

A LONG JOURNEY INTO REPRODUCIBLE COMPUTATIONAL NEUROSCIENCE

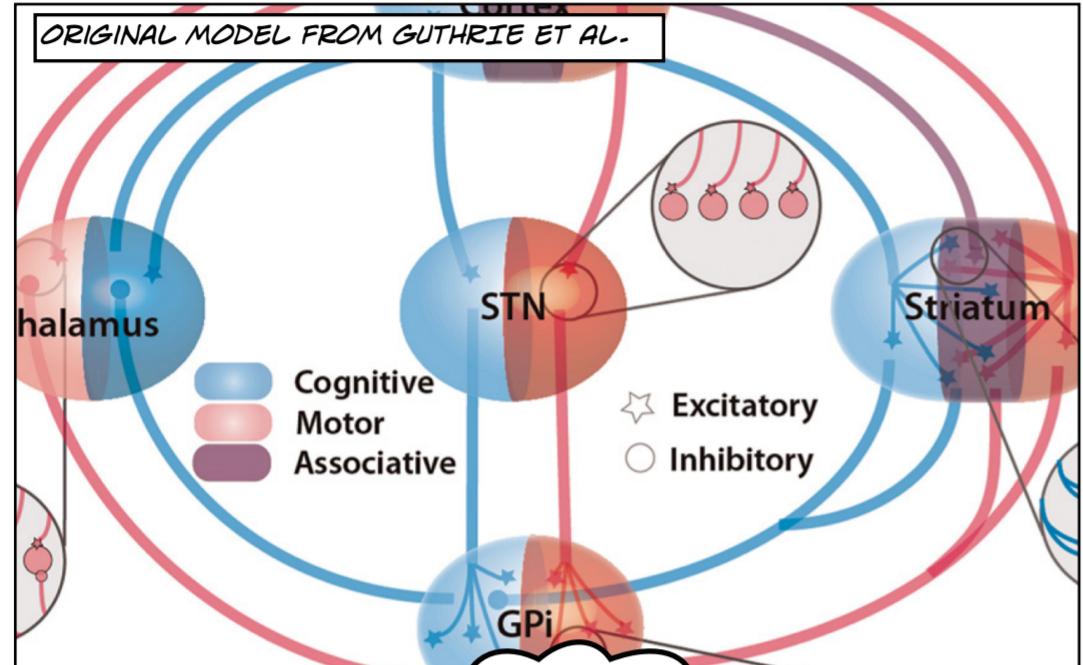
100% PYTHON ! SPIKE FREE !

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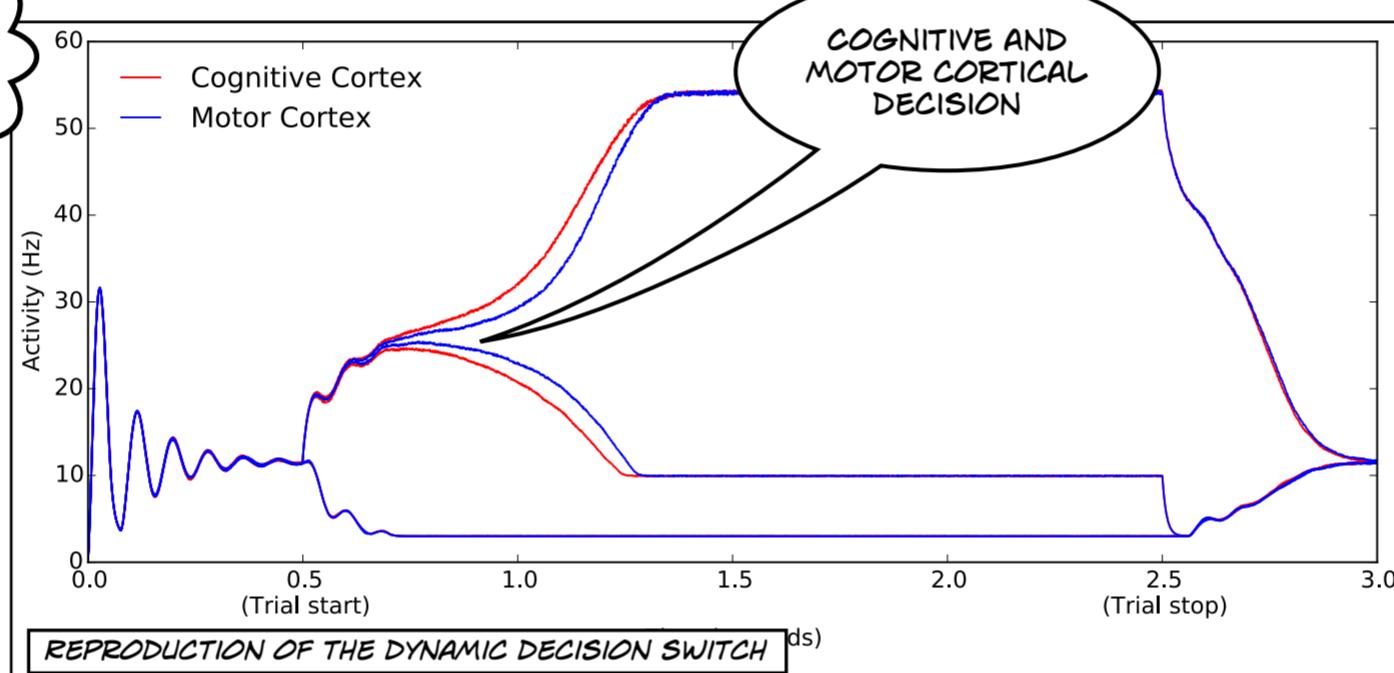
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IN A PREVIOUS MODELLING STUDY, LEBLOIS ET AL. (2006) DEMONSTRATED AN ACTION SELECTION MECHANISM IN CORTICO-BASAL GANGLIA LOOPS BASED ON COMPETITION BETWEEN THE POSITIVE FEEDBACK, DIRECT PATHWAY THROUGH THE STRIATUM AND THE NEGATIVE FEEDBACK, HYPERDIRECT PATHWAY THROUGH THE SUBTHALAMIC NUCLEUS. IN GUTHRIE ET AL. (2013), AUTHORS INVESTIGATED HOW MULTIPLE LEVEL ACTION SELECTION COULD BE PERFORMED BY THE BASAL GANGLIA. TO DO THIS, THE MODEL HAS BEEN EXTENDED IN A MANNER CONSISTENT WITH KNOWN ANATOMY AND ELECTRO-PHYSIOLOGY IN THREE MAIN AREAS. UNFORTUNATELY, THE INFORMATION PROVIDED BY THE ARTICLE WERE NOT SUFFICIENT TO REPRODUCE THE MODEL !!!

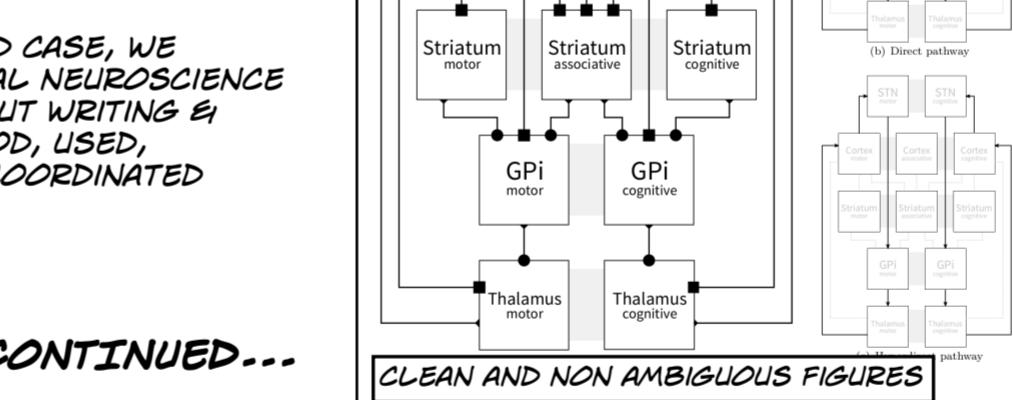
IF REPRODUCIBILITY IS THE HALLMARK OF SCIENCE, NON-REPRODUCIBILITY SEEMS TO BE THE HALLMARK OF COMPUTATIONAL NEUROSCIENCES. GUTHRIE ET AL. (2013) IS A PROTOTYPIC CASE OF SUCH NON-REPRODUCIBLE COMPUTATIONAL NEUROSCIENCE RESEARCH EVEN THOUGH THE PROPOSED MODEL GIVES A FAIR ACCOUNT OF DECISION MAKING IN THE BASAL GANGLIA COMPLEX. WHILE TRYING TO REPLICATE RESULTS STARTING FROM THE ARTICLE DESCRIPTION, WE SOON REALISED SOME INFORMATION WERE UNDISCLOSED, SOME OTHER WERE AMBIGUOUS AND THERE WERE ALSO SOME FACTUAL ERRORS. EVEN AFTER ACCESSING THE ORIGINAL SOURCES (6000 LINES OF PASCAL), WE WERE STILL UNABLE TO UNDERSTAND HOW THE MODEL WORKED. IN THE END, ONLY THE ORIGINAL MATERIAL (A BINARY EXECUTABLE) AND A DIRECT CONTACT WITH THE AUTHORS ALLOWED US TO ACCESS THE WHOLE PICTURE. AFTER TWO MONTHS OF INTENSIVE REFACTORY, WE WERE FINALLY ABLE TO REPLICATE RESULTS USING ONLY 200 LINES OF PYTHON.



[HTTP://GITHUB.COM/ROUGIER/NEUROSCIENCES](http://github.com/rougier/neurosciences)

FROM THIS EXPERIENCE, WHICH IS UNFORTUNATELY NOT AN ISOLATED CASE, WE WOULD LIKE TO SHARE A SIMPLE MESSAGE WITH THE COMPUTATIONAL NEUROSCIENCE COMMUNITY: "DESIGNING COMPUTATIONAL MODELS IS NOT ALL ABOUT WRITING & RUNNING PROGRAMS". IF A MODEL IS TO BE REVIEWED, UNDERSTOOD, USED, REPLICATED AND INTEGRATED, IT REQUIRES A MINIMAL AMOUNT OF COORDINATED EFFORTS. OR THE MODEL WILL BE SOON FORGOTTEN.

TO BE CONTINUED---



BORING BUT
INCREDIBLY
USEFUL !

A Model Summary					
Populations	Twelve: Cortex (motor, associative & cognitive), Striatum (motor, associative & cognitive), GPi (motor & cognitive), STN (motor & cognitive), Thalamus (motor & cognitive)				
Topology	-				
Connectivity	one to one, one to many (divergent), many to one (convergent)				
Neuron model	Dynamic rate model				
Channel model	-				
Synapse model	Linear synapse				
Plasticity	Reinforcement learning rule				
Input	External current in cortical areas (motor, associative & cognitive)				
Measurements	Firing rate				

D1 Neuron Model					
Name	Linear neuron				
Type	Rate model				
Membrane Potential	$\tau dV/dt = -V + I_{syn} + I_{ext} - h$ $U = \max(V, 0)$				

D2 Neuron Model					
Name	Sigmoidal neuron				
Type	Rate model				
Membrane Potential	$\tau dV/dt = -V + I_{syn} + I_{ext} - h$ $U = V_{min} - (V_{max} - V_{min}) / (1 + e^{\frac{V_{max}-V}{V_c}})$				

E Synapse					
Name	Linear synapse				
Type	Weighted sum				
Output	$I_{syn}^B = \sum_{A \in sources} (G_{A \rightarrow B} W_{A \rightarrow B} U_A)$				

F Plasticity					
Name	Reinforcement learning				
Type	Delta rule				
Delta	$\Delta W_{A \rightarrow B} = \alpha \times P_E \times U_B$ $P_E = Reward - V_i$ $\alpha = 0.01$ if $P_E < 0$ (LTD), $\alpha = 0.02$ if $P_E > 0$ (LTP)				

G Input					
Type	Cortical input				
Description	A trial is preceded by a settling period (500ms) and followed by a reset period. At time $t = 0$, two shapes are presented in cortical cognitive area ($I_{ext} = 7$ at $\{i_1, i_2\}$) at two different locations in cortical motor area ($I_{ext} = 7$ at $\{j_1, j_2\}$) and the cortical associate area is updated accordingly ($I_{ext} = 7$ at $\{i_1, i_2\} \times \{j_1, j_2\}$).				
Timing	Trial start Stimulus onset -500ms 0 Stimulus offset Reset 2500 ms 3000 ms				

H Measurements					
Site	Cortical areas				
Data	Activity in cognitive and motor cortex Cortico-striatal weights				

I Environment					
OS	OSX 10.9 (maverick)				
Language	Python 2.7.6 (brew installation)				
Libraries	Numpy 1.8.1 (pip installation) SciPy 0.13.3 (pip installation)				
Tools	IPython 1.2.1 (pip install) Matplotlib 1.3.0 (pip install) DANA 0.5.0 (pip install) Safari browser (native)				

TABULAR DESCRIPTION OF THE MODEL
(SEE NORDLIE ET AL. (2009))



DANA RULES !

DANA IS A PYTHON FRAMEWORK FOR DISTRIBUTED, ASYNCHRONOUS, NUMERICAL AND ADAPTIVE COMPUTING. THE COMPUTATIONAL PARADIGM SUPPORTING THE DANA FRAMEWORK IS GROUNDED ON THE NOTION OF A UNIT THAT IS A ESSENTIALLY A SET OF ARBITRARY VALUES THAT CAN VARY ALONG TIME UNDER THE INFLUENCE OF OTHER UNITS AND LEARNING. EACH UNIT CAN BE CONNECTED TO ANY OTHER UNIT (INCLUDING ITSELF) USING A WEIGHTED LINK AND A GROUP IS A STRUCTURED SET OF SUCH HOMOGENEOUS UNITS.

[HTTP://DANA.LORIA.FR](http://dana.loria.fr)