

Parameter	Value	Units	Description
N	100	-	Number of neurons per population
dt	1	ms	Integration time step
T	50	ms	Stimulus pulse duration
$\tau_{stim}$	50	ms	Decay constant of stimulus
$\tau_w$	40	ms	Time window for firing rate integration
$p_r$	30	Hz	Rate of Poisson stimulus pulse
$\sigma_N$	N (0,100)		Gaussian white noise at membrane
$\rho$	1/7	-	Fractional change of synaptic activation
$\tau_s^E, \tau_s^I, \tau_s^{inp}$	80, 10, 10	ms	Time constant for synaptic activation for excitatory (EE and IE), inhibitory (EI), and input connections
$g_L$	10	nS	Leak conductance
$C_m$	200	pF	Membrane capacitance
$E_L$	-60	mV	Leak reversal potential
$E_E, E_I$	-5, -70	mV	Excitatory and inhibitory reversal potentials
$v_{th}, v_{th}^I$	-55, -50	mV	Spiking threshold potential (excitatory, inhibitory)
$v_{rest}$	-60	mV	Resting potential
$v_{hold}$	-61	mV	Reset potential
$t_{ref}$	3	ms	Absolute refractory period
$\tau_p, \tau_d$	2000, 1000	ms	LTP/LTD eligibility trace time constant, recurrent connections
$T_{p,max}, T_{d,max}$	0.0033, 0.00345	-	Saturation level, LTP/LTD eligibility trace, recurrent connections
$\eta_p, \eta_d$	45 x 3500, 25 x 3500	ms <sup>-1</sup>	Activation rate, LTP/LTD eligibility trace, recurrent connections
$\tau_p^{FF}, \tau_d^{FF}$	200, 800	ms	LTP/LTD eligibility trace time constant, feed forward connections
$T_{p,max,FF}$	0.0034	-	Saturation level, LTP eligibility trace, feed forward connections
$T_{d,max,FF}$	0.00345 (MARKOVIAN FF) 0.0045 (MARKOVIAN A2A)	-	Saturation level, LTD eligibility trace, feed forward connections
$\eta_p^{FF}$	20 x 3500 (MARKOVIAN FF) 8.8 x 3500 (MARKOVIAN A2A)	ms <sup>-1</sup>	Activation rate, LTP eligibility trace, feed forward connections
$\eta_d^{FF}$	15 x 3500 (MARKOVIAN FF) 10 x 3500 (MARKOVIAN A2A)	ms <sup>-1</sup>	Activation rate, LTD eligibility trace, feed forward connections
$r_{th}$	10	Hz	Hebbian activation threshold (recurrent connections)
$r_{th}^{FF}$	20 (MARKOVIAN FF) 30 (MARKOVIAN A2A)	Hz	Hebbian activation threshold (feed forward connections)
$T_{reward}$	25	ms	Duration of neuromodulator presentation upon change in stimulus
$T_{tr}$	25	ms	Duration of refractory period for traces following neuromodulator presentation
$d_{reward}$	25	ms	Novelty delay upon change in stimulus
$\eta$	0.16(recurrent) 20 (feed-forward, MARKOVIAN FF) 32 (feed-forward, MARKOVIAN A2A)	ms <sup>-1</sup>	Learning rates, recurrent and feed forward connections (note that these are scaled by the delay period, so are implemented in MATLAB as $\eta = 2 * \eta_{fixed} / T_{reward}$ ). Slower learning rates will be more stable but take more trials to converge to fixed-points.
$\phi$	0.26 (0.3)	-	Sparsity of fixed connections, implemented in MATLAB as 0.3, which results in an effective sparsity of 0.26 because of random number generator oddities
$W_{EE}^{MT}, W_{EI}^{MT}$	0.2, -70	nS	Synaptic connection strength, Timer to Messenger excitatory to excitatory (EE) and inhibitory to excitatory (EI) connections
$W_{EI}^{TT}, W_{EI}^{MM}$	-100, -100	nS	Synaptic connection strength, intercolumnar Timer-Timer and Messenger-Messenger inhibitory to excitatory (EI) connections
$W_{IE}^{TT}, W_{IE}^{MM}$	0.2, 1	nS	Synaptic connection strength, intracolumnar Timer-Timer and Messenger-Messenger excitatory to inhibitory (IE) connections

**Supplementary File 1. Table of Main Model Parameters.** For full code, see <http://modeldb.yale.edu/266774>