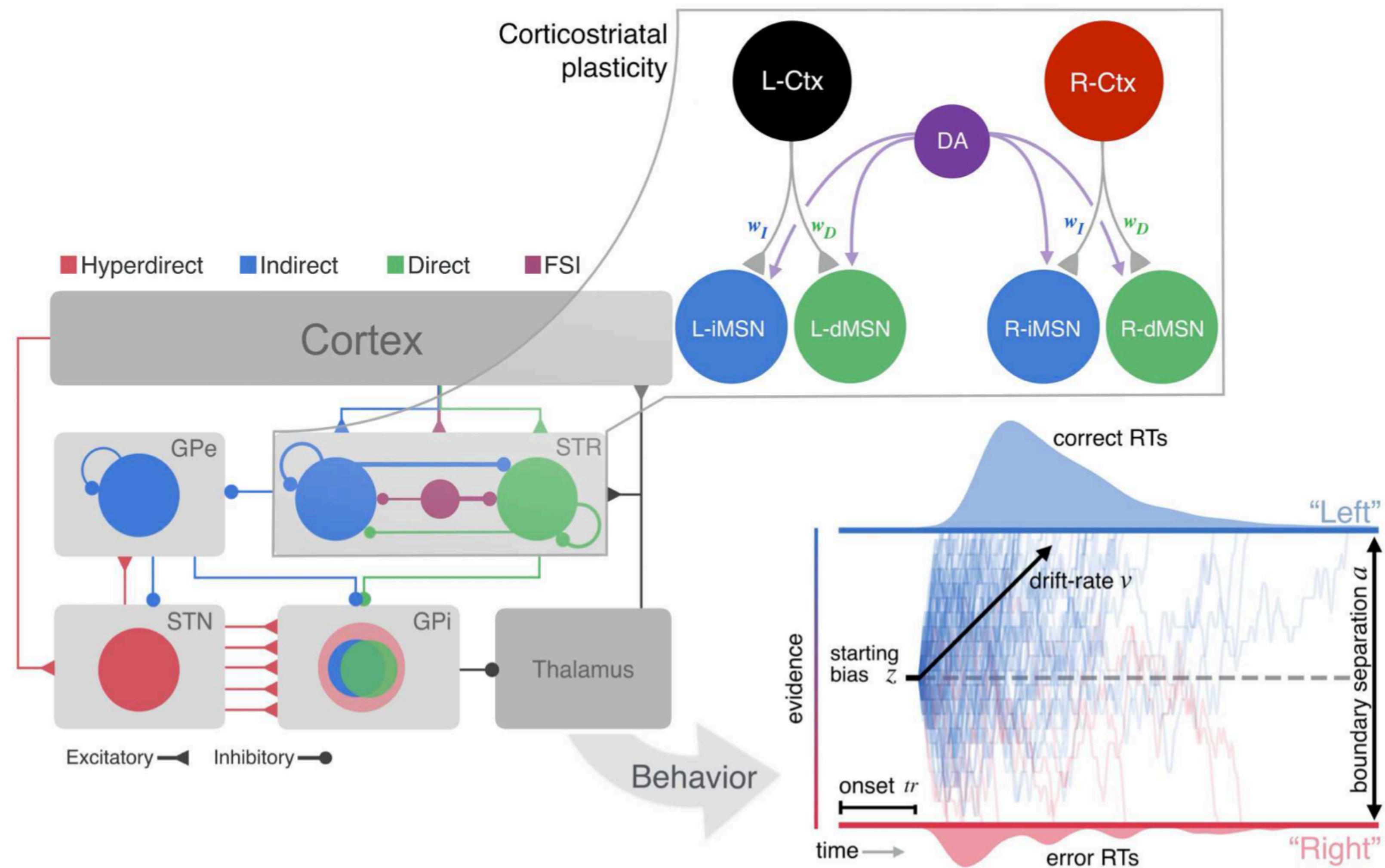


# How do you change your mind?

# Readings for today

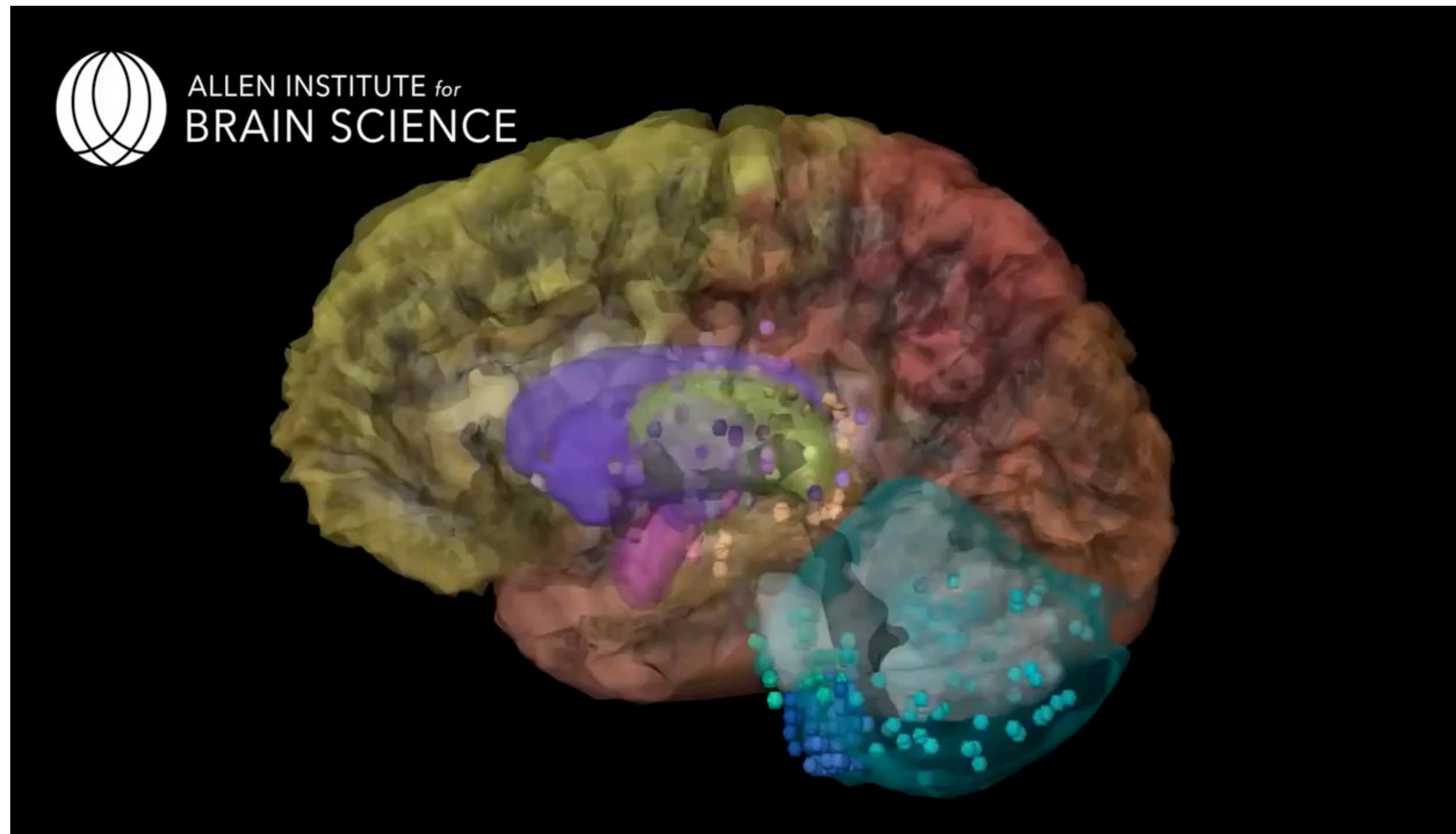
- Shine, J. M. (2021). The thalamus integrates the macrosystems of the brain to facilitate complex, adaptive brain network dynamics. *Progress in Neurobiology*, 199, 101951.

# The problem of choice



What happens when the world suddenly changes and old values need to change?

# Deep dive in neuroanatomy



https://human.brain-map.org/static/brainexplorer

ALLEN BRAIN ATLAS  
DATA PORTAL

HOME HUMAN BRAIN TOOLS

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Search...

**Allen Human Brain Atlas - Brain Explorer® 2**

The Brain Explorer 2 software is a desktop application for viewing the human brain anatomy and gene expression data in 3-D. Using the Brain Explorer 2 software, you can:

- View a fully interactive version of the Allen Human Brain Atlas in 3-D.
- View gene expression data in 3-D: inflated cortical surfaces are colored by gene expression values of nearby samples.
- View expression data from different donors side-by-side.
- Explore anatomically-labeled MRI images and cortical surfaces.
- Investigate probes or samples of interest in more detail with direct links back to the Allen Human Brain Atlas web page.

After installing the Brain Explorer 2 software, you can view gene expression data by performing a gene search from the Microarray page or from within the application's main window. Please see the documentation for more information.

Please verify your system meets the requirements before installing.

**Windows Minimum Configuration**

- Operating System: Microsoft Windows 7
- CPU: Intel Core Duo or AMD 1.8GHz
- System Memory: 1GB
- Graphics Card: Hardware 3D OpenGL accelerated AGP or PCI Express with 64MB RAM
- Screen: 1024x768, 32-bit true color
- Hard Disk: 200MB free space

Note: The Brain Explorer 2 software is known to work with the following video chipsets: nVidia GeForce 9400/9600, nVidia Quadro FX 1800/3800/5600, ATI Radeon 9600, ATI Radeon HD 3200/4500, Intel Q35/Q45 Express

**Mac Minimum Configuration**

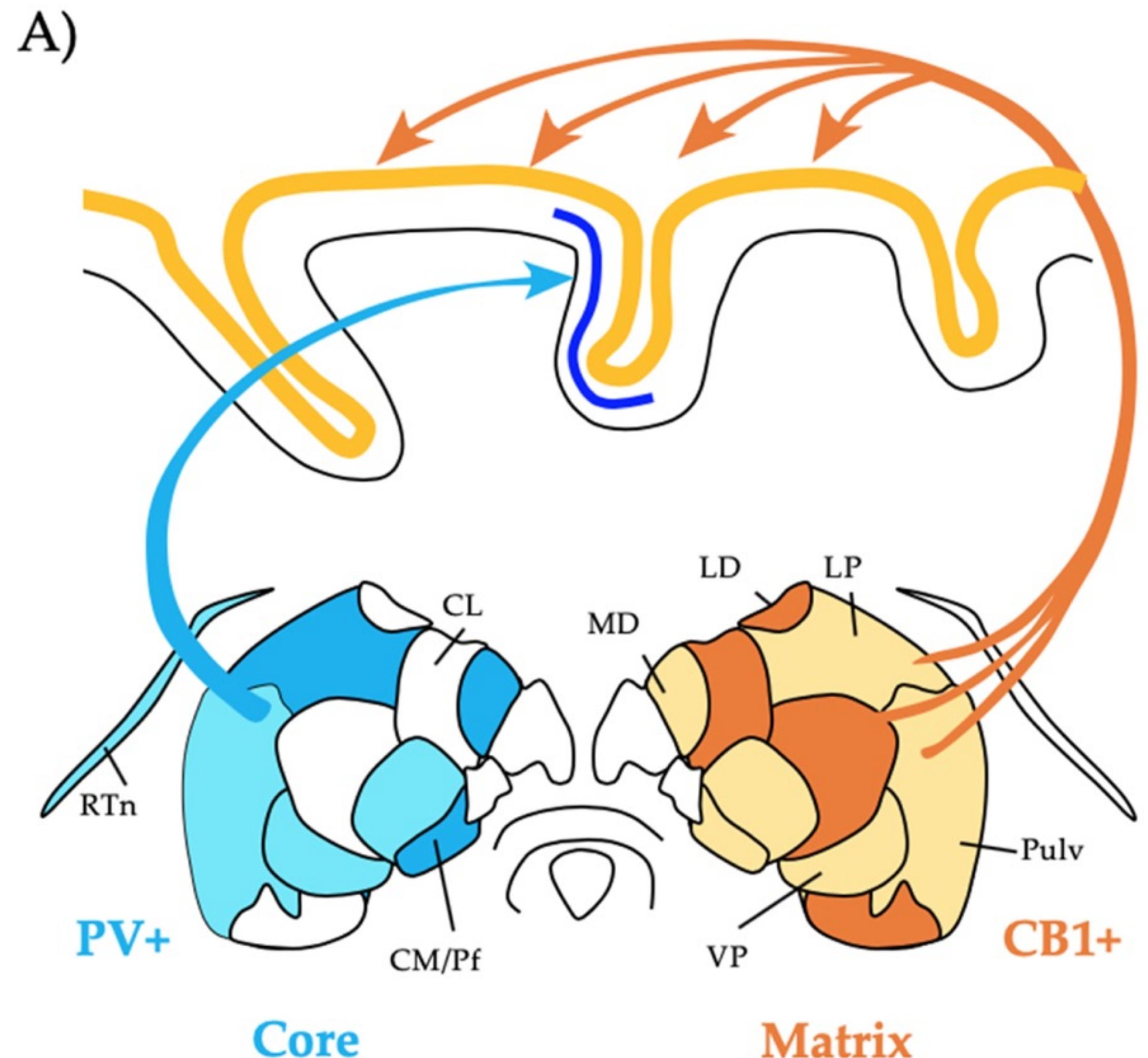
- Operating System: OS X 10.6.8
- CPU: Intel 1.8GHz
- System Memory: 1GB
- Graphics Card: 3D-capable with 64MB RAM
- Screen: 1024x768, 32-bit millions of colors
- Hard Disk: 200MB free space

Note: Please install the latest system updates from Apple to ensure you have the latest video card drivers.

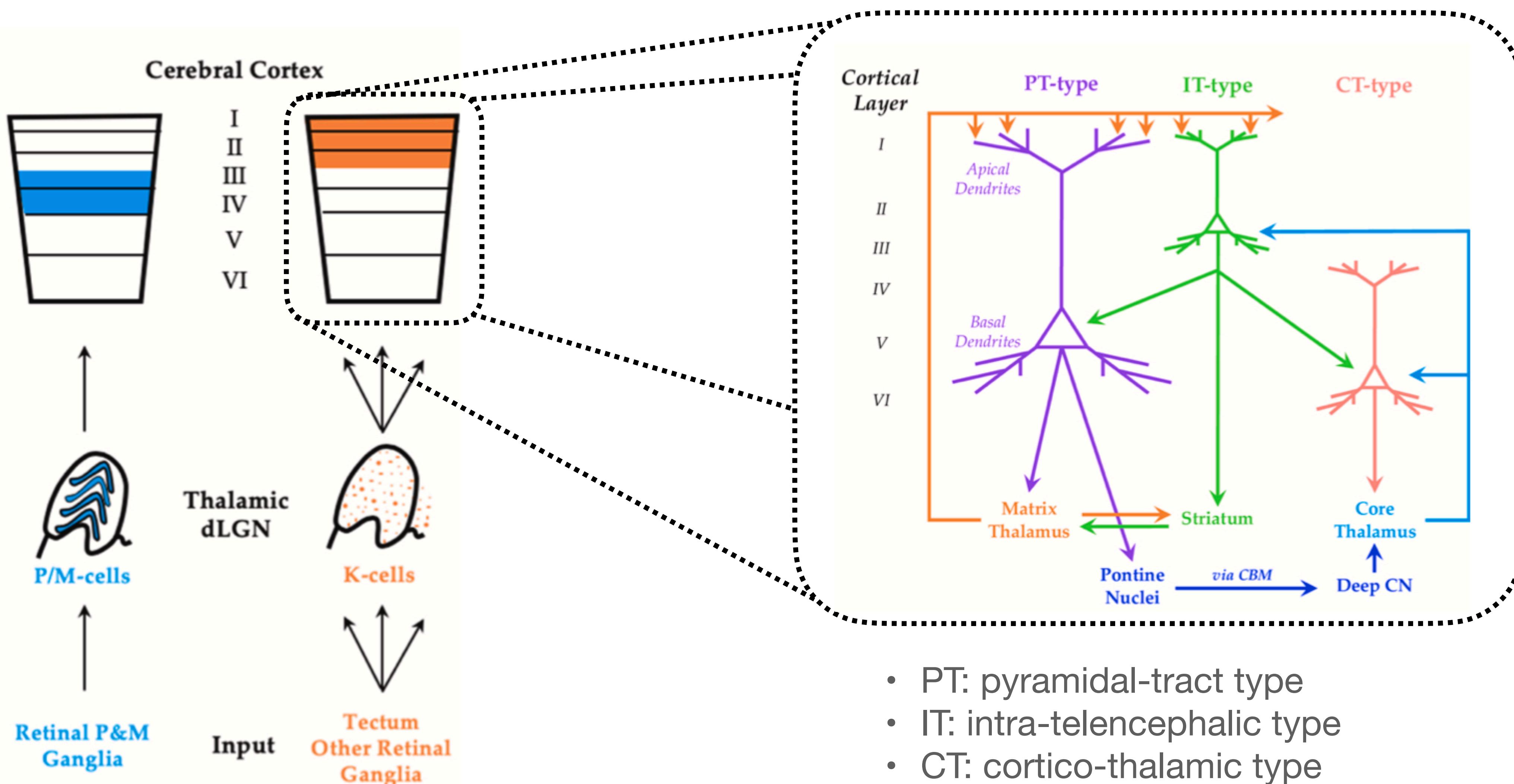
<http://support.amd.com/us/gpudownload/Pages/index.aspx>  
<http://www.nvidia.com/content/drivers/drivers.asp>  
<http://www.intel.com/support/graphics/>

Download for Windows Download for Mac

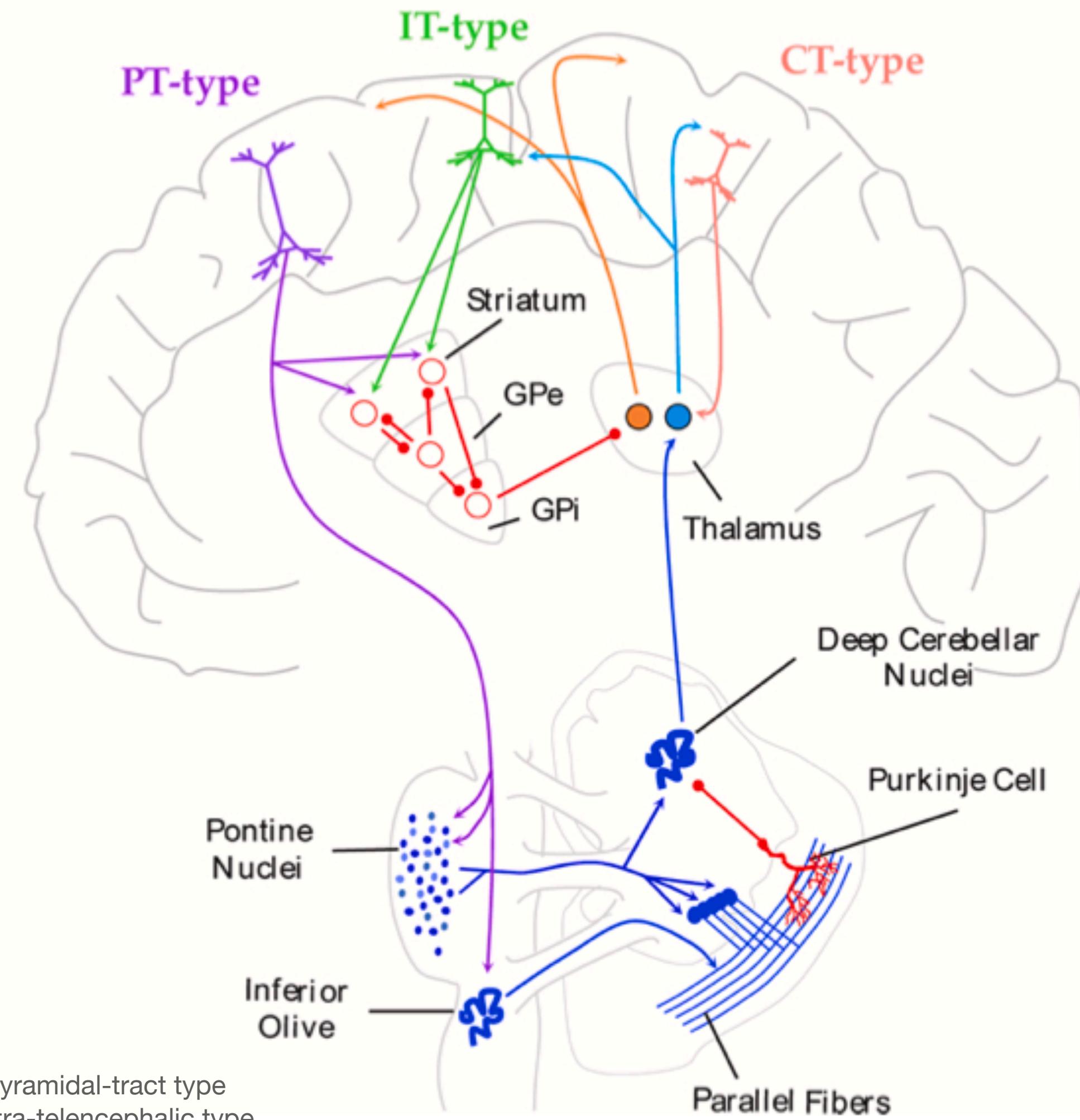
# Focus on the thalamus



# Cortical layers



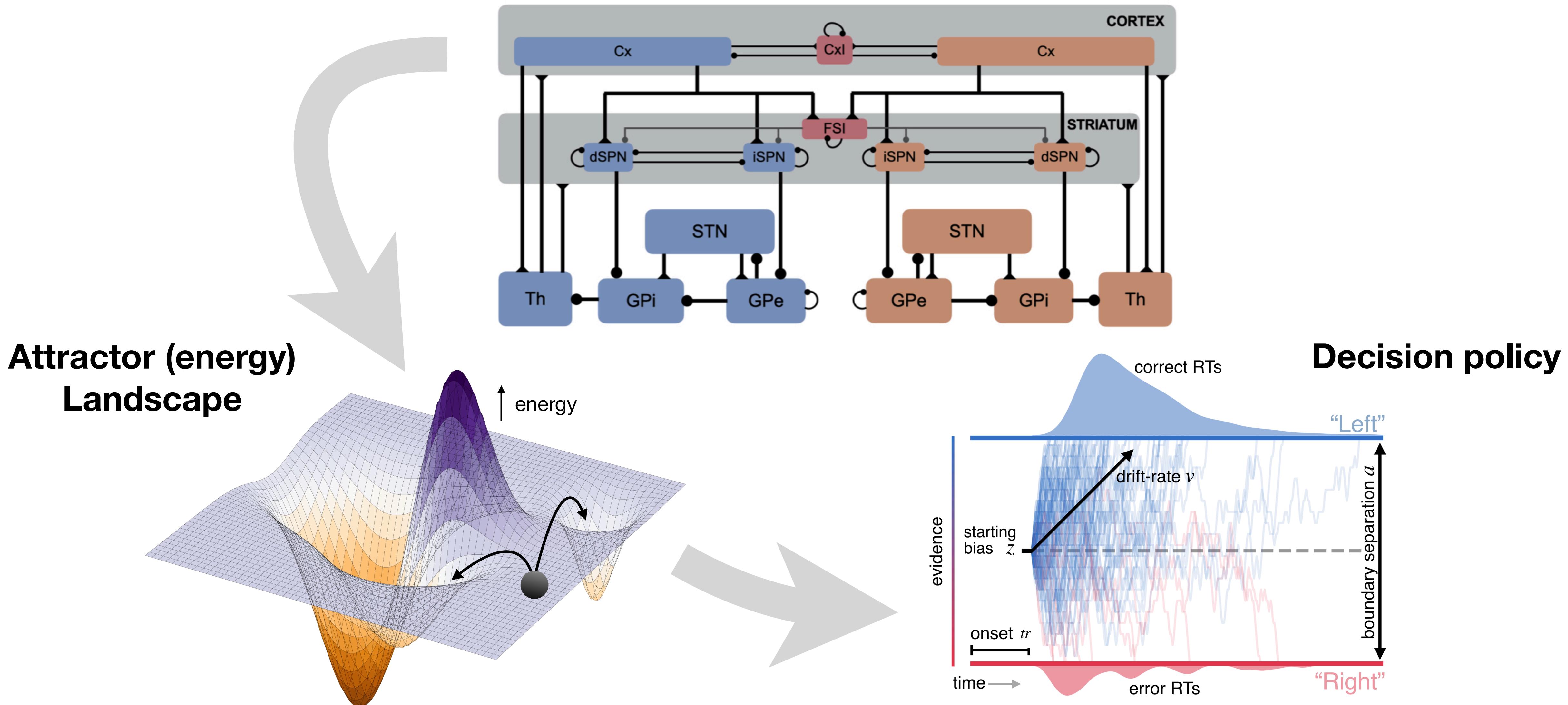
# Anatomy of an interaction



## Points of interaction

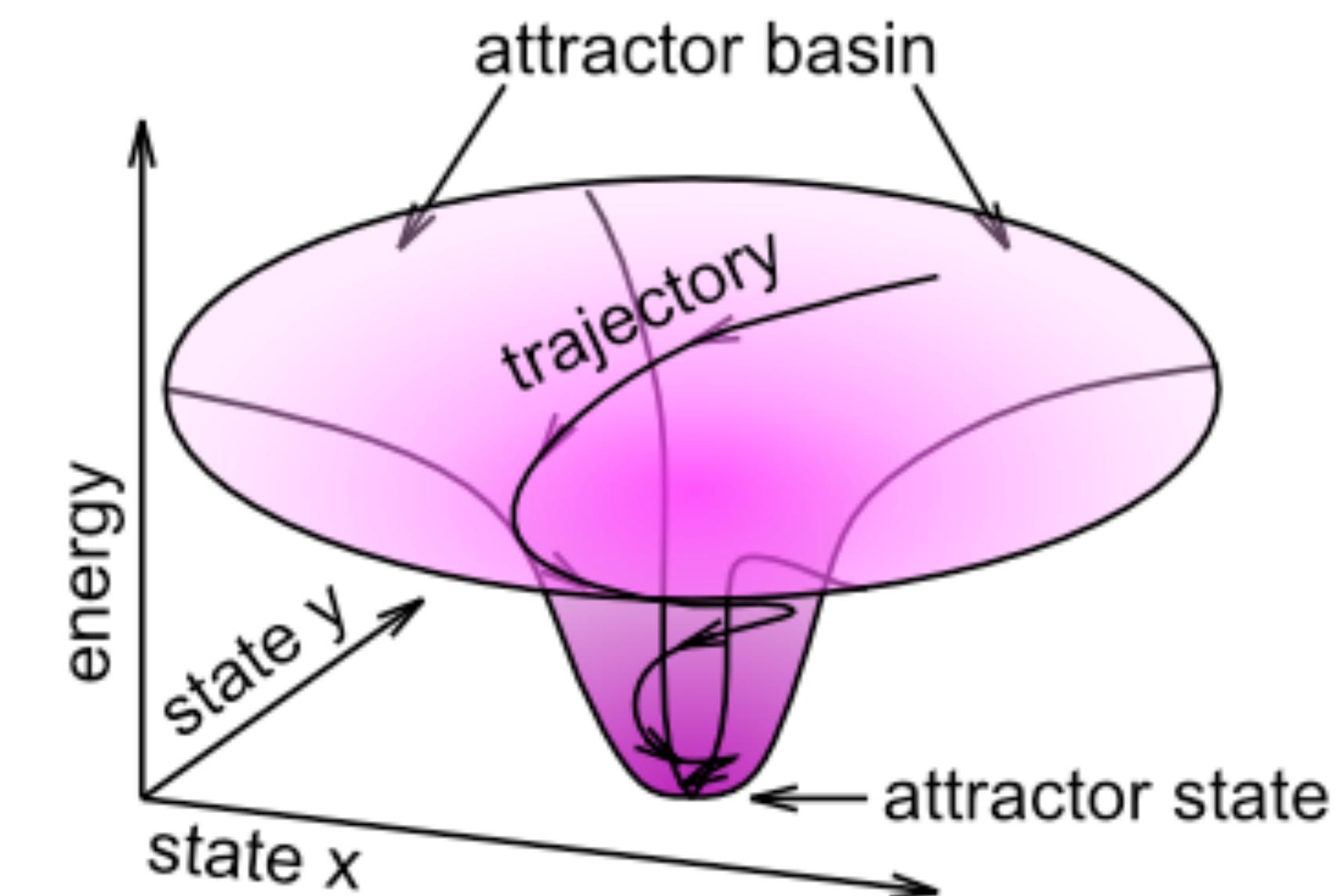
- *Pontine nuclei*: PT cells that innervate the striatum (hyper-direct pathway) modulate cells in the pontine that stimulate cerebellar parallel fibers (cell bodies).
- *Inferior olivary nucleus*: Same pattern as pontine nuclei except for cells that terminate at parallel fiber dendrites.
- *Thalamus*: outputs from basal ganglia and cerebellum converge on different cells in the same thalamic nuclei.

# Energy landscapes in neural circuits



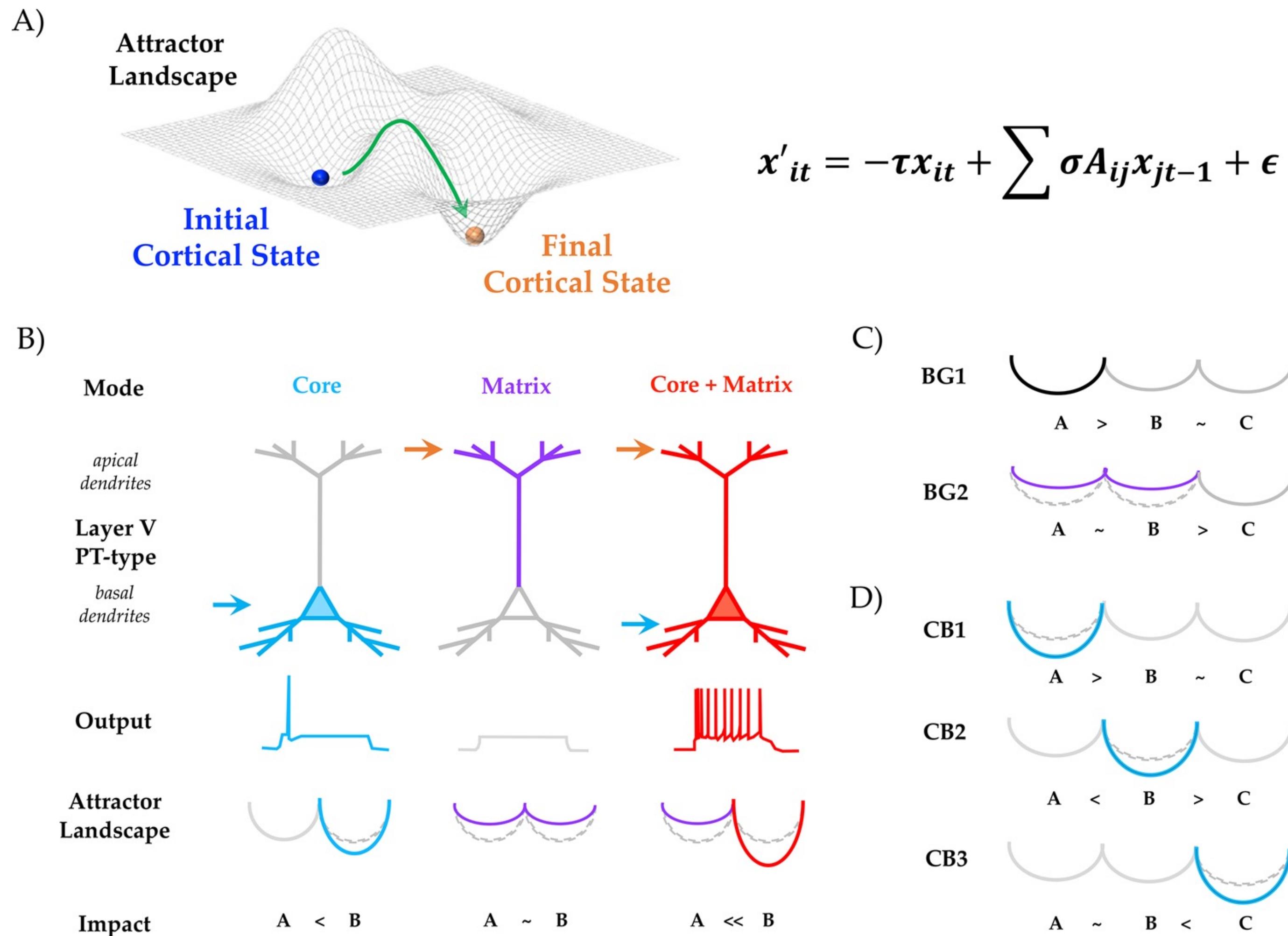
# Attractors

## Lorenz attractor



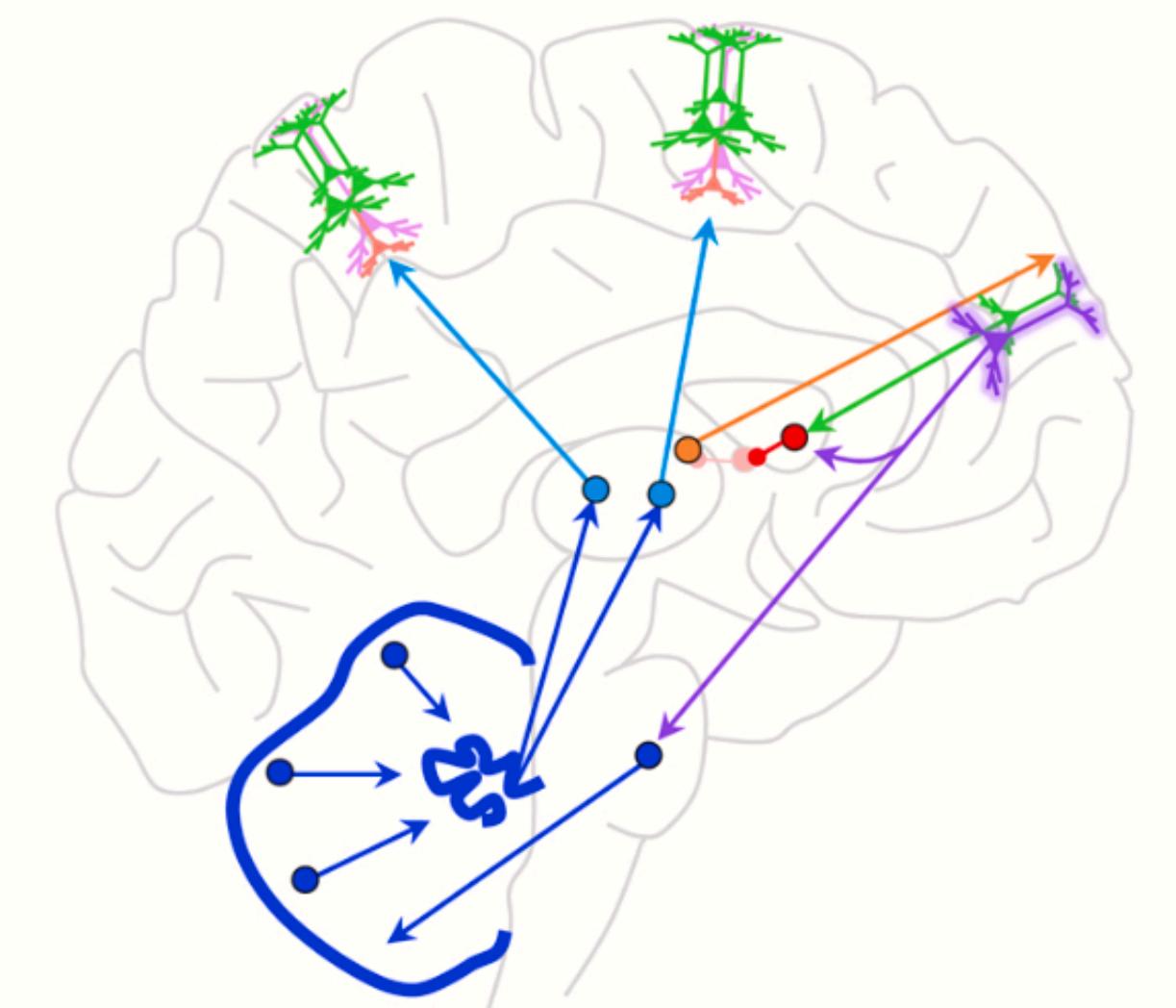
[https://med.libretexts.org/Bookshelves/Pharmacology\\_and\\_Neuroscience/Book%3A\\_Computational\\_Cognitive\\_Neuroscience\\_\(O%27Reilly\\_and\\_Munakata\)/03%3A\\_Networks/3.04%3A\\_Bidirectional\\_Excitatory\\_Dynamics\\_and\\_Attractors](https://med.libretexts.org/Bookshelves/Pharmacology_and_Neuroscience/Book%3A_Computational_Cognitive_Neuroscience_(O%27Reilly_and_Munakata)/03%3A_Networks/3.04%3A_Bidirectional_Excitatory_Dynamics_and_Attractors)

# A theory of control



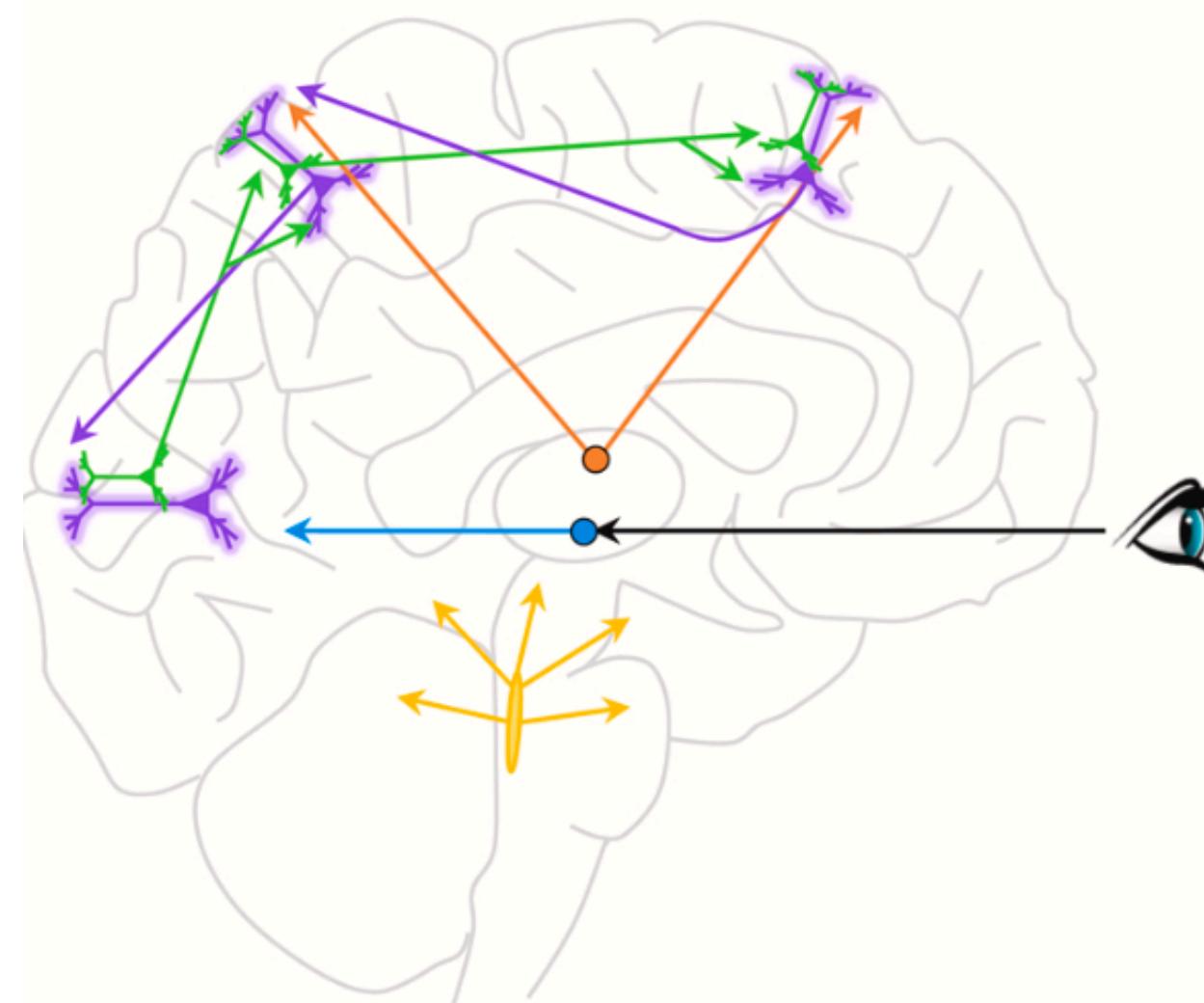
- Basal ganglia make attractor wells more shallow, via control of matrix cells in the thalamus, making network states harder to settle and thus less likely.
- Cerebellum deepens attractor wells through control of the core cells, making those decisions more likely to occur.
- Together they can sculpt new energy landscapes and shape future decisions.

# Map to different decision systems



**System 1**

Fast, implicit, & automatic



**System 2**

Slow, deliberative, & serial

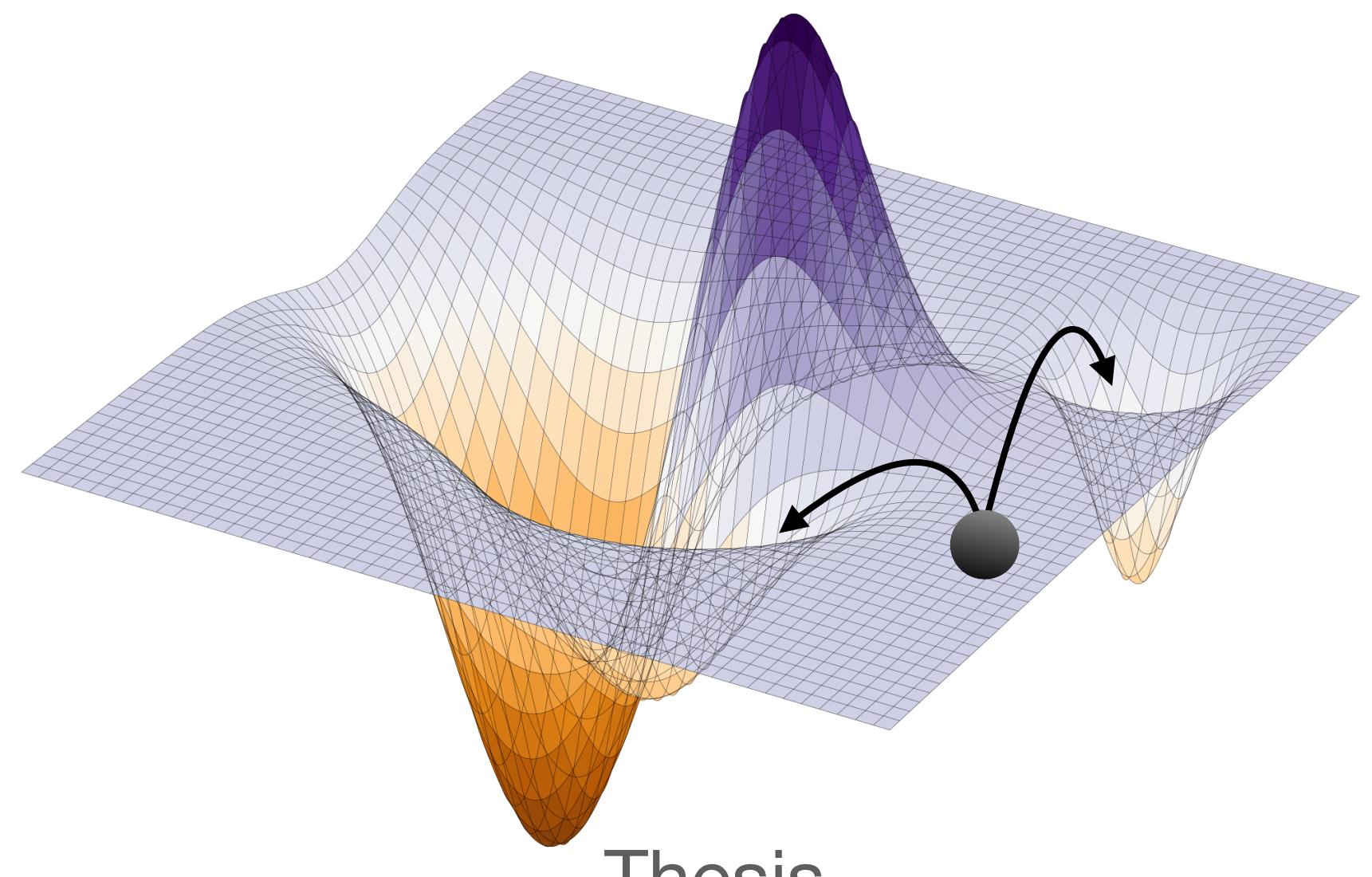
# Take home message

- The basal ganglia appear to terminate on matrix cells in the thalamus, which have a distributed set of connections with cortex.
- The cerebellum terminates on core thalamic cells, which have more focal cortical projections.
- The anatomy of these two systems lays out a circuit-level logic for controlling the dynamics of cortical states, shifting certainty of individual decisions by making attractor basins more or less shallow.

# Debate time

Shine: The basal ganglia & cerebellum work to *change* the attractor landscape that determine the states of cortical networks in order to change future actions.

Prompt: Does it make sense to change the attractor landscape (i.e., states that cortical networks can be in) or how the cortex navigates existing states (i.e., the path)?



**Group A:** Landscapes change

**Group B:** Trajectories change

Timeline:

