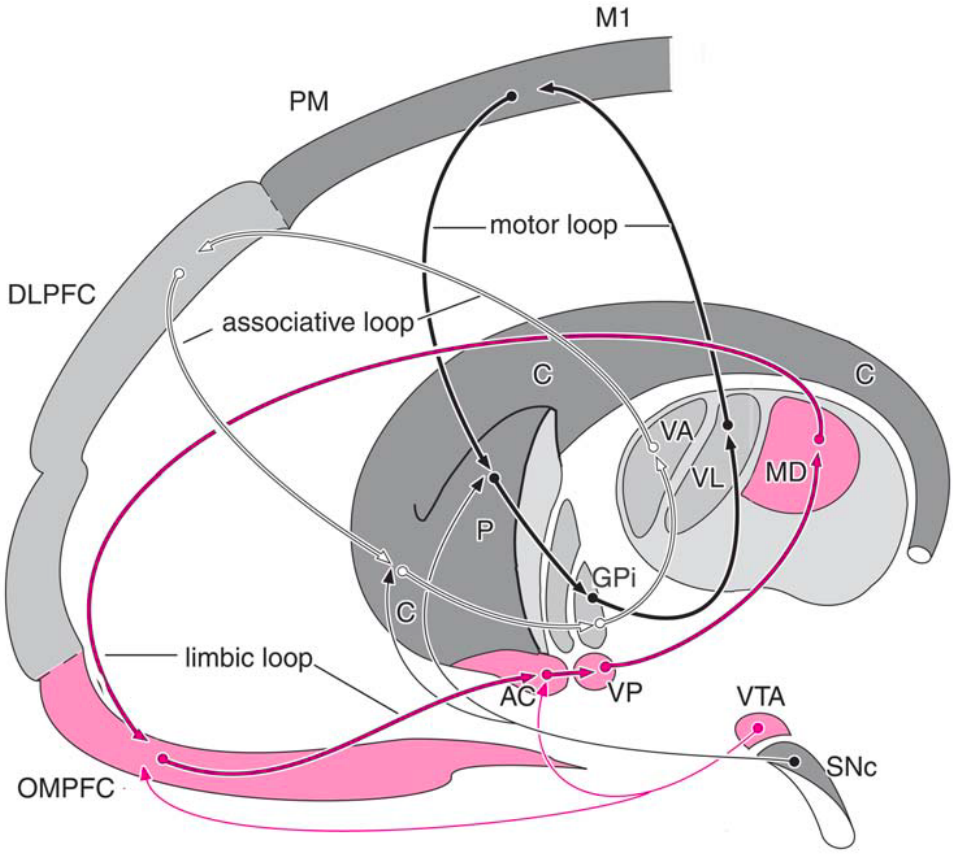
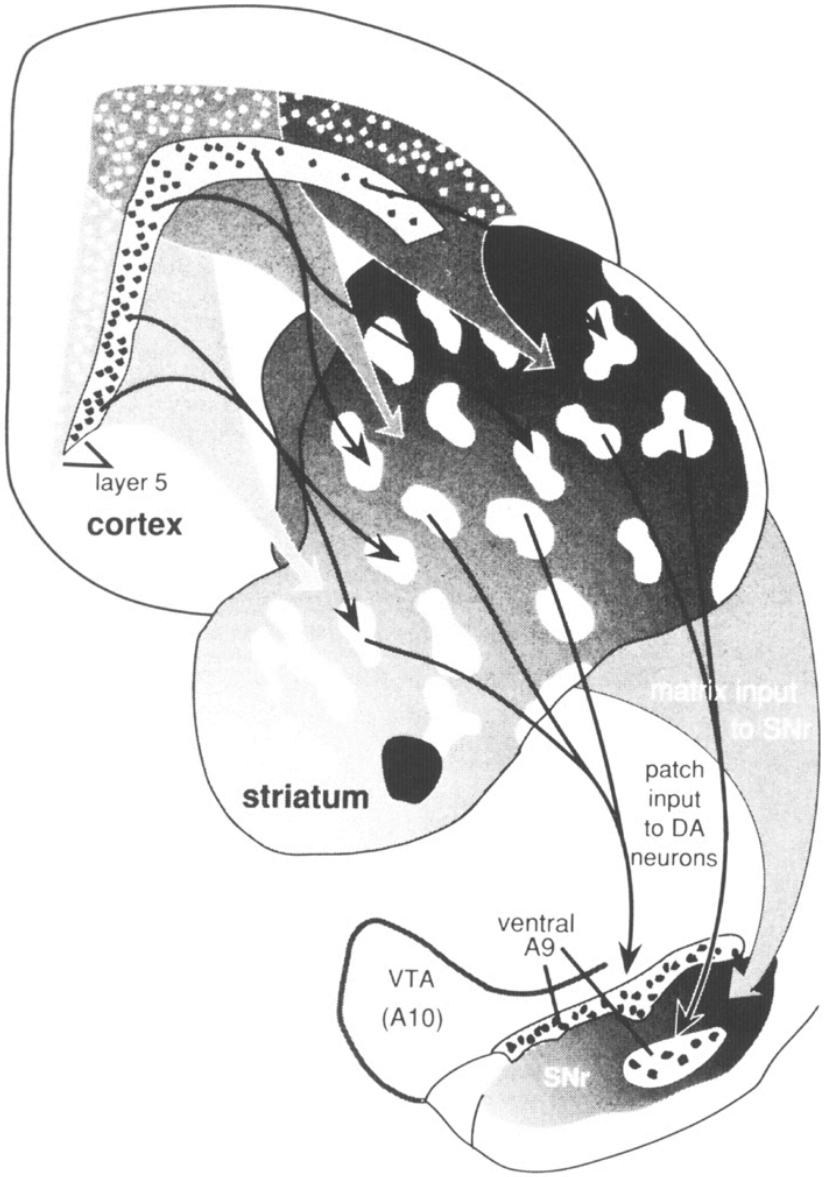
Corticostriatal Pathways





Virtual Neuroanatomy

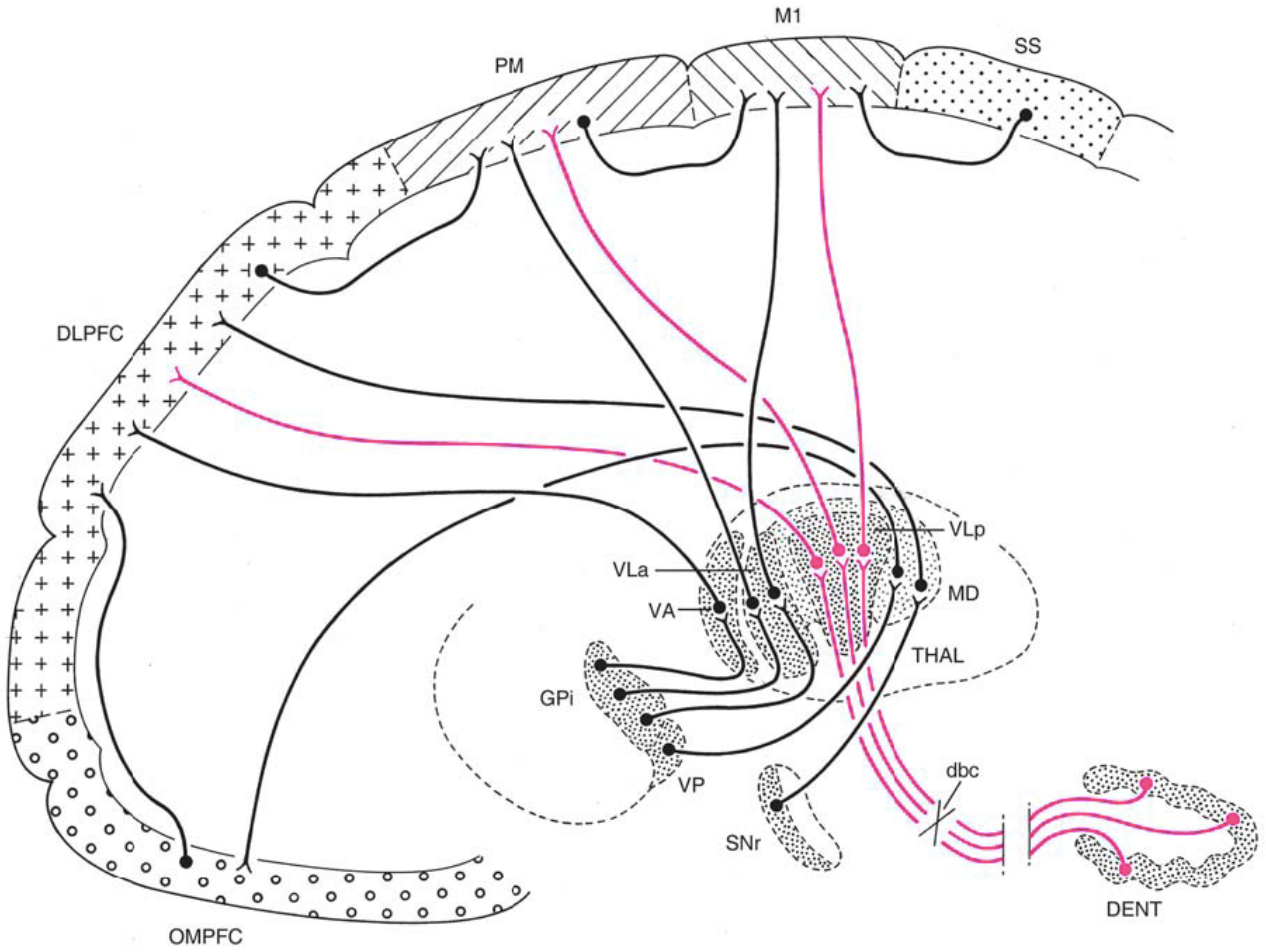
Lecture Date: 09/25/2014

Outline

1. Background
2. Afferents & Efferents
3. Neurophysiology
4. Behavioral correlates
5. Physiological correlates
6. Neurochemical systems
7. Clinical Pathologies

1) Background

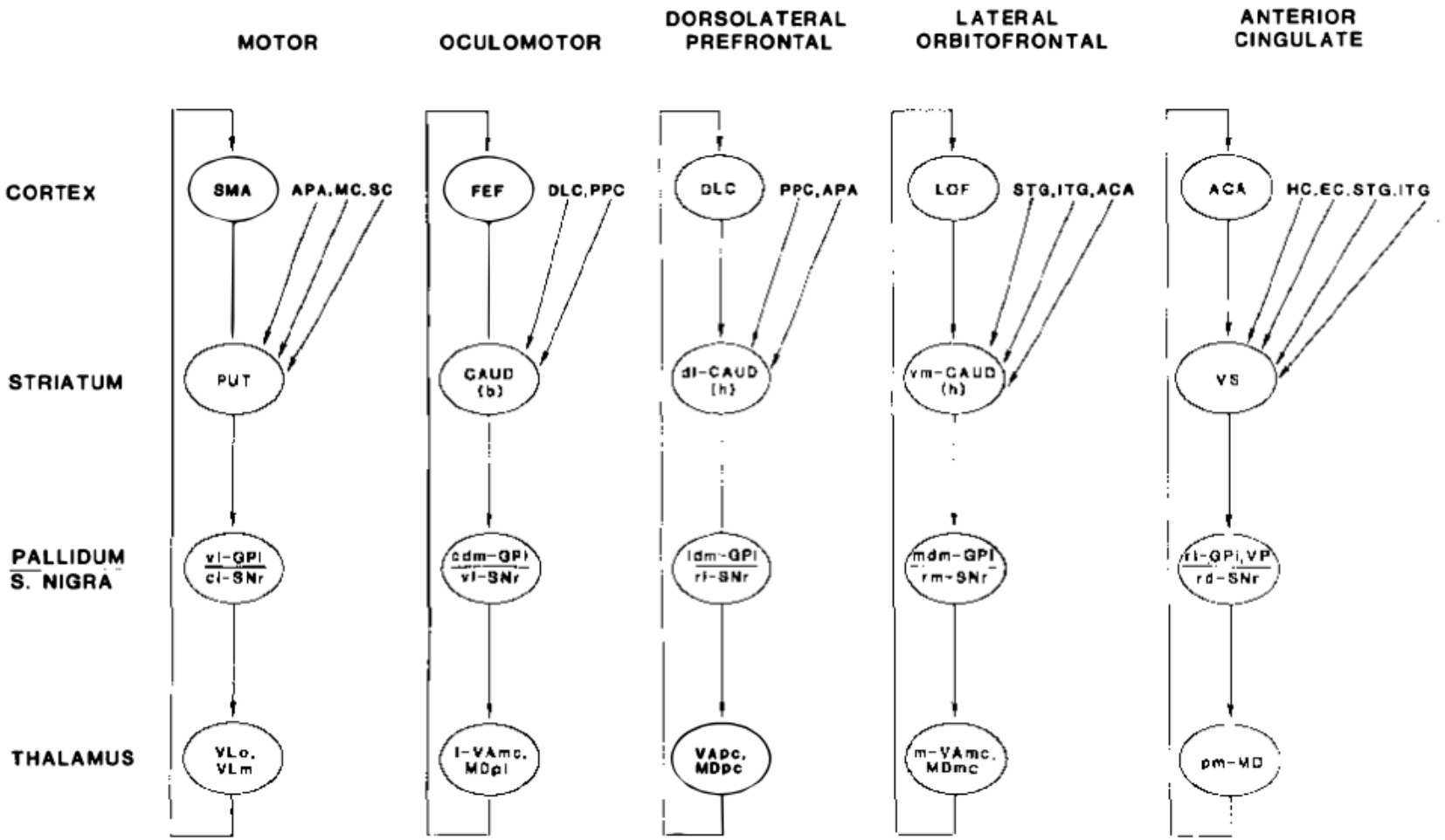
Corticostriatal pathways



Sole source of cortical input into the basal ganglia nuclei.

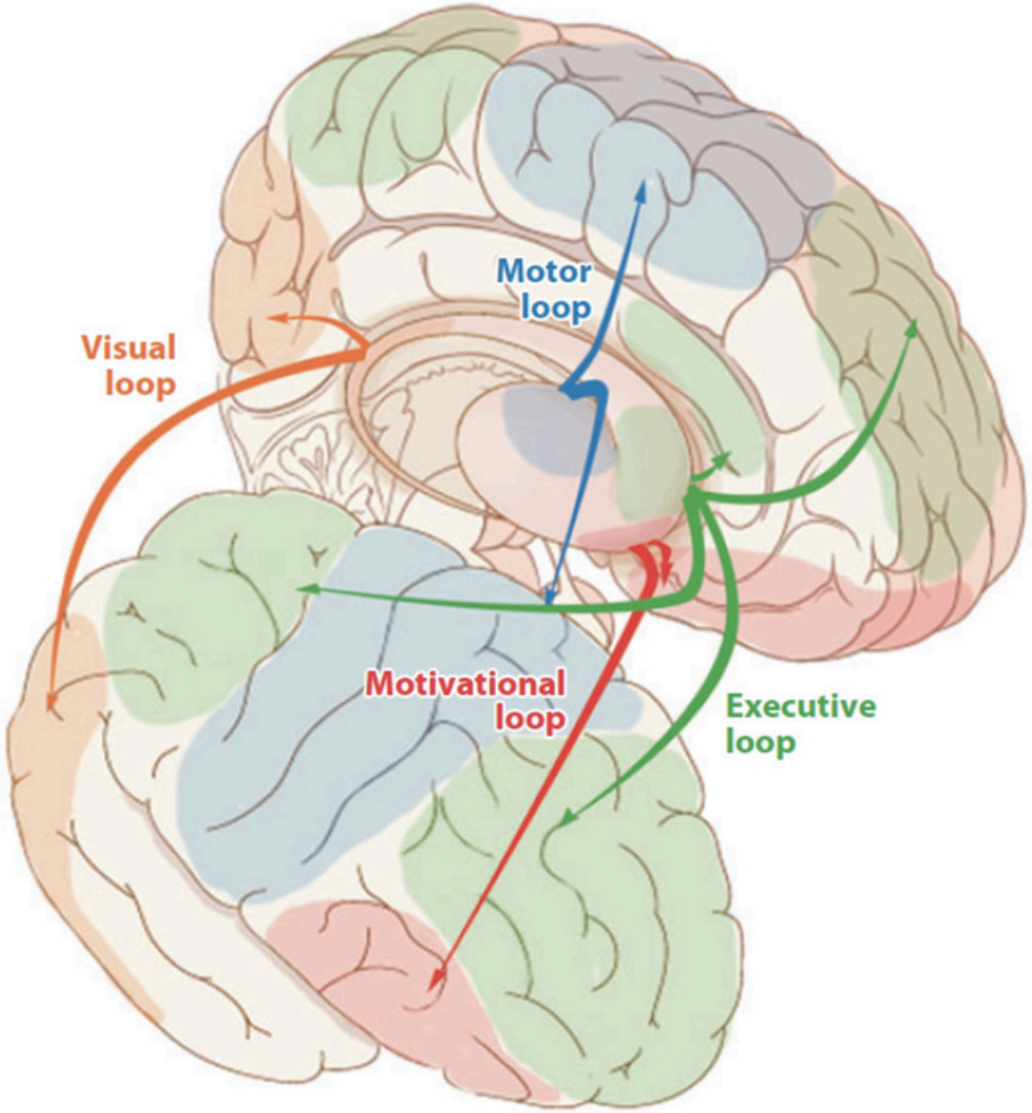
(from Nieuwenhuys, Voogd, & van Huijzen 2008)

Functionally defined loops



Organized as a set of parallel & independent functional loops (Alexander, de Young, & Strick 1986)

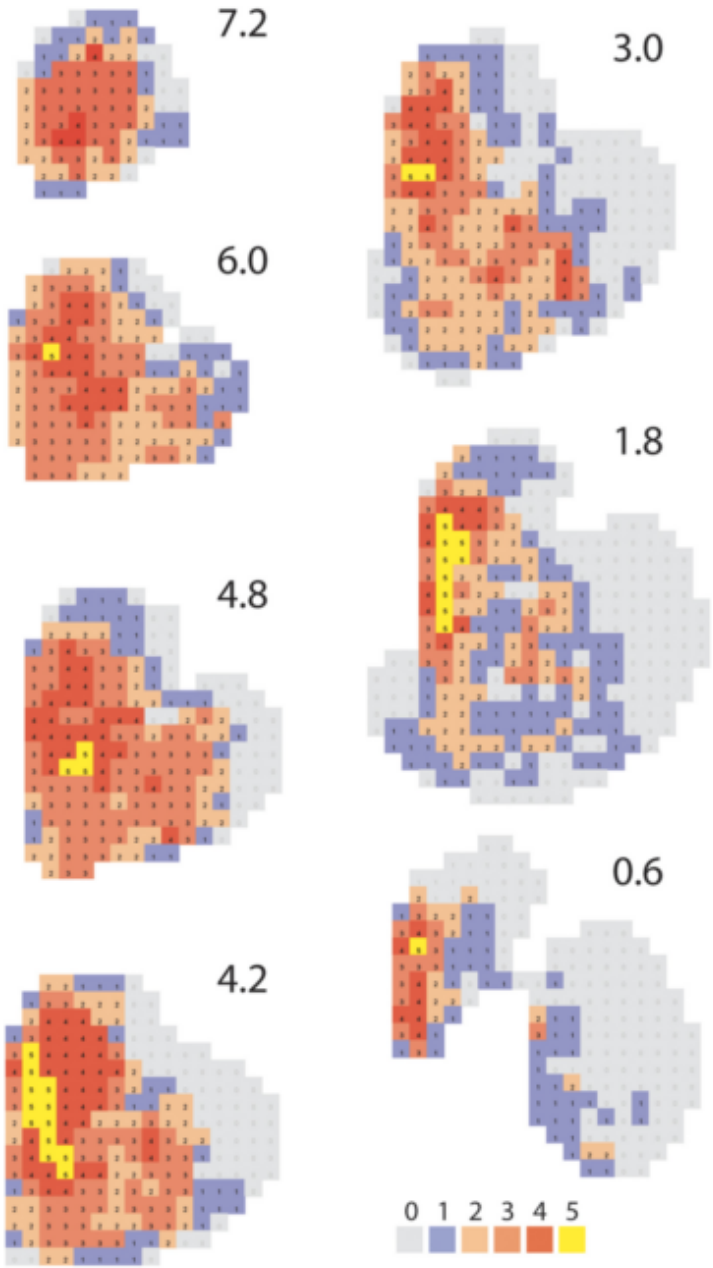
Functionally defined loops



The separation of these loops is thought to be based on functional roles rather than pure anatomical organization.

(from Seger 2013)

Convergence fields

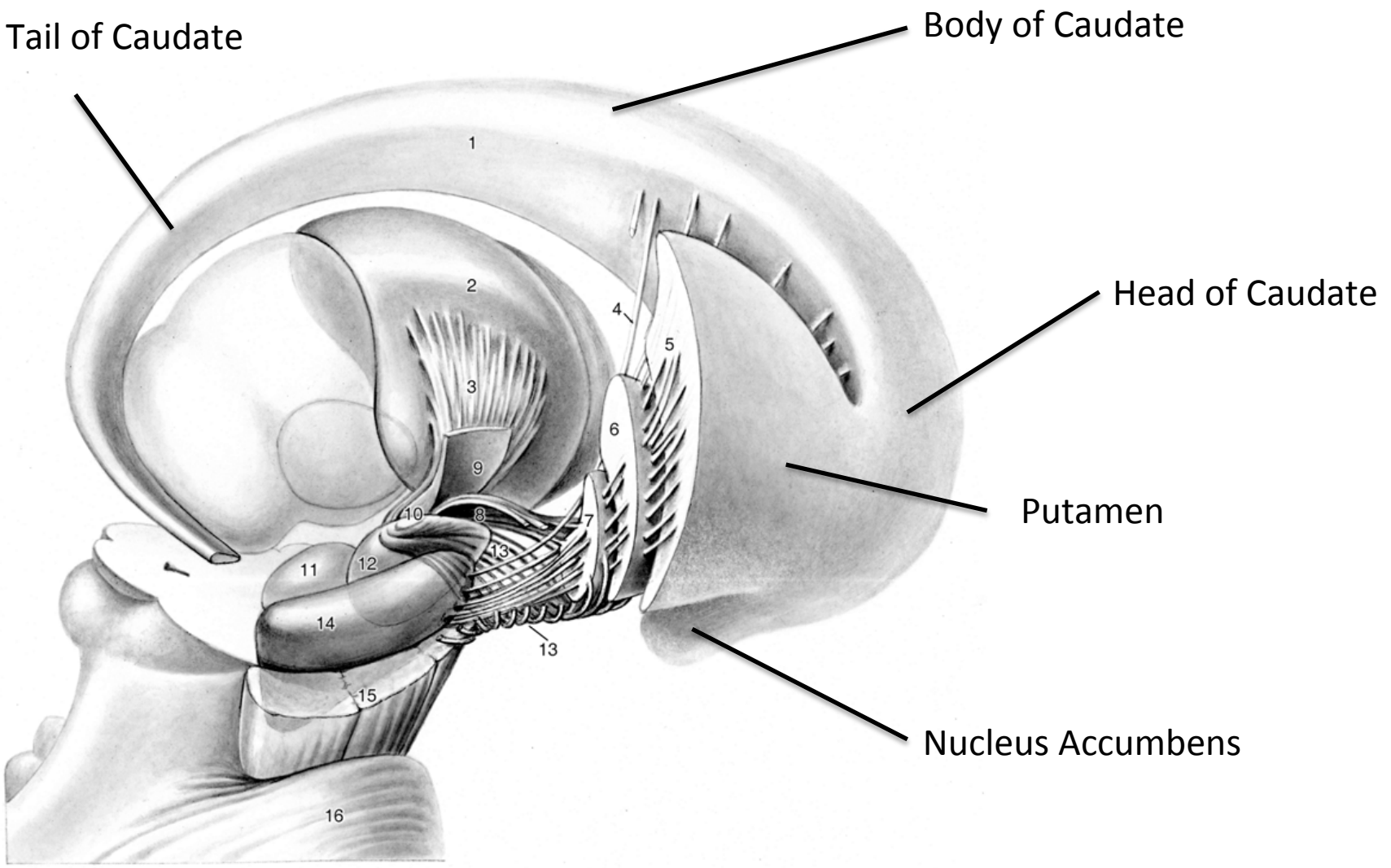


(from Averbeck et al. 2014)

While each loop is considered to be largely independent, there are examples of overlapping inputs across each loop.

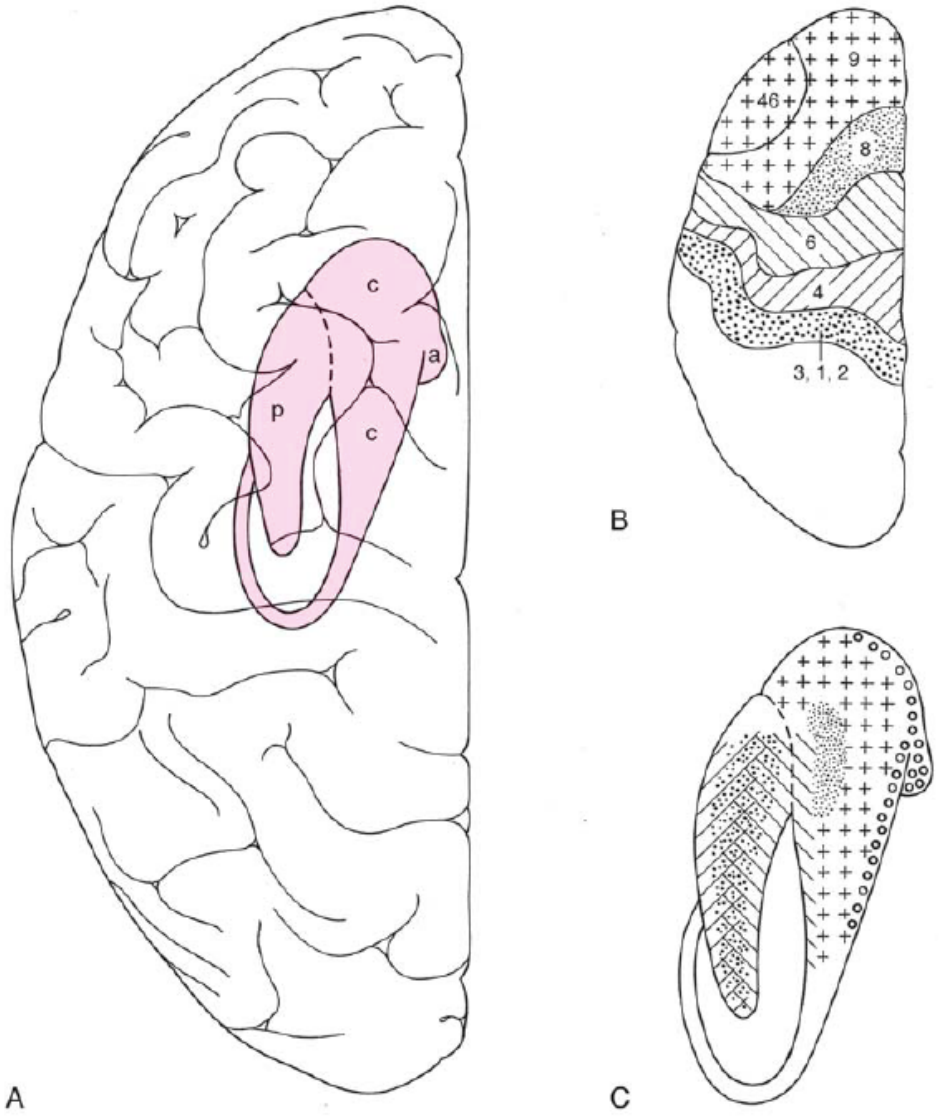
2) Afferents & Efferents

Striatal Nuclei



(from Nieuwenhuys, Voogd, & van Huijzen 2008)

Medial-lateral Topography

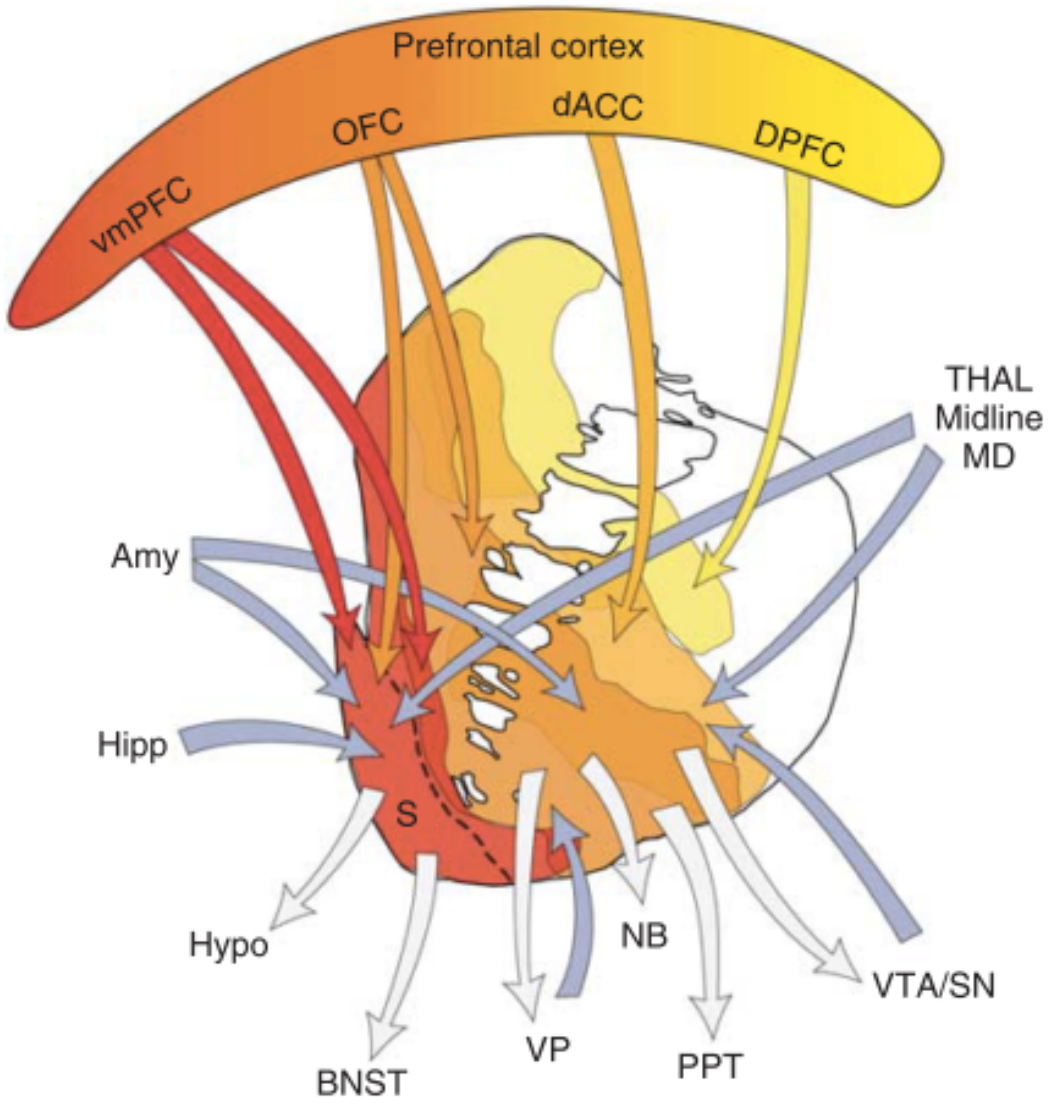


(from Nieuwenhuys, Voogd, & van Huijzen 2008)

Traditional view of the topographical organization of the systems is:

1. Putamen: Sensorimotor
2. Head of Caudate: vmPFC, OFC
3. Body of Caudate: DLPFC
4. Tail of Caudate: PPC, Occipital

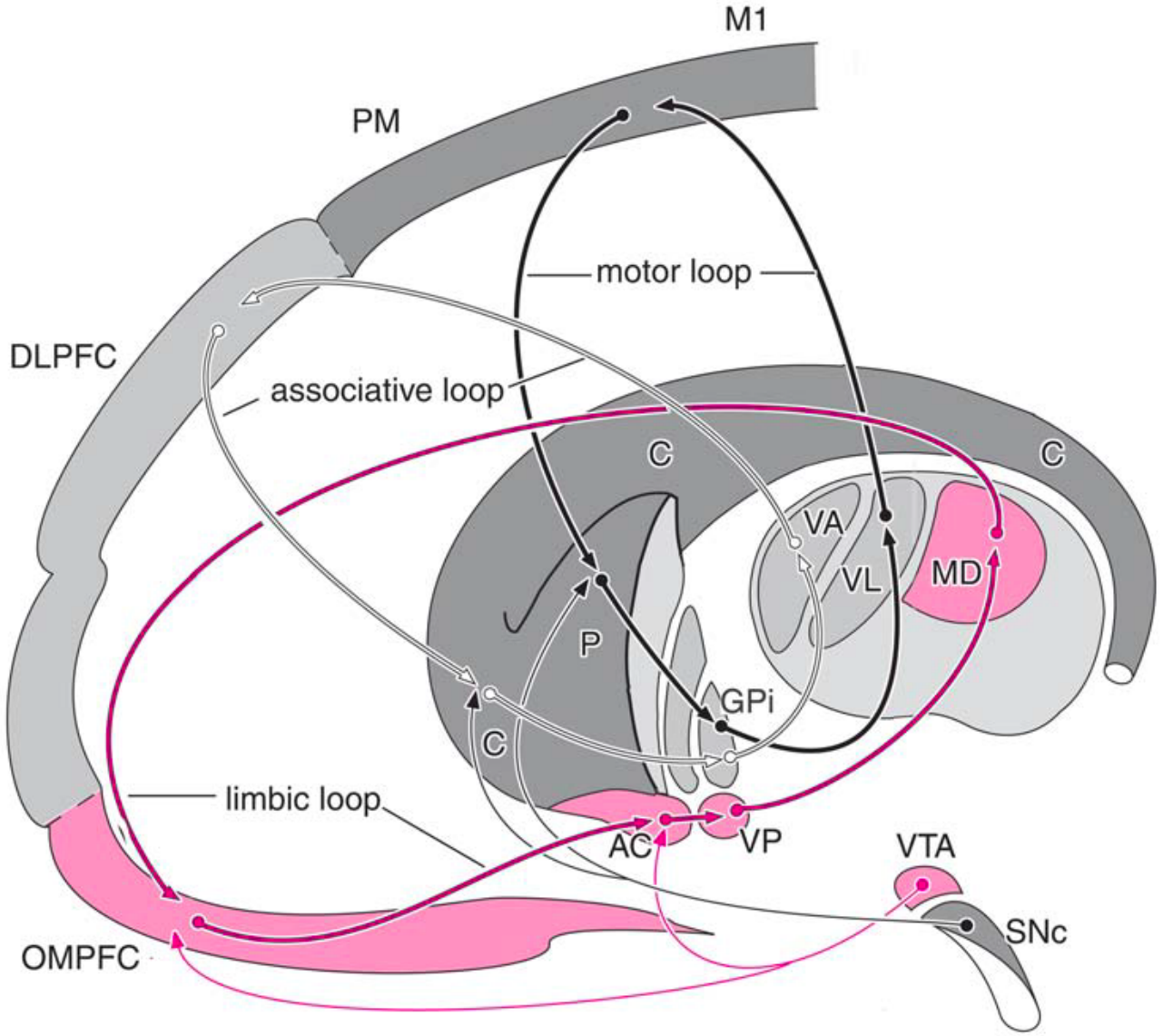
Medial-lateral Topography



(Coronal View)

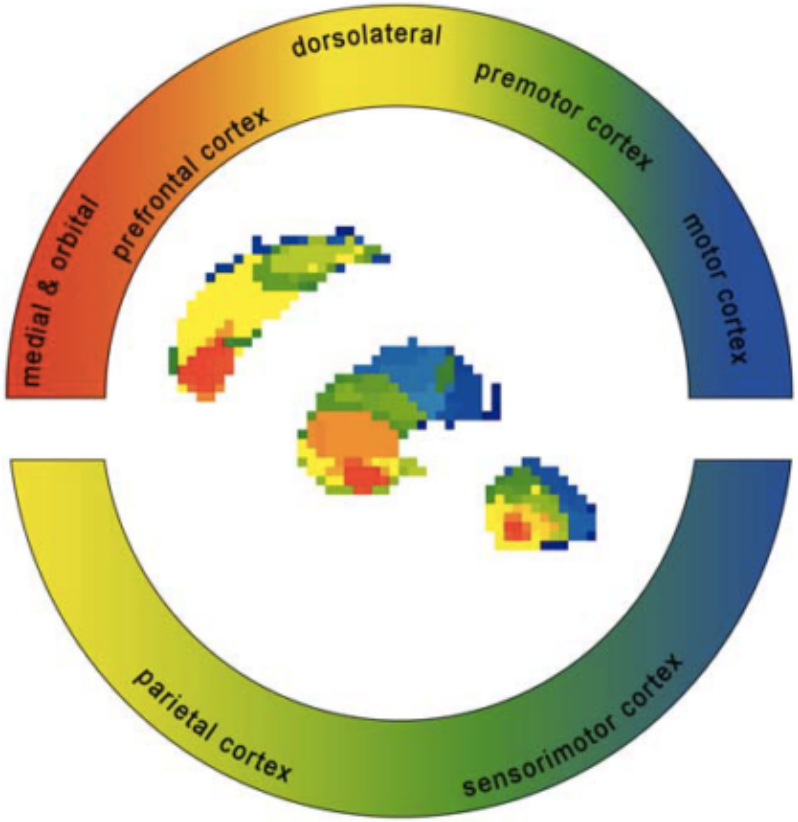
(from Haber & Knutsen 2010)

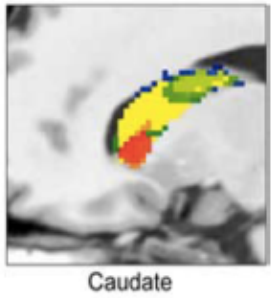
Rostral-Caudal Topography

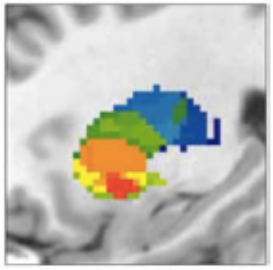


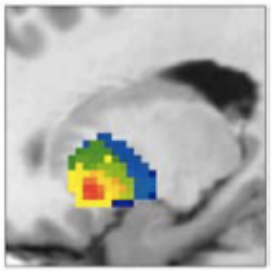
(from Nieuwenhuys, Voogd, & van Huijzen 2008)

Rostral-Caudal Topography




Caudate

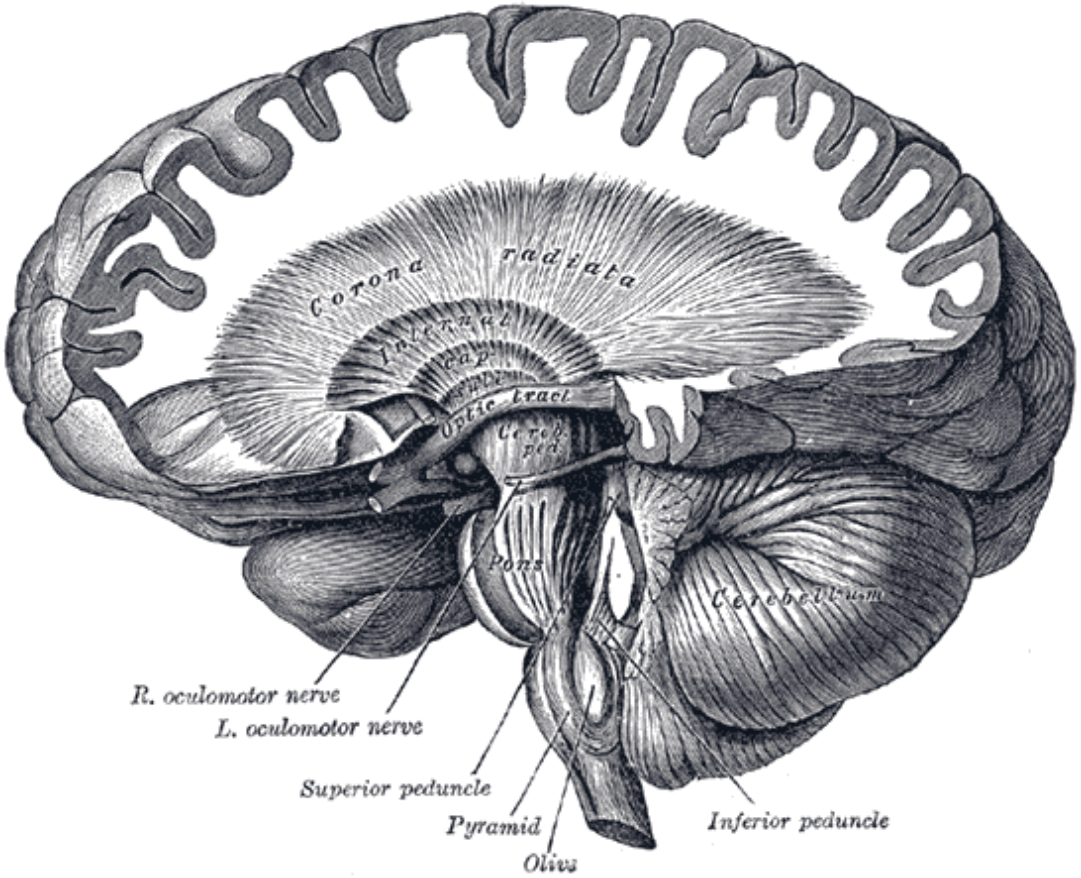

Putamen


Pallidum

More recently it's been suggested that within each pathway, there is also a rostral-caudal organization of these projections.

(from Draganski et al. 2008)

Path

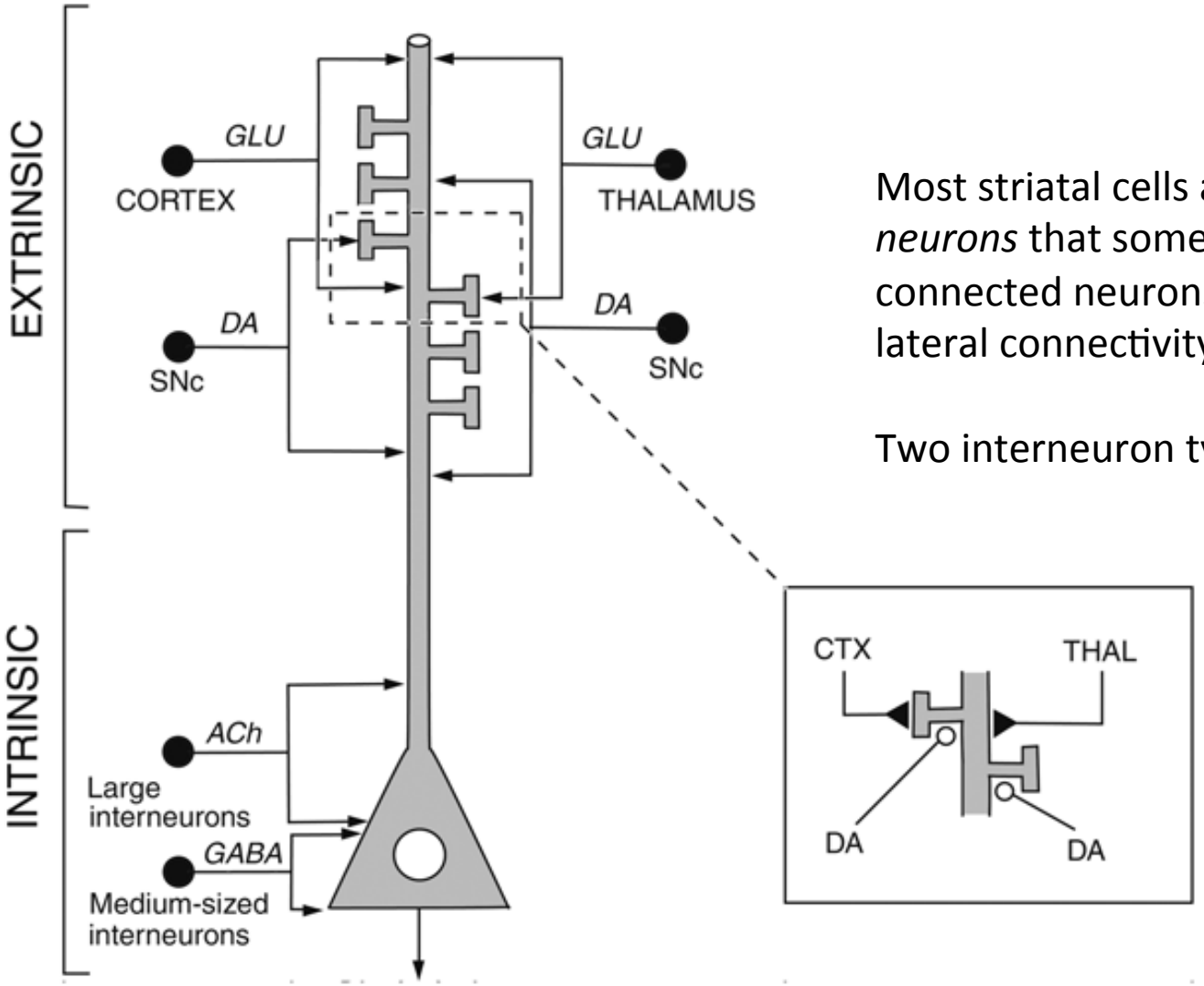


Most projections converge as part of the corona radiata and terminate on striatal nuclei.

(image from WikiPedia)

3) Neurophysiology

Cell physiology

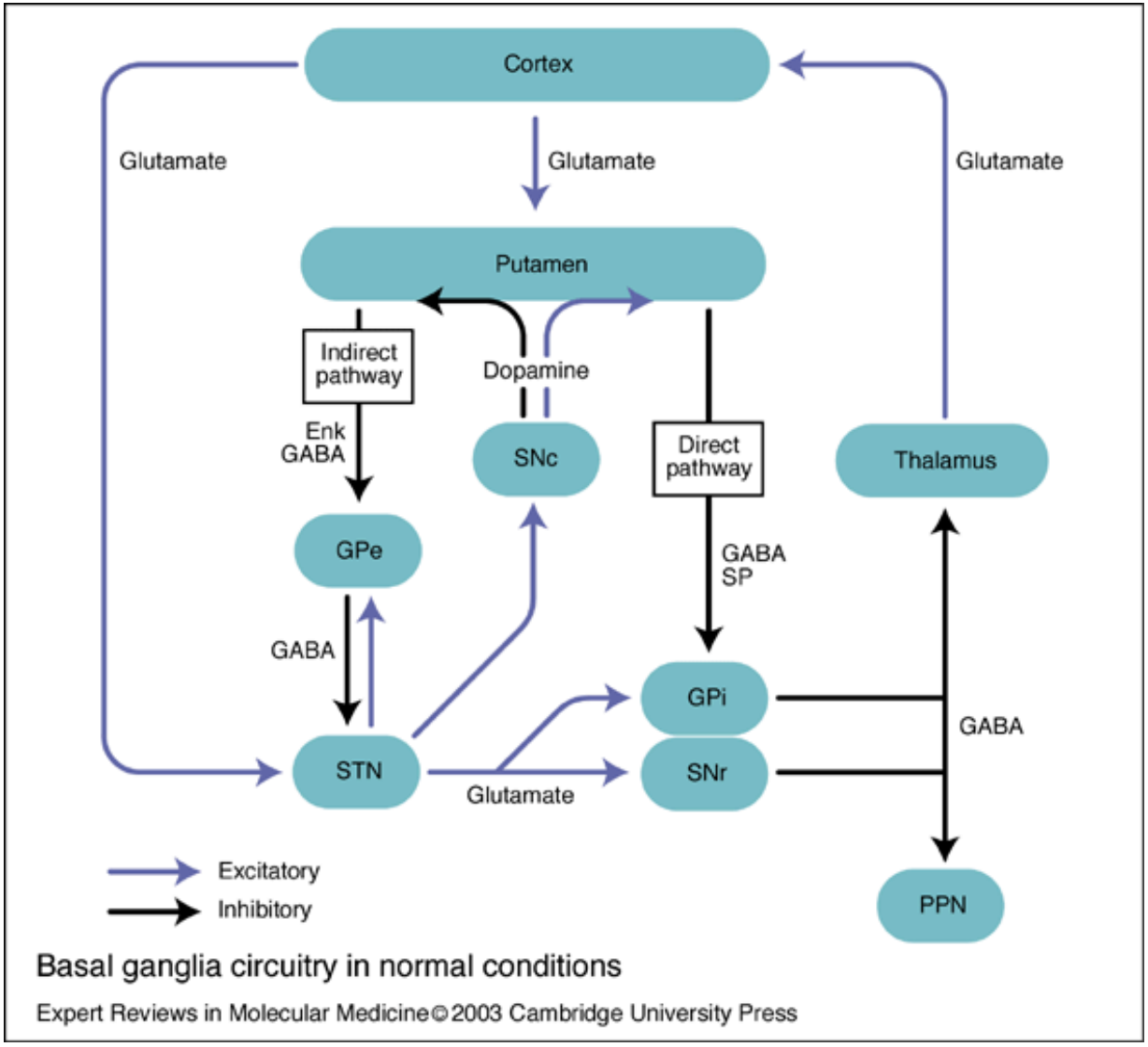


Most striatal cells are *medium spiny neurons* that some of the most densely connected neurons in the brain. Very little lateral connectivity.

Two interneuron types: Large & Medium.

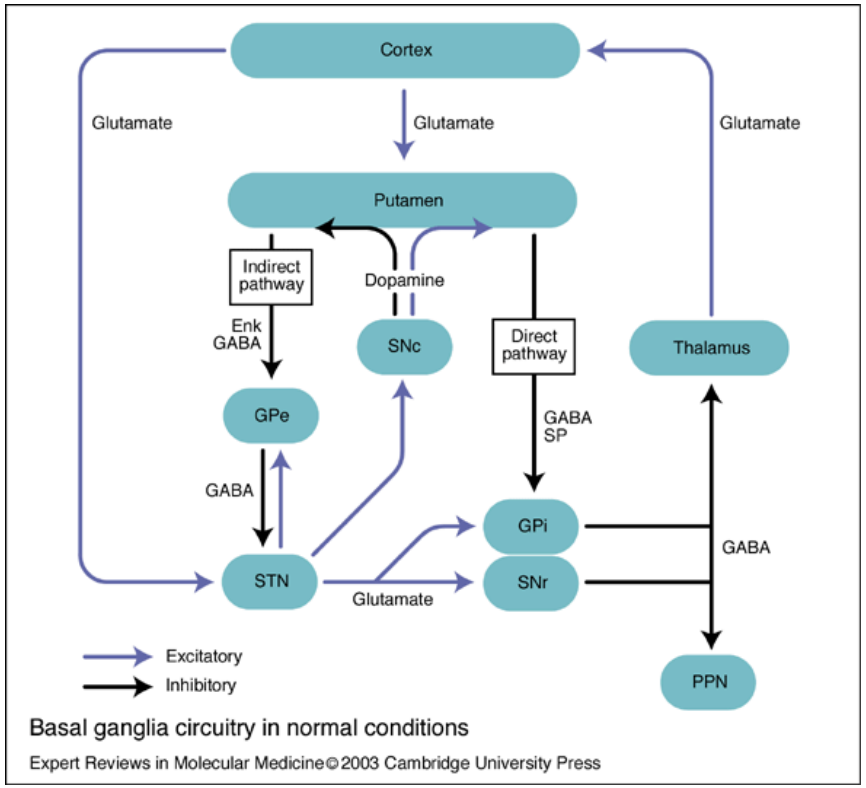
(from Nieuwenhuys, Voogd, & van Huijzen 2008)

Opposing Pathways



(from Simon et al. 2003)

Opposing Pathways

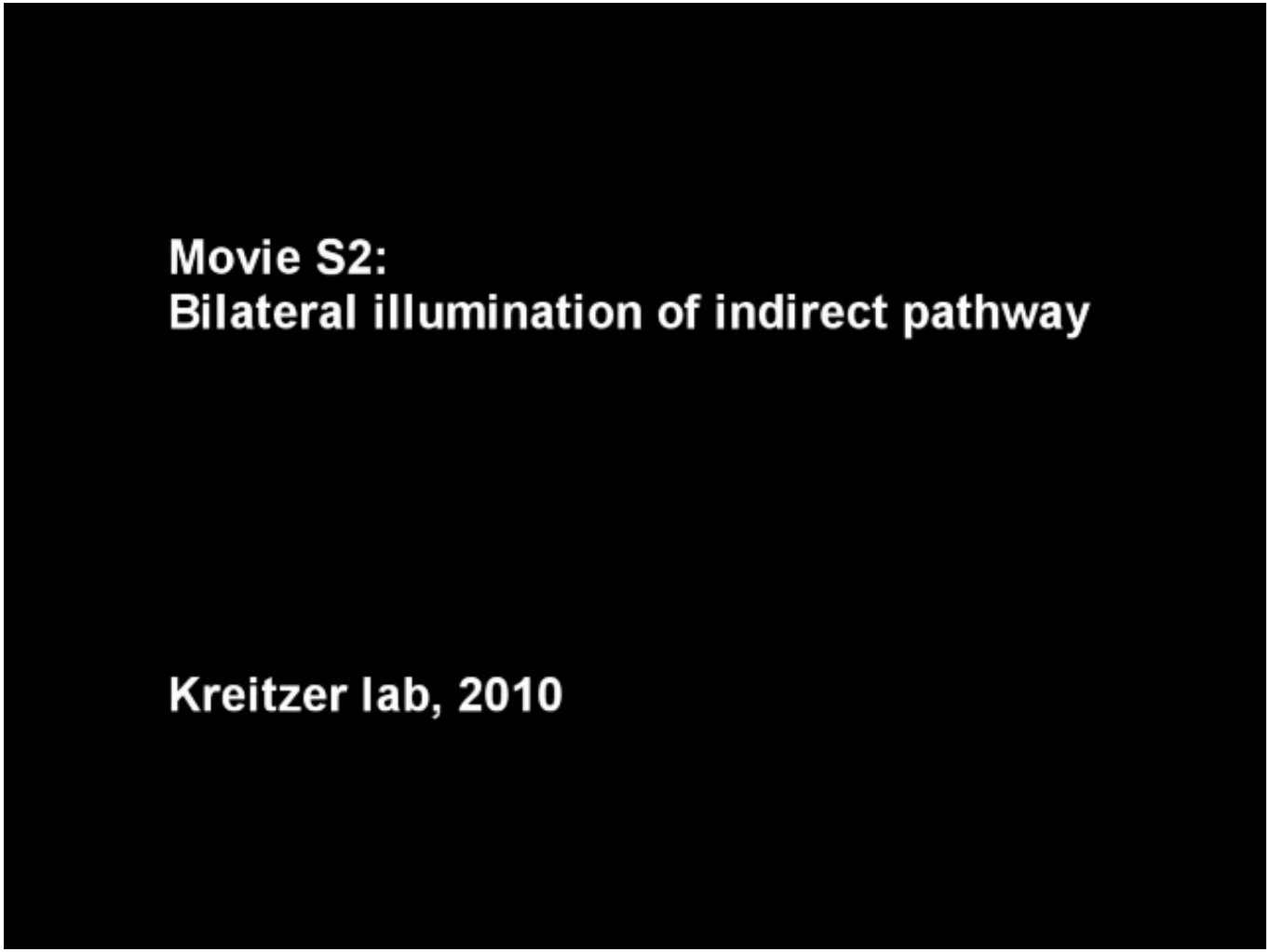


Direct (Go) Pathway:
D1-modulated pathway that facilitates thalamic output.

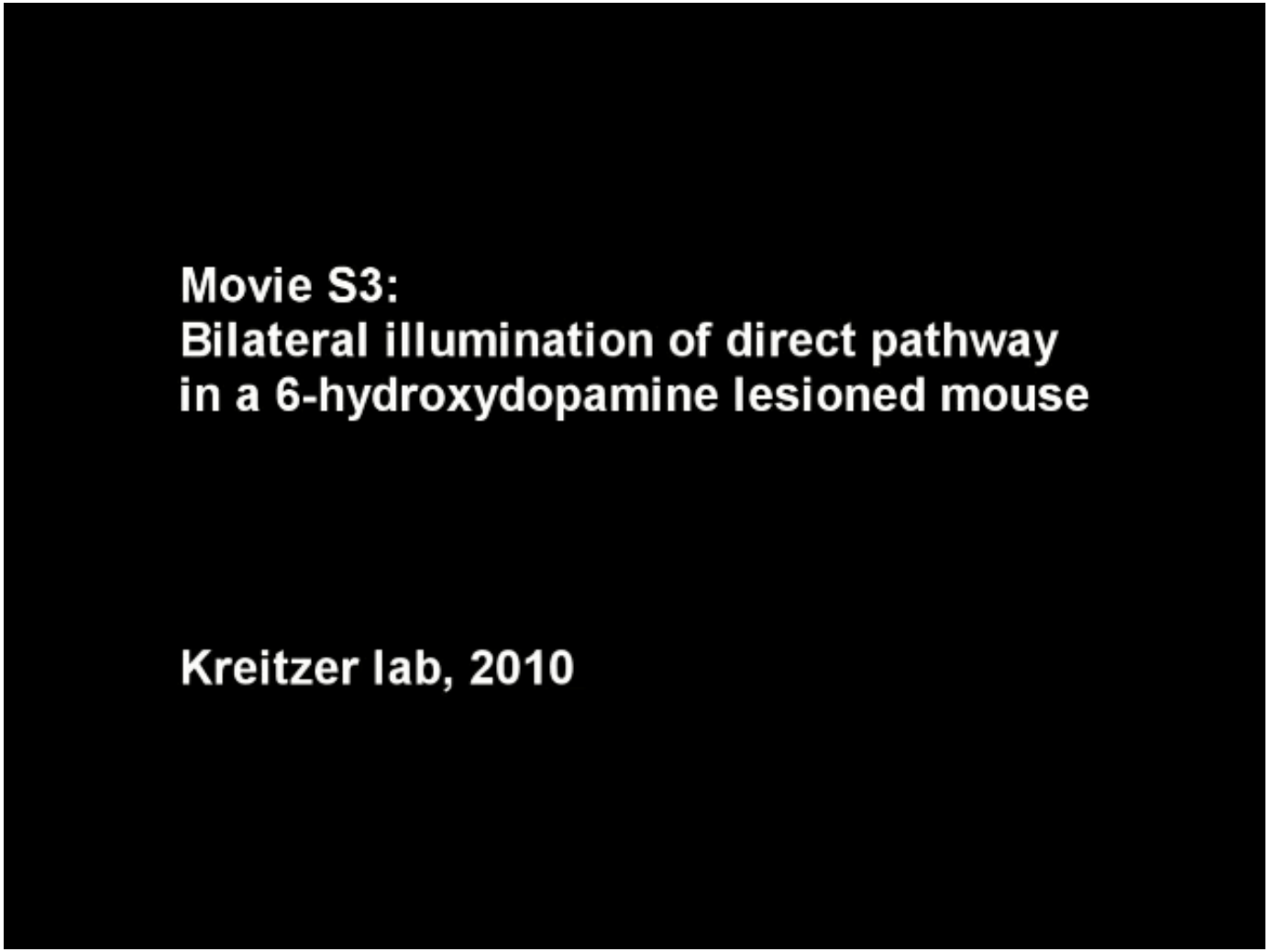
Indirect (No-Go) Pathway:
D2-modulated circuit that suppresses thalamic output.

(from Simon et al. 2003)

Indirect Pathway Activation

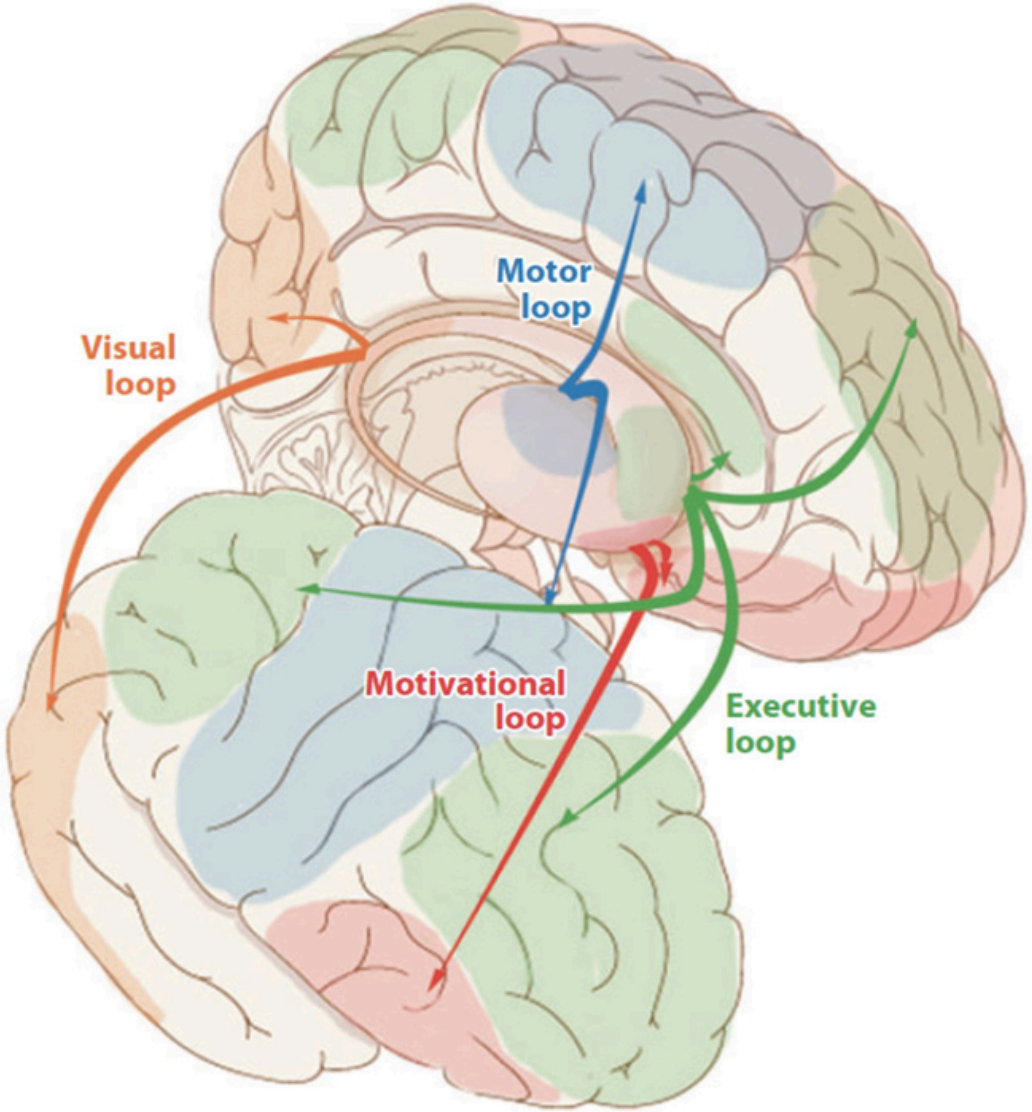


Direct Pathway Activation



5) Behavioral correlates

Four global circuits based on behavior

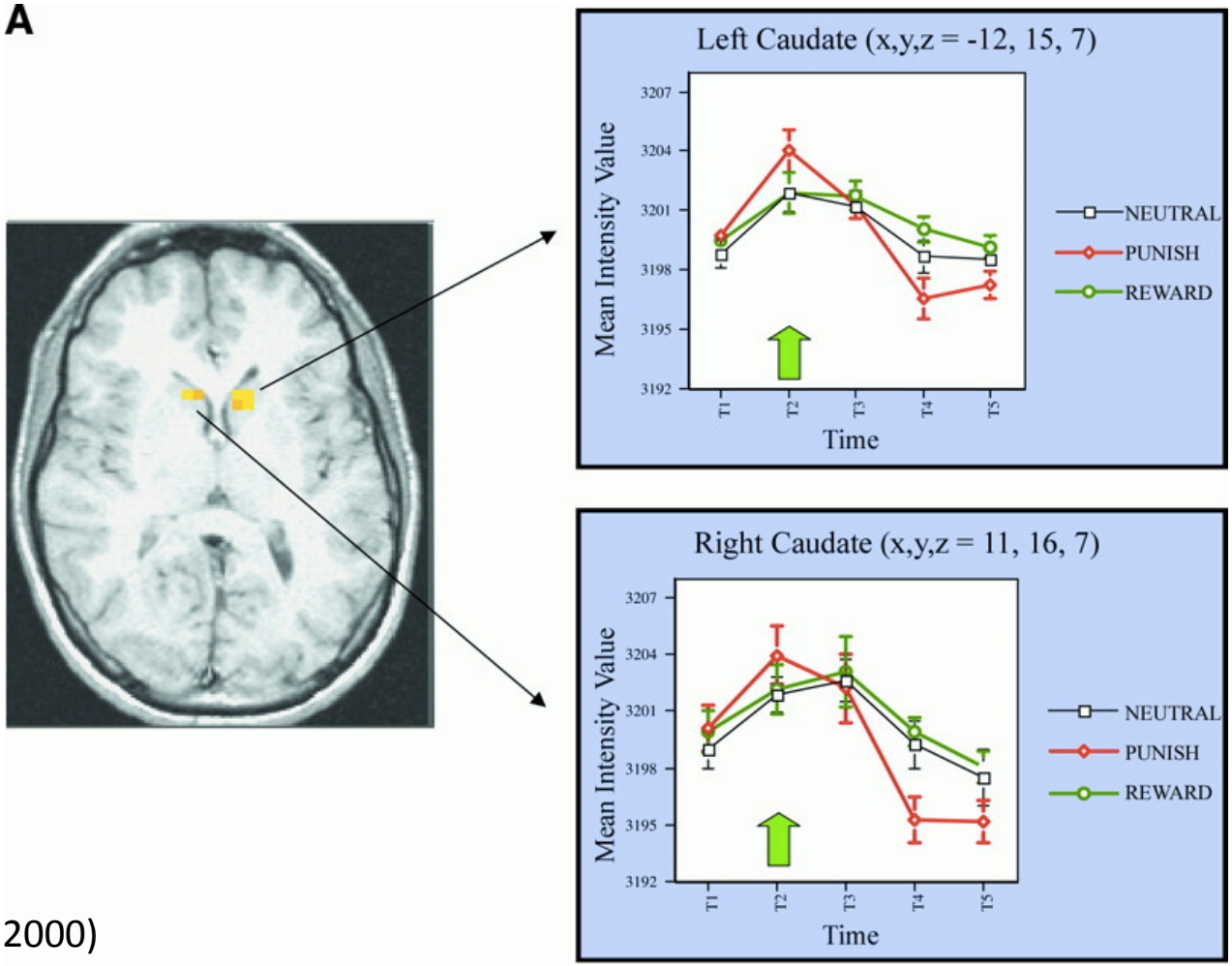


1. Reward processing
2. Executive control
3. Motor control
4. Visual processing

(from Seger 2013)

Reward/Punishment

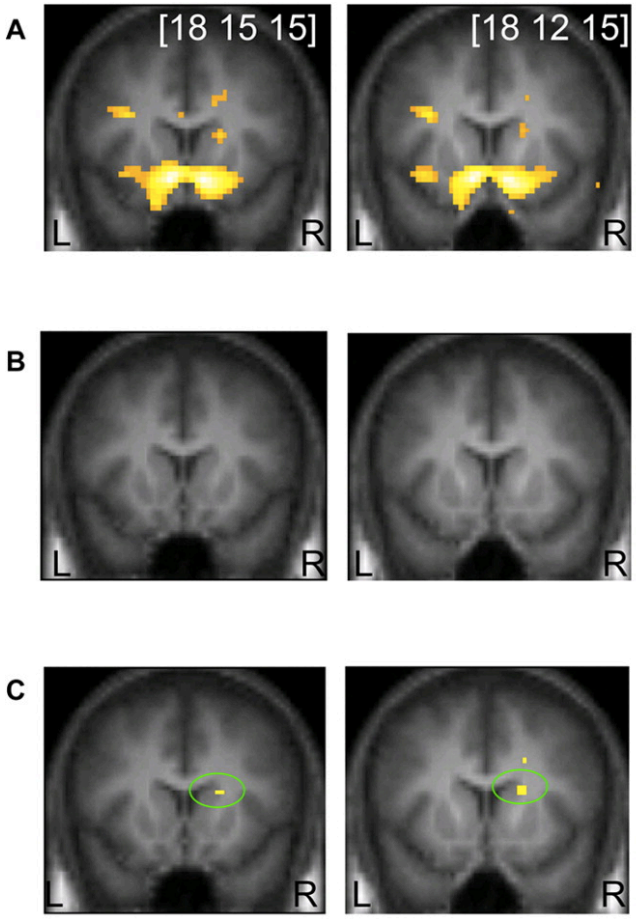
Ventral striatal regions respond preferentially to reinforcement cues (punishment or reward).

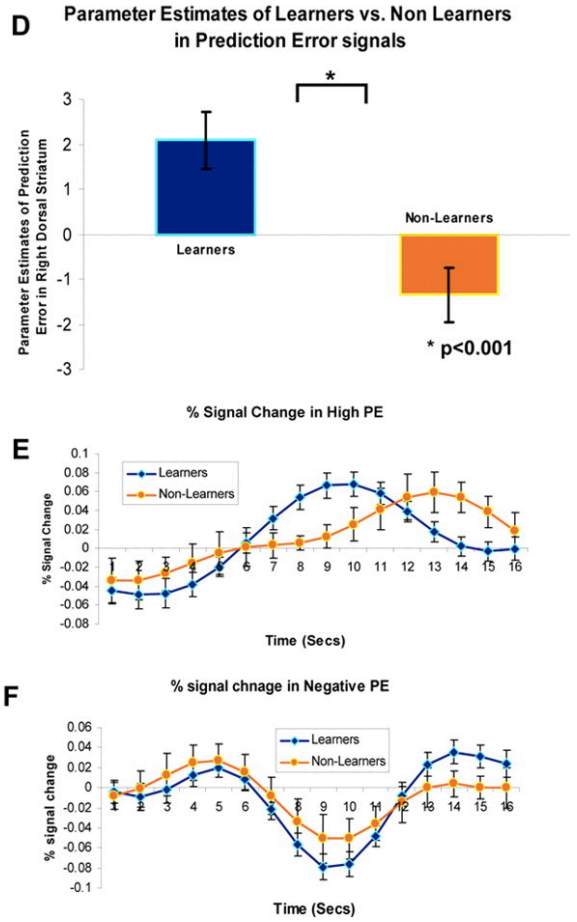


(from Delgado et al. 2000)

Reinforcement learning

As a result of the reward processing responses, the striatal nuclei)and cortical striatal circuit) are linked to reinforcement learning

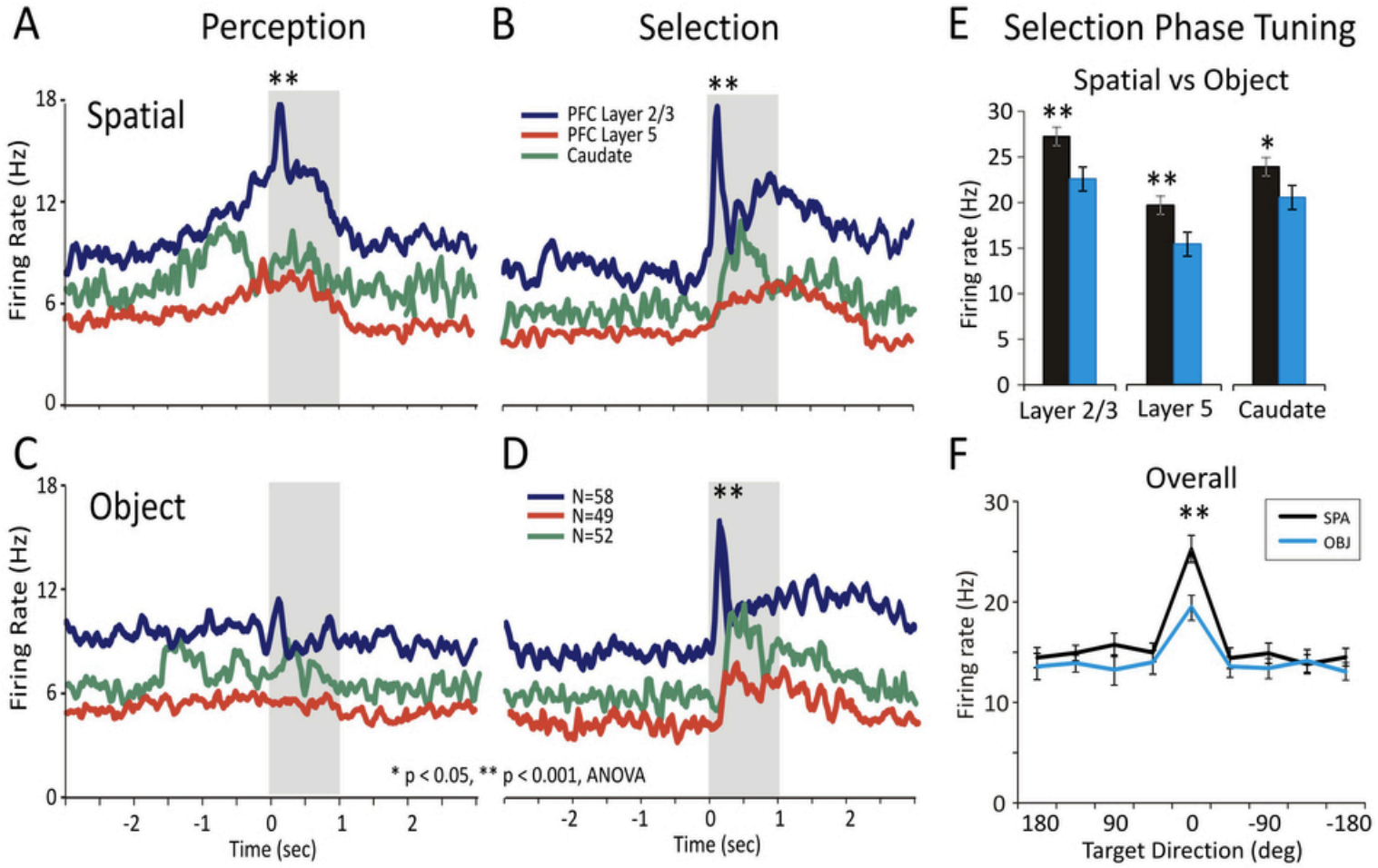




(from Schonberg et al. 2007)

Executive & Motor Control

The opposition between the direct and indirect pathway have been linked to both gating (or suppression) of executive decisions and motor behaviors.



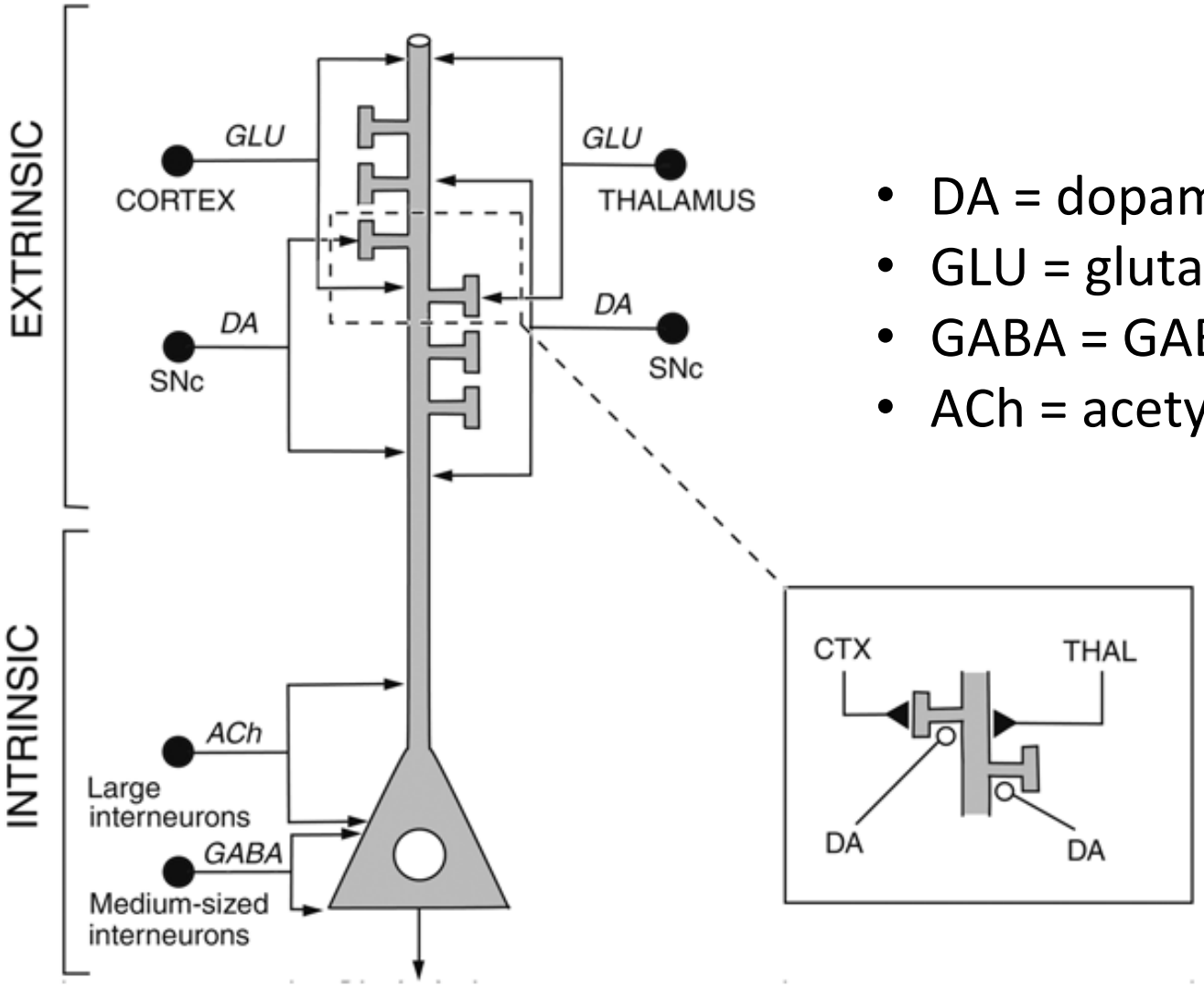
(from Opris et al., 2013)

5) Physiological Correlates

(none that I could directly find)

6) Neurochemical systems

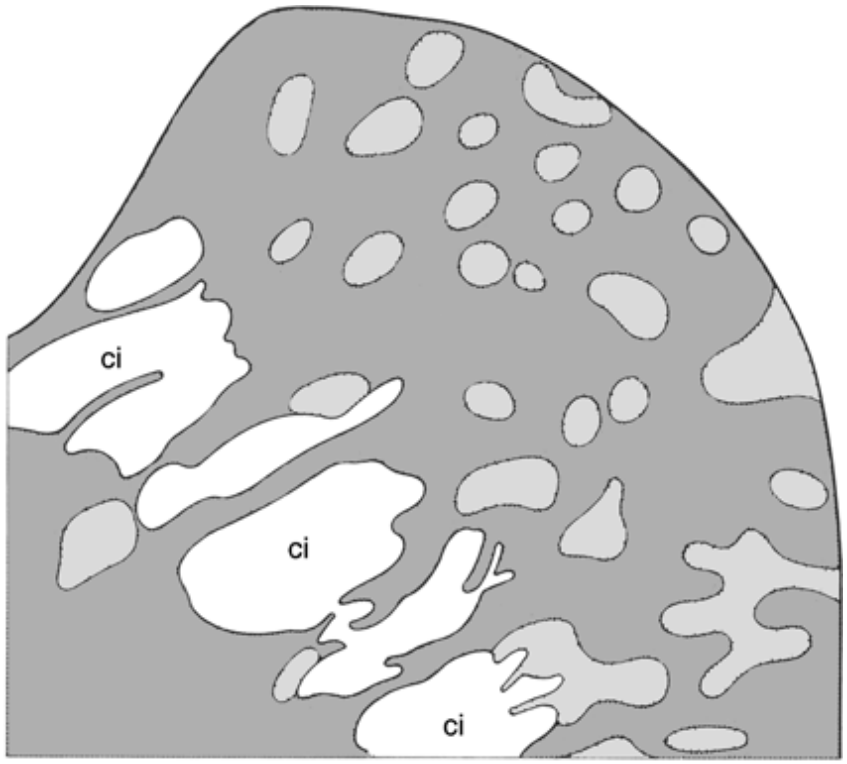
Major neurotransmitters



- DA = dopamine
- GLU = glutamate
- GABA = GABA
- ACh = acetylcholine

(from Nieuwenhuys, Voogd, & van Huijzen 2008)

Biochemical organization



Striosomes (light gray):

- ACh poor.
- Dense innervations from orbitofrontal & insular prefrontal cortex.
- D1 & D2.

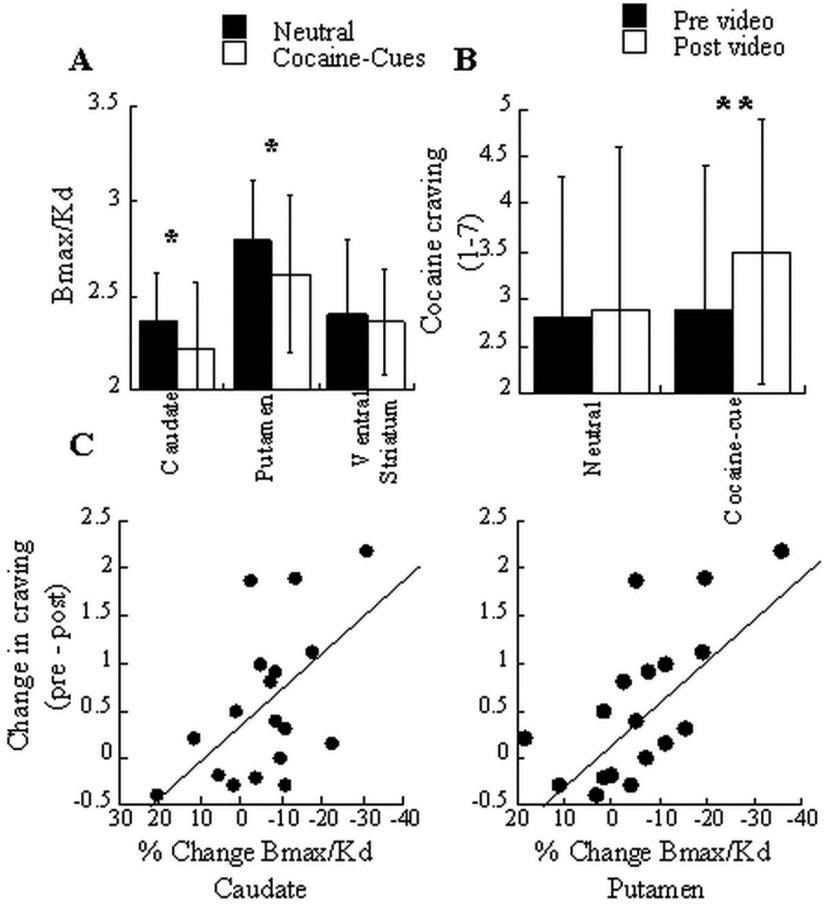
Matrisomes (dark gray):

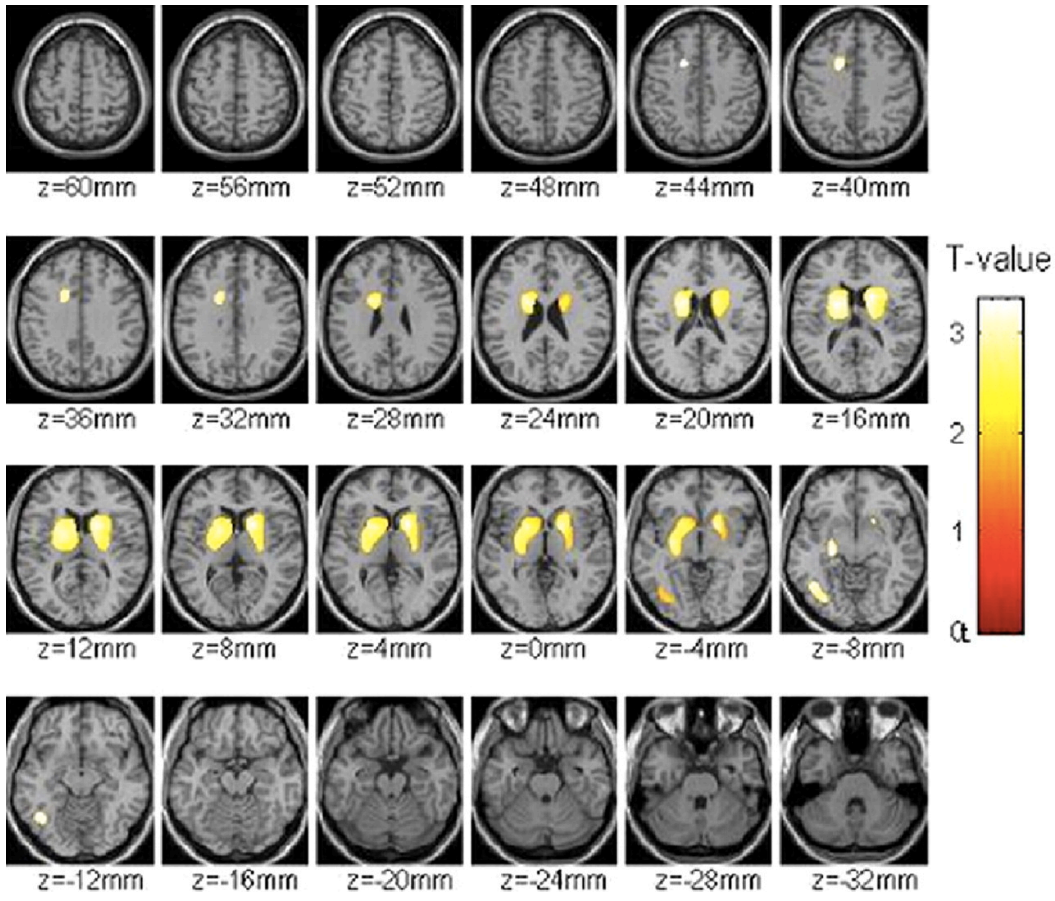
- ACh rich.
- Distributed innervations from most of neocortex.
- Predominantly D2.

(from Nieuwenhuys, Voogd, & van Huijzen 2008)

7) Clinical Pathologies

Addiction





Greater dorsal and ventral striatum reactivity is associated with increased craving in a variety of addiction disorders.

(from Volkow et al. 2006)

Huntington's Disease

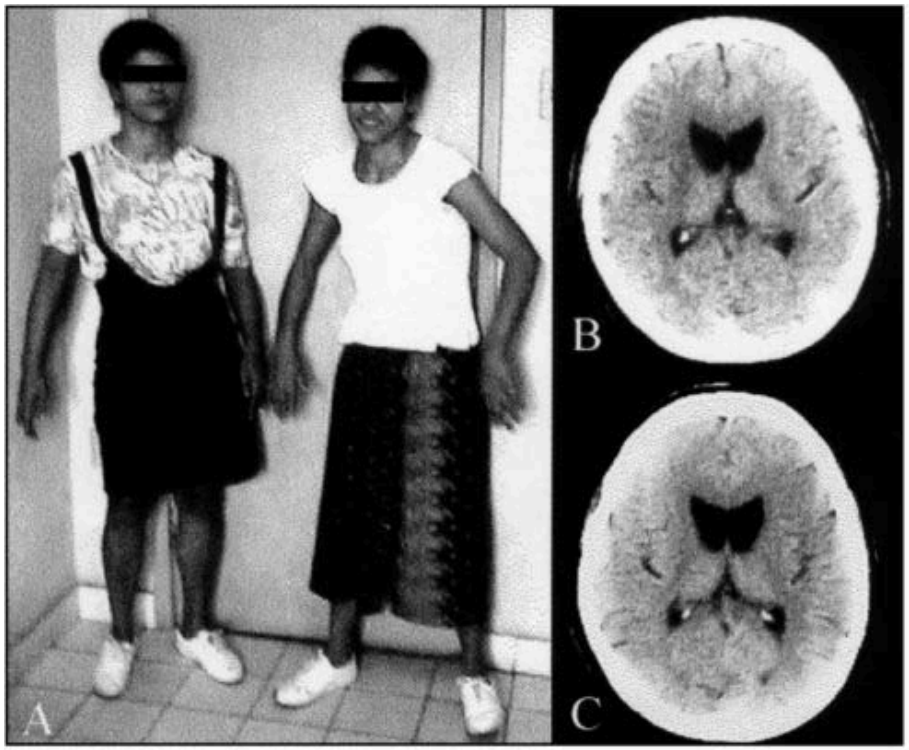
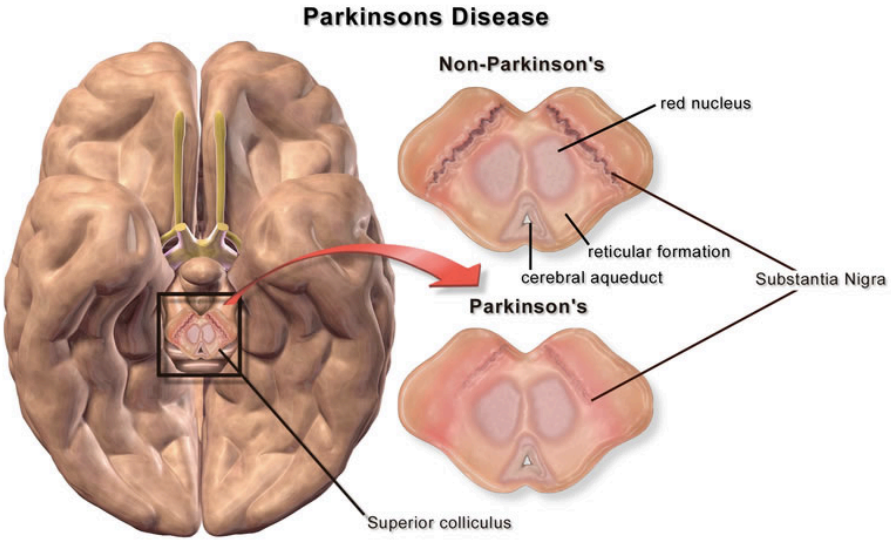


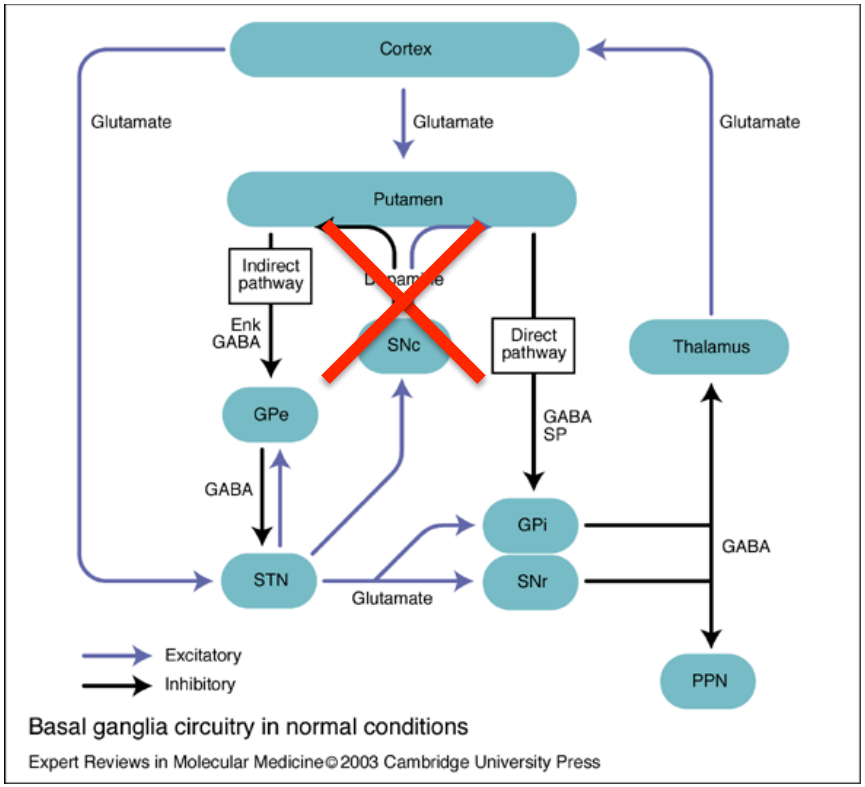
Fig 1. Phenotipically identical twins (A) and skull computed tomography showing head of caudate nucleus atrophy (B and C).

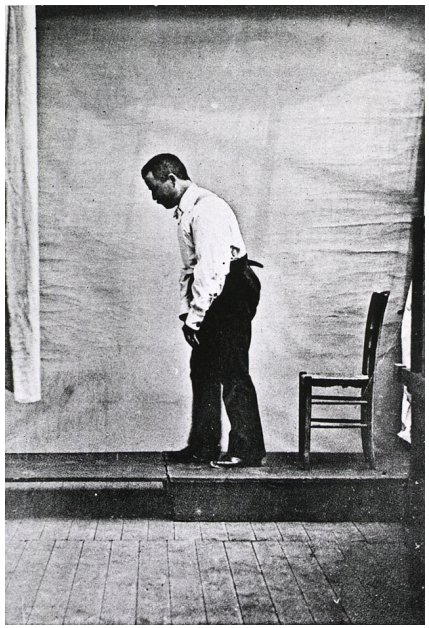
A genetic syndrome presenting with choreas (quick, spastic movements of the hands and feet) and associated with degeneration of medium spiny neurons.

(from Levy et al. 1999)

Parkinson's Disease

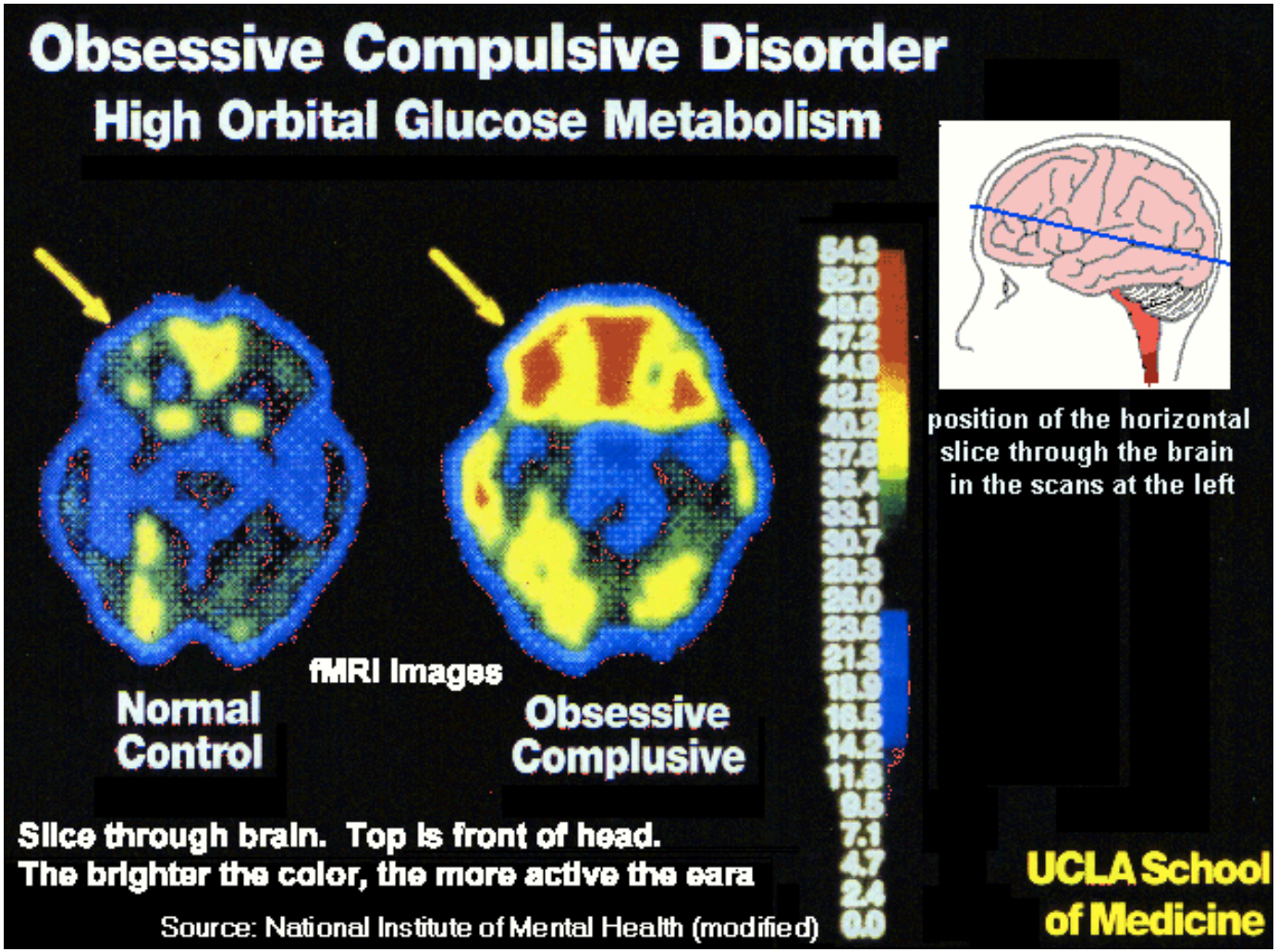






A neurological disorder characterized by slow movements, uncontrolled tremor, postural changes, micographia, dementia & depression. Due to a loss of the dopamingeric inputs into the striatum and neocortex

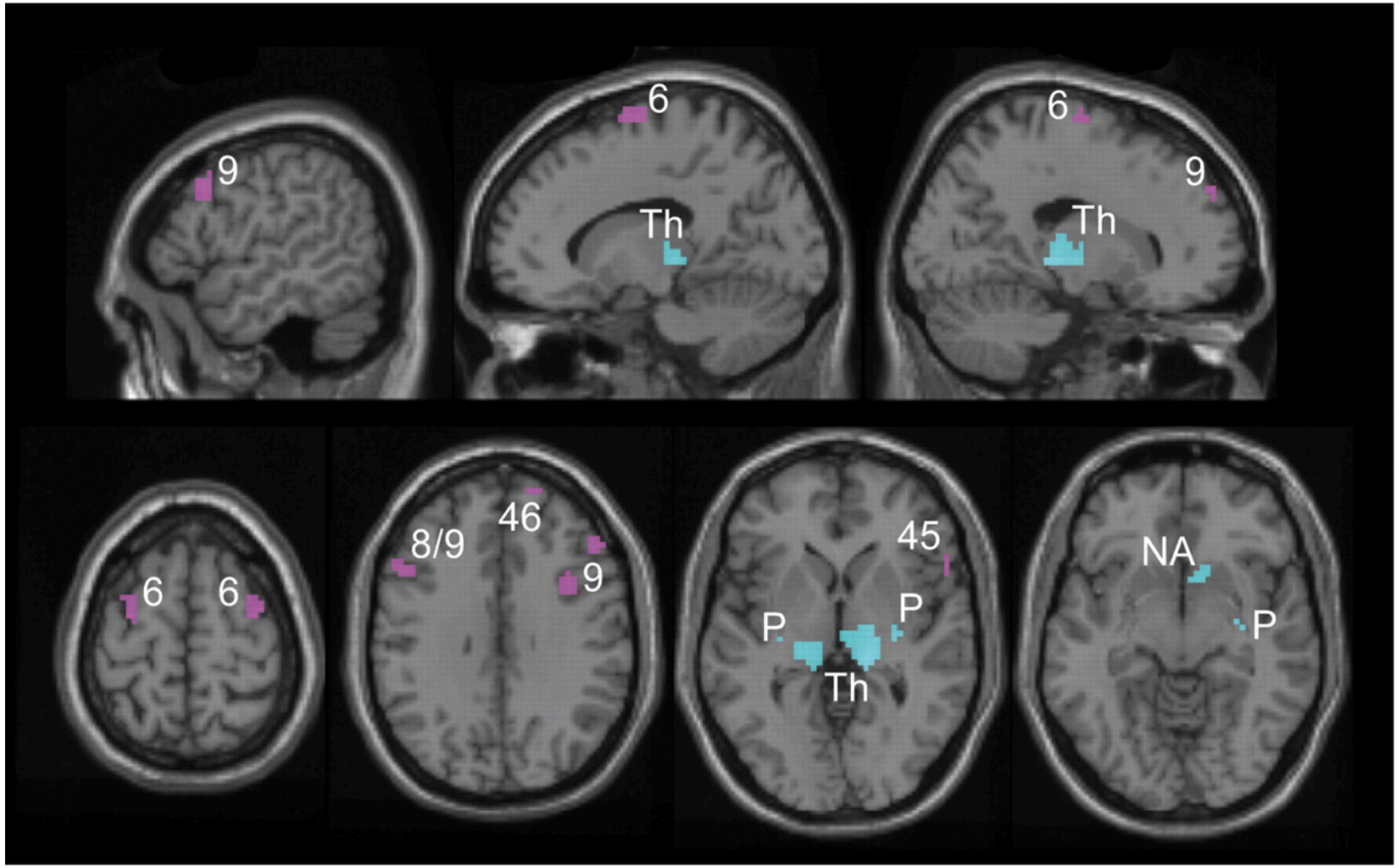
Obsessive Compulsive Disorder



OCD is associated with hyperactivity of orbitofrontal and ventral striatal areas.

(see Rapoport 1990)

Tourette's Syndrome



Tourette's syndrome is associated with reduced volume of striatal nuclei (blue voxels) and hyper activity during movement execution.

(from Baym et al. 2007)

Summary

1. Background
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5. Physiological correlates
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