Electronic Appendix for:

Action Selection and Refinement in Subcortical Loops Through Basal Ganglia and Cerebellum

Houk JC, Bastianen C, Fansler D, Fishbach A, Fraser D, Reber PJ, Roy SA, Simo LS

Northwestern University Medical School, Chicago (j-houk@northwestern.edu)

Implementation details of the minimal model for competitive pattern classification

The network was implemented using Matlab (the Mathworks) as described in Fansler et al. (2004). The set of programs that implement the model is included in the attached zip file (HoukModel.zip) and a brief overview of the key programs is given below. Note that the model does not use spiking neurons and the neuronal firing rate is calculated as a sigmoidal function of a neuron's membrane potential. Throughout the appendix, function names will be annotated with italics and bold characters and variable names with italics characters. We would like to thank Aaron Gruber for sharing his code for the spiny neurons and for his help in developing this code.

dope_main – This is the main simulation program.

Syntax: [*total_syn_exc*, *total_syn_inh*] = ***dope_main***(*num_sims*, *plot_flag*, *post_syn*)

The different model's layers and the connection matrices between the layers are defined and set here. Then the model runs for a predetermined period of time (*sim_end_time* seconds). The state of the network is saved each iteration to a file ('model_output.mat' at Matlab's current directory). *Num_sims* is the number of loops one wishes to run. For statistical significance, several thousand loops are needed. Note, however, that for plotting purposes only one simulation can be used. If *plot_flag* is set to 1, plots are generated during the simulation run. If *post_syn* is set to 1, post-synaptic inhibition is used. If *post_syn* is set to 0 pre-synaptic inhibition is used. The network is currently set with a high noise level (variable *noise_strength*) that should cause misclassification errors about 25% of the time. Lower or higher level of noise can be set by changing the value of *noise_strength*.

The function ***dope_main*** returns the total synaptic activity (separated to excitatory – *total_syn_exc* and inhibitory - *total_syn_inh*) in the caudate layer of the model. These are the simulated proxies for the BOLD level for comparison with fMRI activation level. See lines 129-130 in the function ***dope_main*** for more details.

CD_layer and ***CD_funct*** – These are the functions that implement the Gruber model for caudate spiny neurons (Gruber et al., 2003). The parameters and the differential equations are given very clearly in ***CD_funct*** (parameter names generally follow the convention used in the Gruber manuscript). ***CD_layer*** solves the equations given in ***CD_funct*** using the 5^{th} order runge kutta method (see the function ***rk5_6***), and converts the spiny neurons membrane potential to firing rate using a sigmoidal function.

References

Gruber, A. J., S. A. Solla, D. J. Surmeier and J. C. Houk (2003). "Modulation of striatal single units by expected reward: A spiny neuron model displaying dopamine-induced bistability." *J. Neurophysiology* 90: 1095-1114.

Fansler D., A. Fishbach, D. Fraser, L. E. Miller and J. C. Houk (2004). Event sequence detection utilizing a minimal network of striatal spiny neurons. *Motor Systems Day*, Northwestern University.