

# Appendix: Black-box and surrogate optimization for tuning spiking neural models of striatum plasticity

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## SUPPLEMENTARY MATERIALS

### 2 Neuron models and parameters used

3 We used conductance-based versions of the Leaky-Integrate and Fire (LIF) neuron model (Gerstner  
4 and Kistler, 2002) in every layer of the network, but with different parameters. We classify the neuron  
5 types according to the layer they belong to: cortical neurons for the input, striatal neurons for the learning  
6 layer, and action neurons for the output. There is also a dopaminergic neuron that receives the rewards and  
7 punishments.

8 The parameters used for each type were manually tuned to obtain reasonable firing rates. For the cortical  
9 neurons we used a number of spikes per input cycle (with 8 cycles per second) close to Masquelier et al.  
10 (2009) and Garrido et al. (2016). For the striatal neurons, we tuned the parameters to obtain a mean firing  
11 rate of around one spike per second to be within biological ranges (Miller et al., 2008) but with activity  
12 peaks of two or three spikes per input cycle (16-24 spikes per second). The action neurons are tuned to fire  
13 every input cycle if they receive enough stimulation from its channel (at least two more spikes from D1  
14 neurons than D2 neurons each cycle). The dopamine neuron was tuned to have a firing range from 50 to  
15 350 spikes per second. The parameters used for each neuron type are shown at supplementary Table 1.

Parameter	Cortical	Striatal	Action	Dopaminergic
$e_{exc}$ (mV)	0.0	0.0	0.0	0.0
$e_{inh}$ (mV)	−85.0	−85.0	−85.0	−85.0
$\tau_{AMPA}$ (ms)	5.0	5.0	5.0	5.0
$\tau_{GABA}$ (ms)	10.0	30.0	60.0	10.0
$\tau_{ref}$ (ms)	1.0	15.0	15.0	1.0
$C_m$ (pF)	250.0	50.0	100.0	250.0
$g_{leak}$ (nS)	25.0	10.0	25.0	25.0
$V_{thr}$ (mV)	−40.0	−50.0	−40.0	−65.0
$e_{leak}$ (mV)	−65.0	−65.0	−65.0	−40.0

**Table 1.** Neuron parameters used in the model.

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