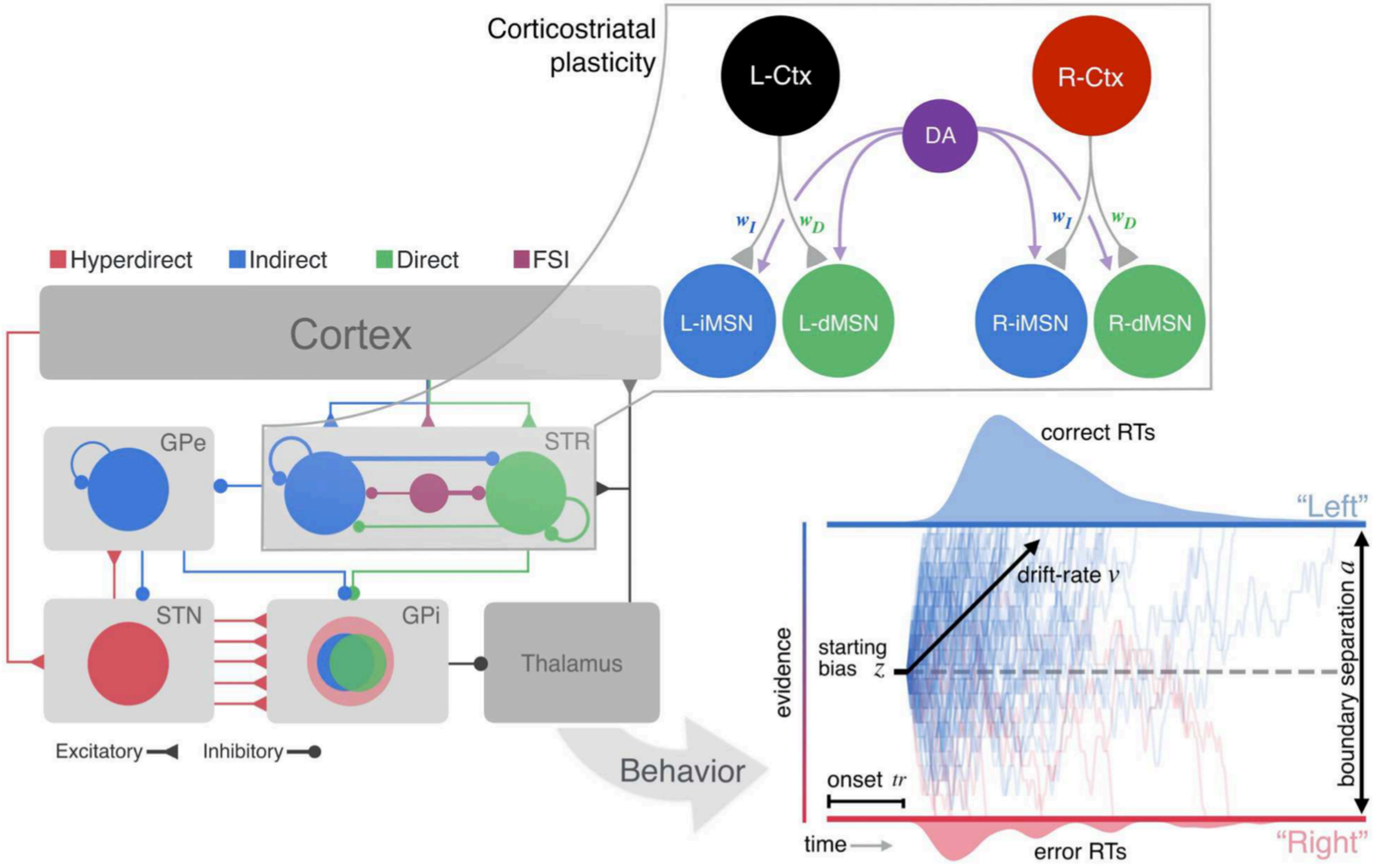
How do you change your mind?

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.

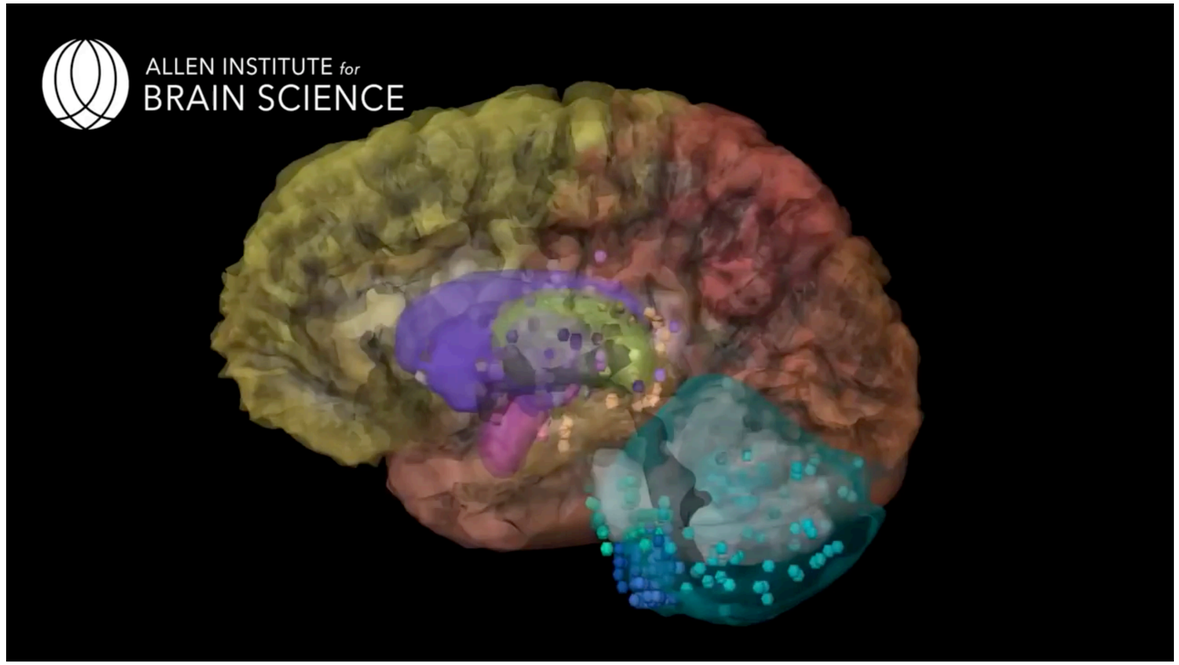
The problem of choice

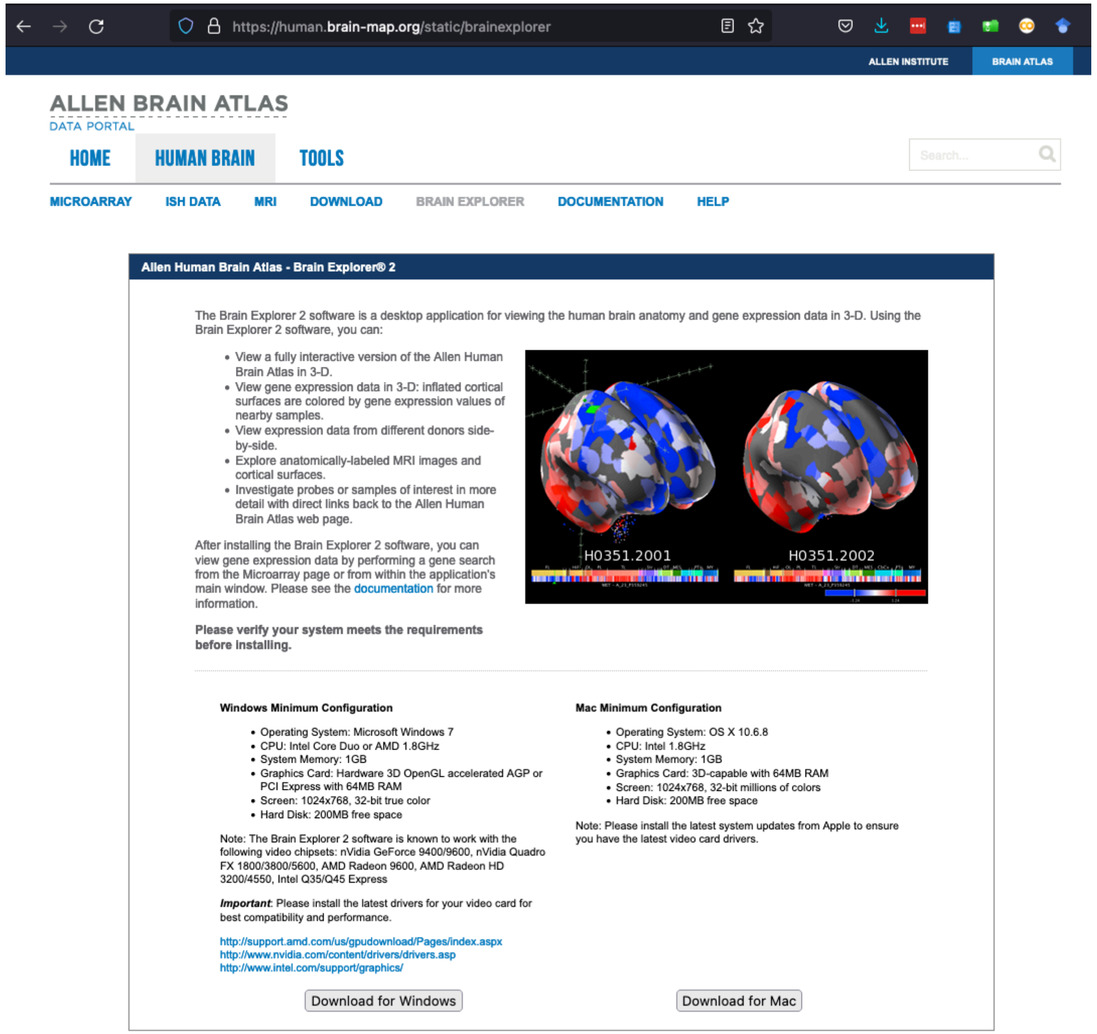


What happens when the world suddenly changes and old values need to change?

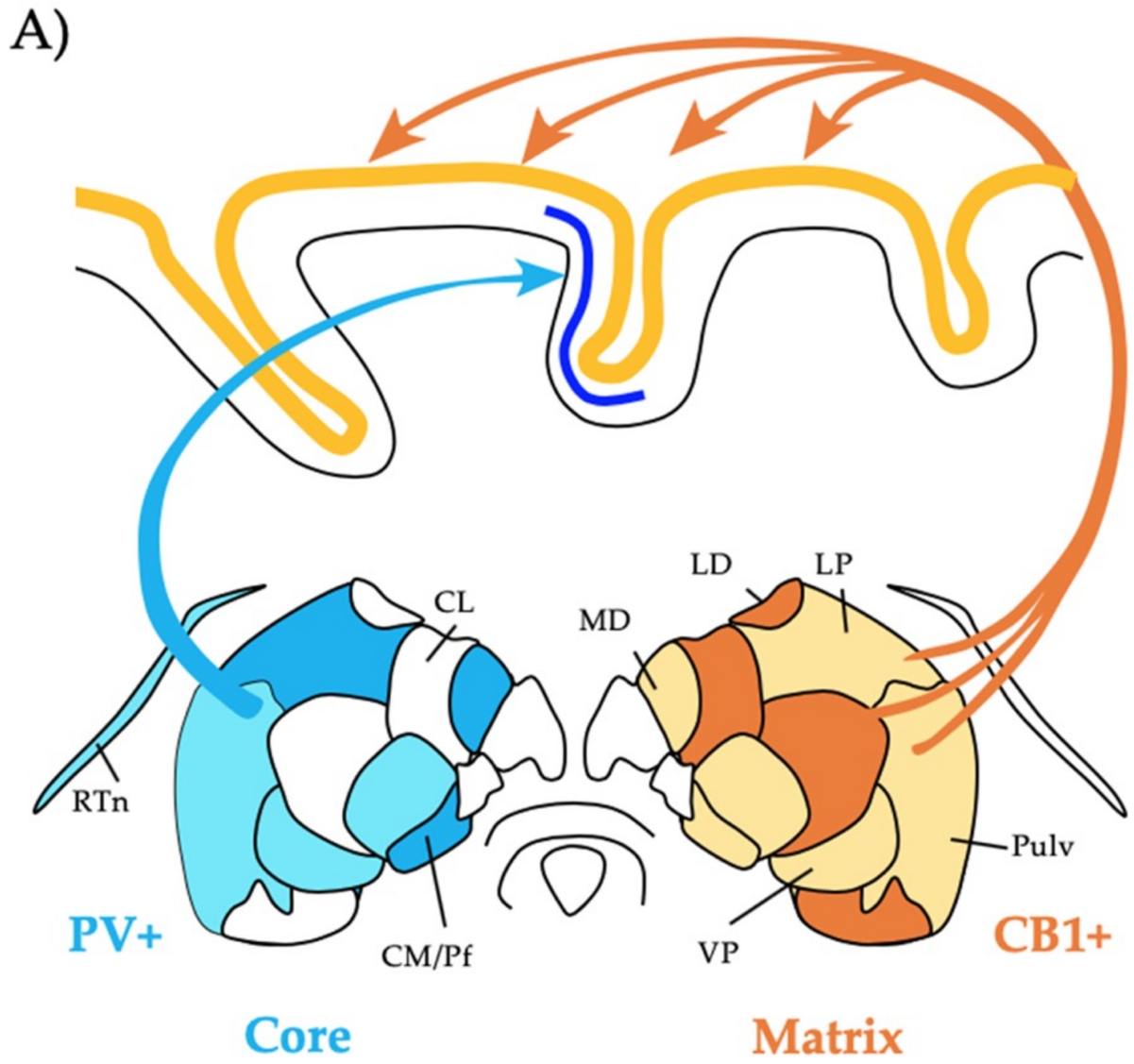
(Dunovan et al. 2019)

Deep dive in neuroanatomy



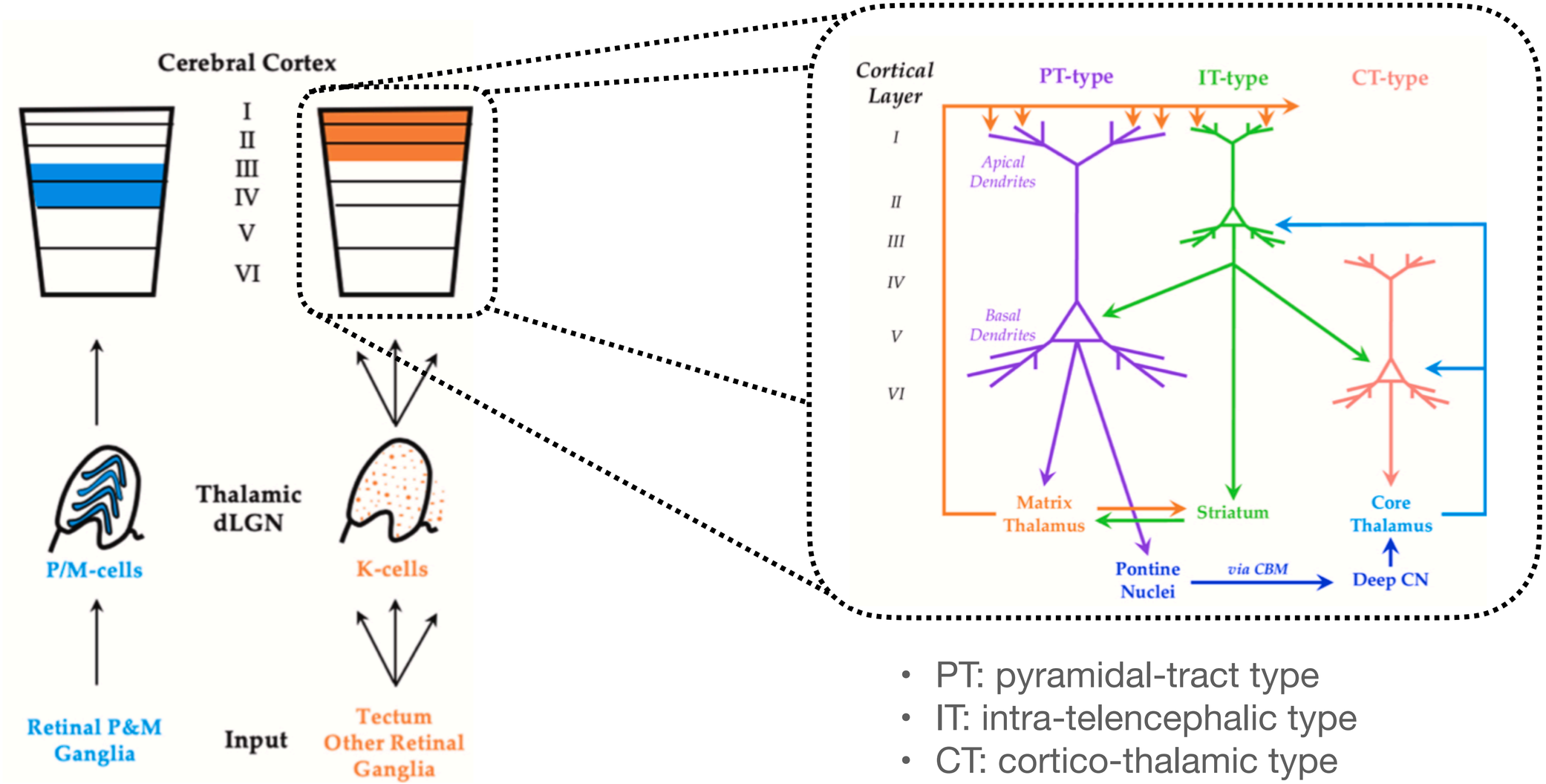


Focus on the thalamus



(Shine 2021)

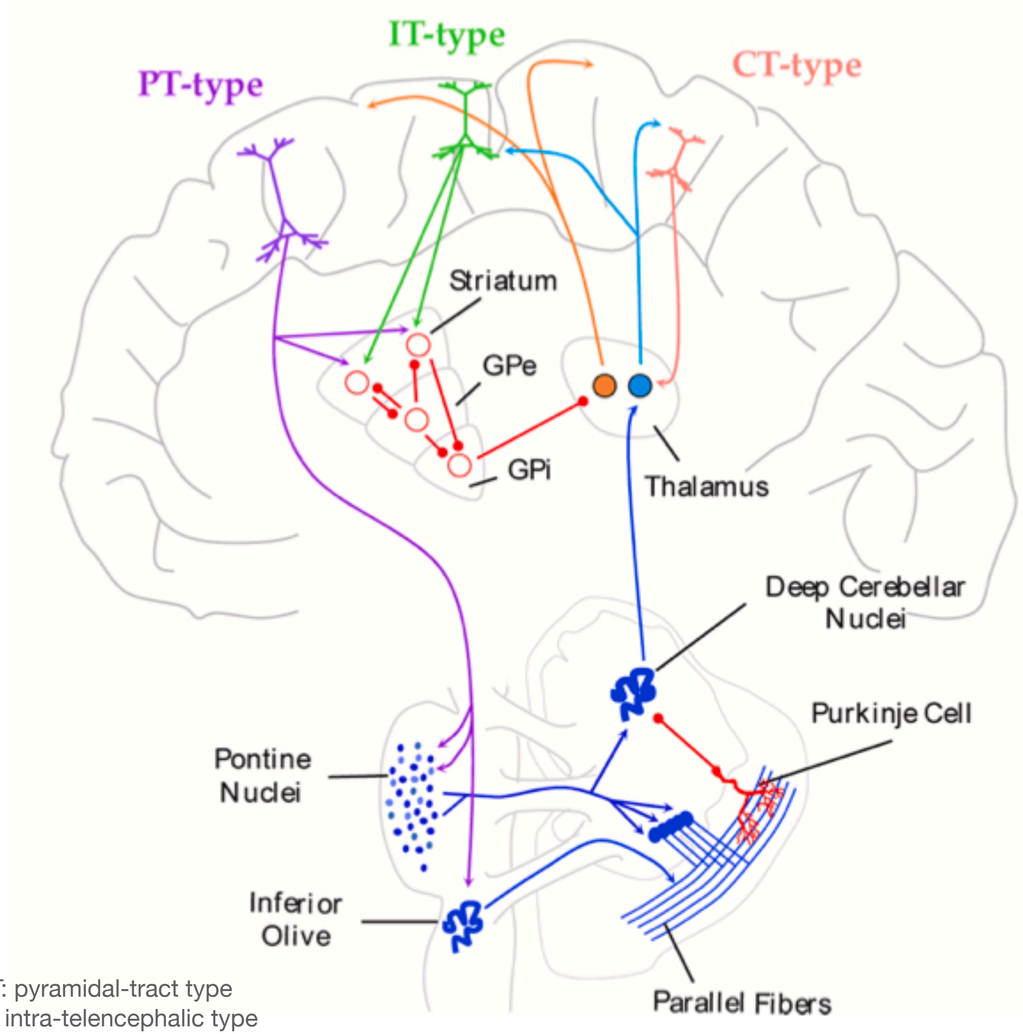
Cortical layers



- PT: pyramidal-tract type
- IT: intra-telencephalic type
- CT: cortico-thalamic type

(Shine 2021)

Anatomy of an interaction



- PT: pyramidal-tract type
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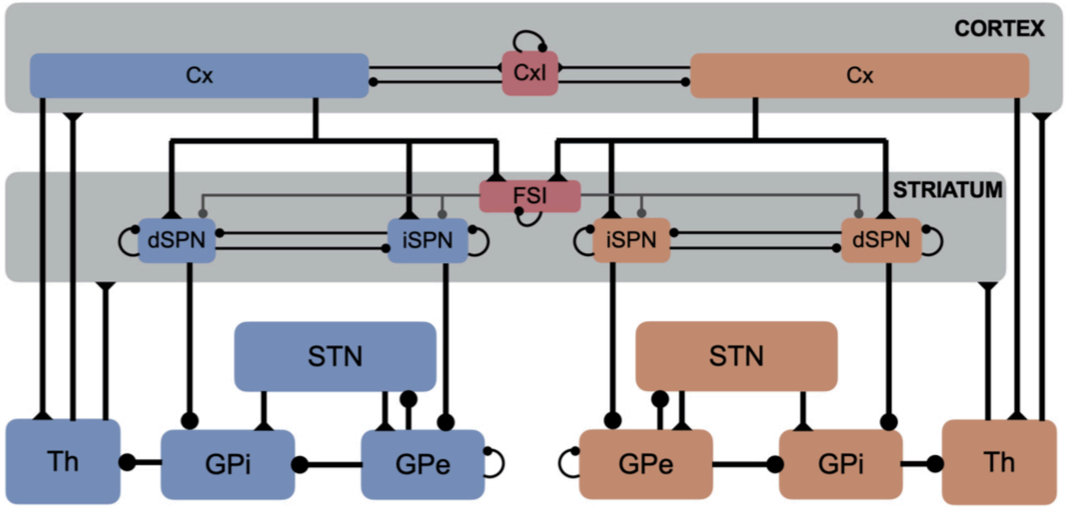
Points of interaction

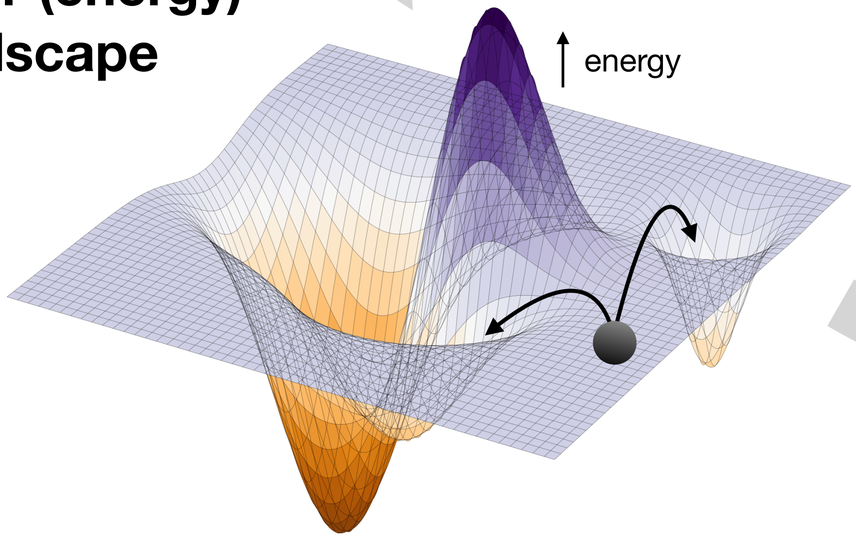
- *Pontine nuclei*: PT cells that innervate the striatum (hyper-direct pathway) modulate cells in the pontine that stimulate cerebellar parallel fibers (cell bodies).
- *Inferior olivary nucleus*: Same pattern as pontine nuclei except for cells that terminate at parallel fiber dendrites.
- *Thalamus*: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

(Shine 2021)

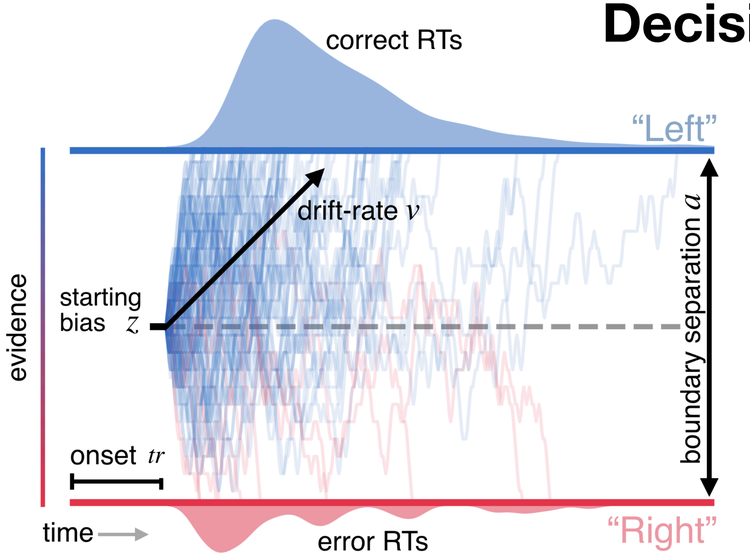
Energy landscapes in neural circuits



Attractor (energy) Landscape

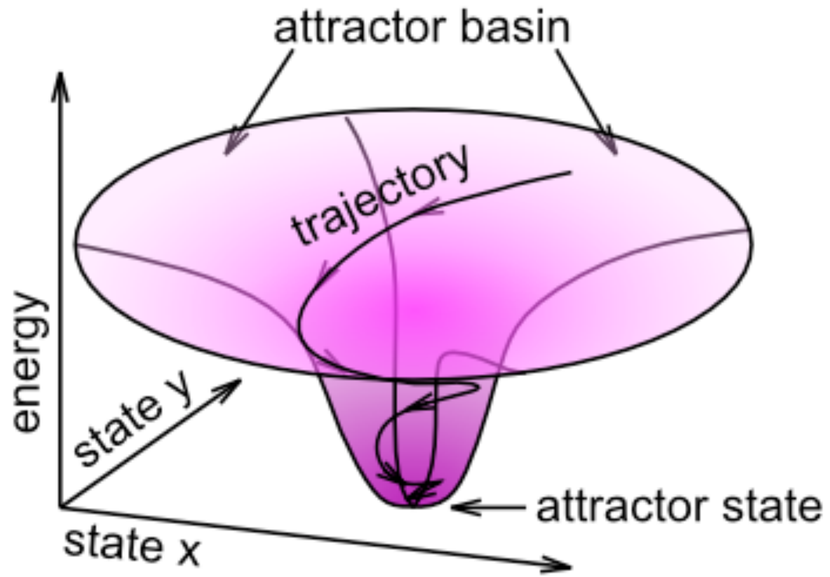


Decision policy



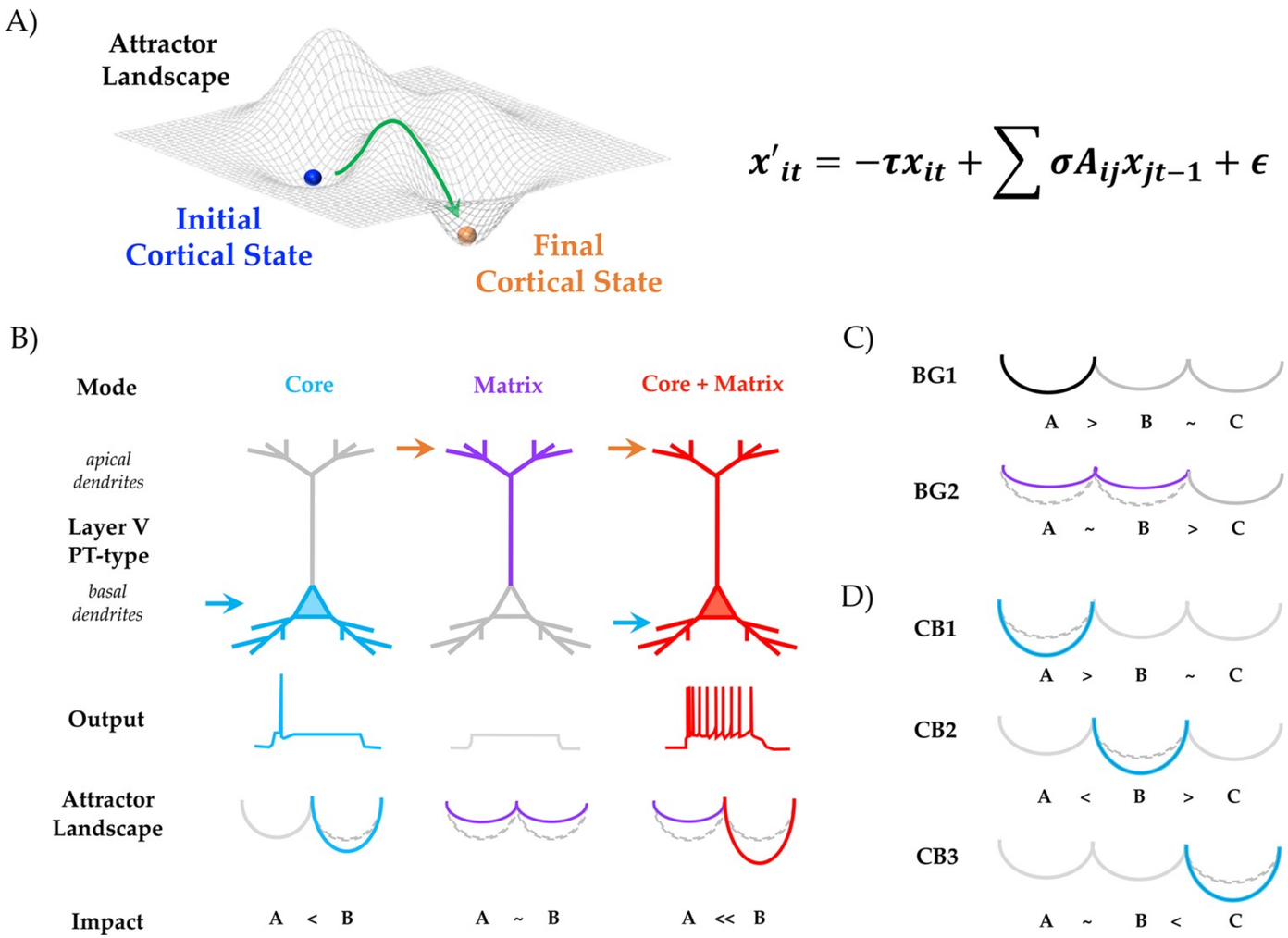
Attractors

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

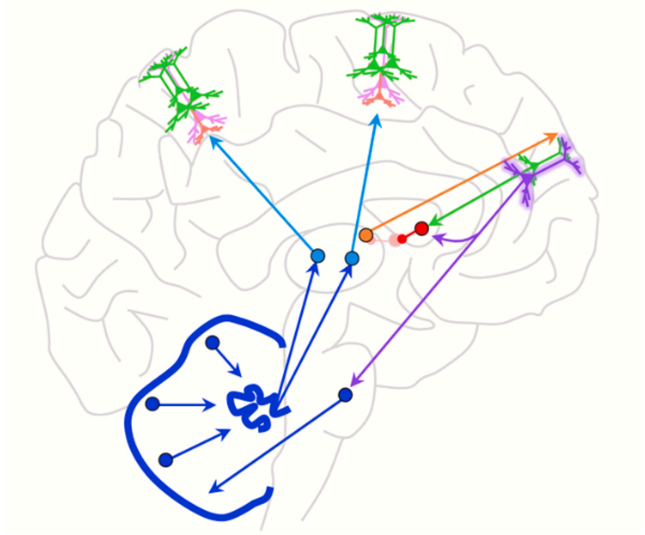
A theory of control



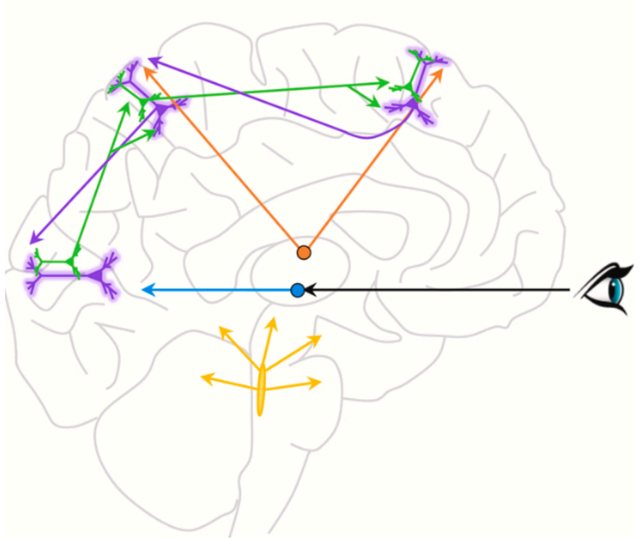
- Basal ganglia make attractor wells more shallow, via control of matrix cells in the thalamus, making network states harder to settle and thus less likely.
- Cerebellum deepens attractor wells through control of the core cells, making those decisions more likely to occur.
- Together they can sculpt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

(Shine 2021)

Map to different decision systems



System 1 → Fast, implicit, & automatic



System 2 → Slow, deliberative, & serial

(Kahneman 2013; Shine 2021)

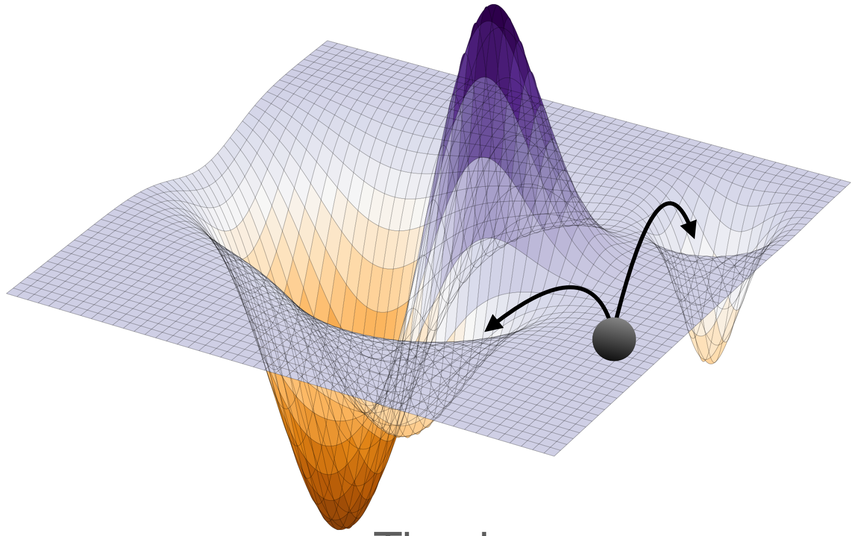
Take home message

- 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: