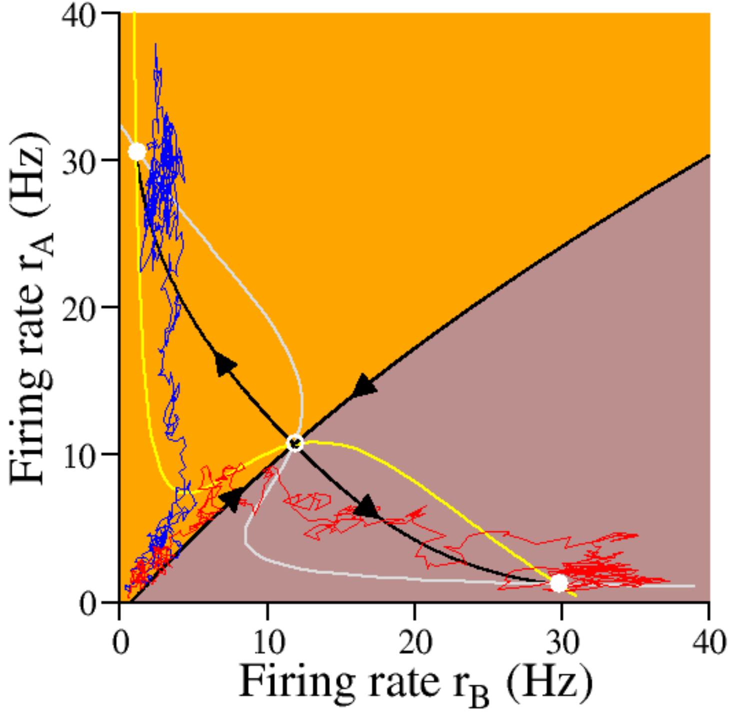




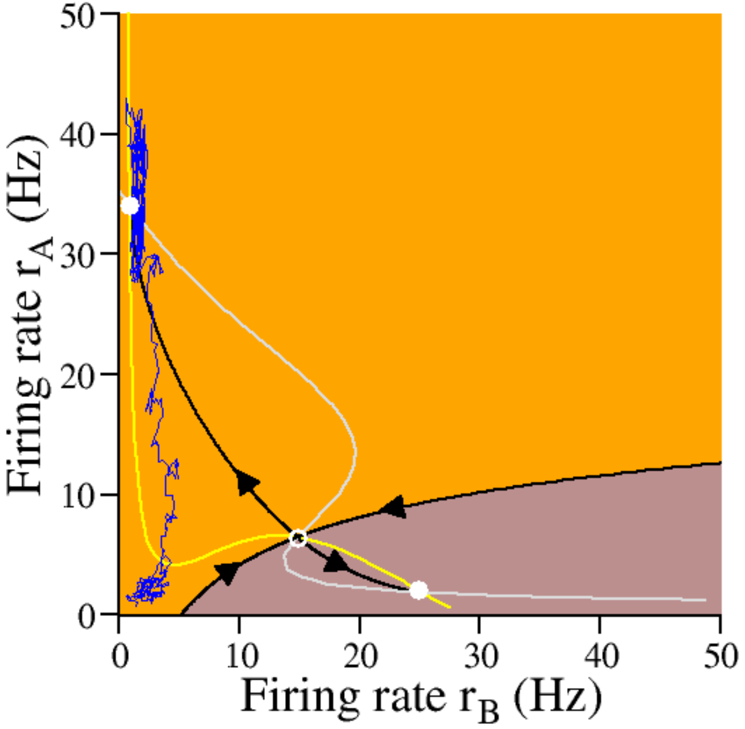
Without stimulation



Stimulus with c'=6.4%

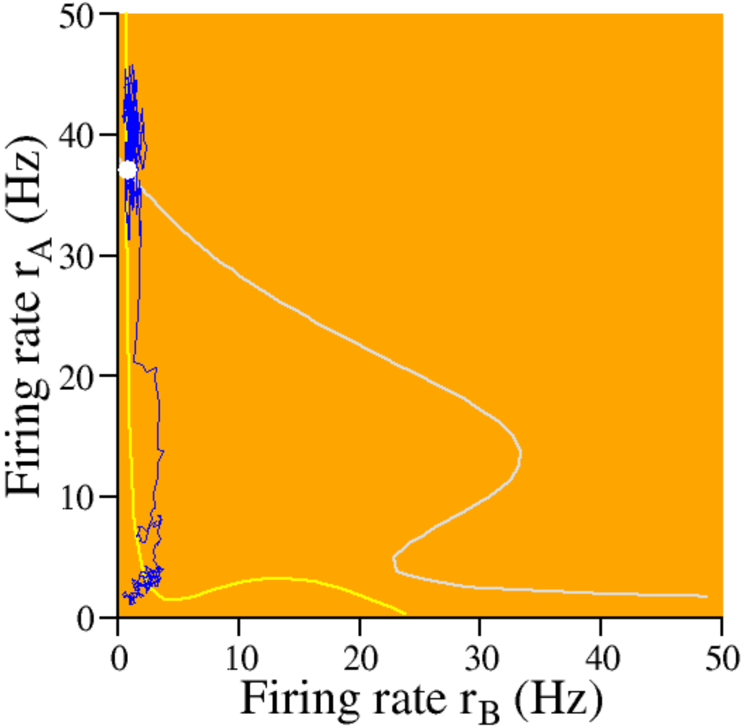


c’=51.2%



Firing rate r_A (Hz)
Firing rate r_B (Hz)
0
10
20
30
40
50

c’=75%



Firing rate r_A (Hz)
Firing rate r_B (Hz)
0
10
20
30
40
50