motor programming - assessment of impairments related to basal ganglia and cerebellum role in motor control

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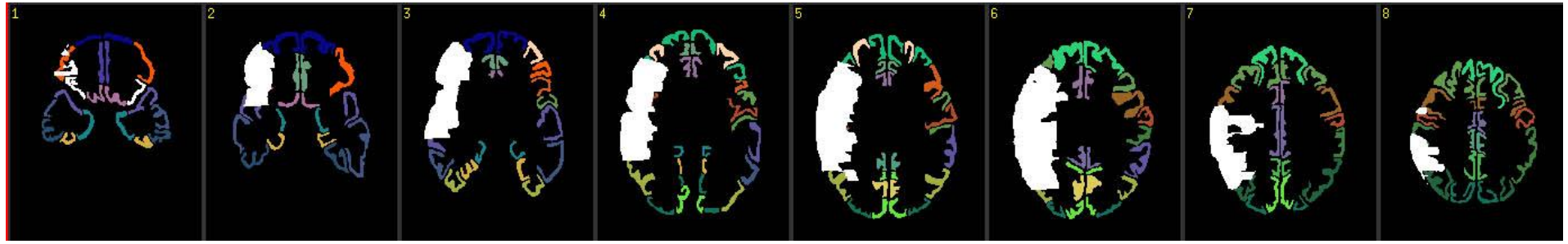

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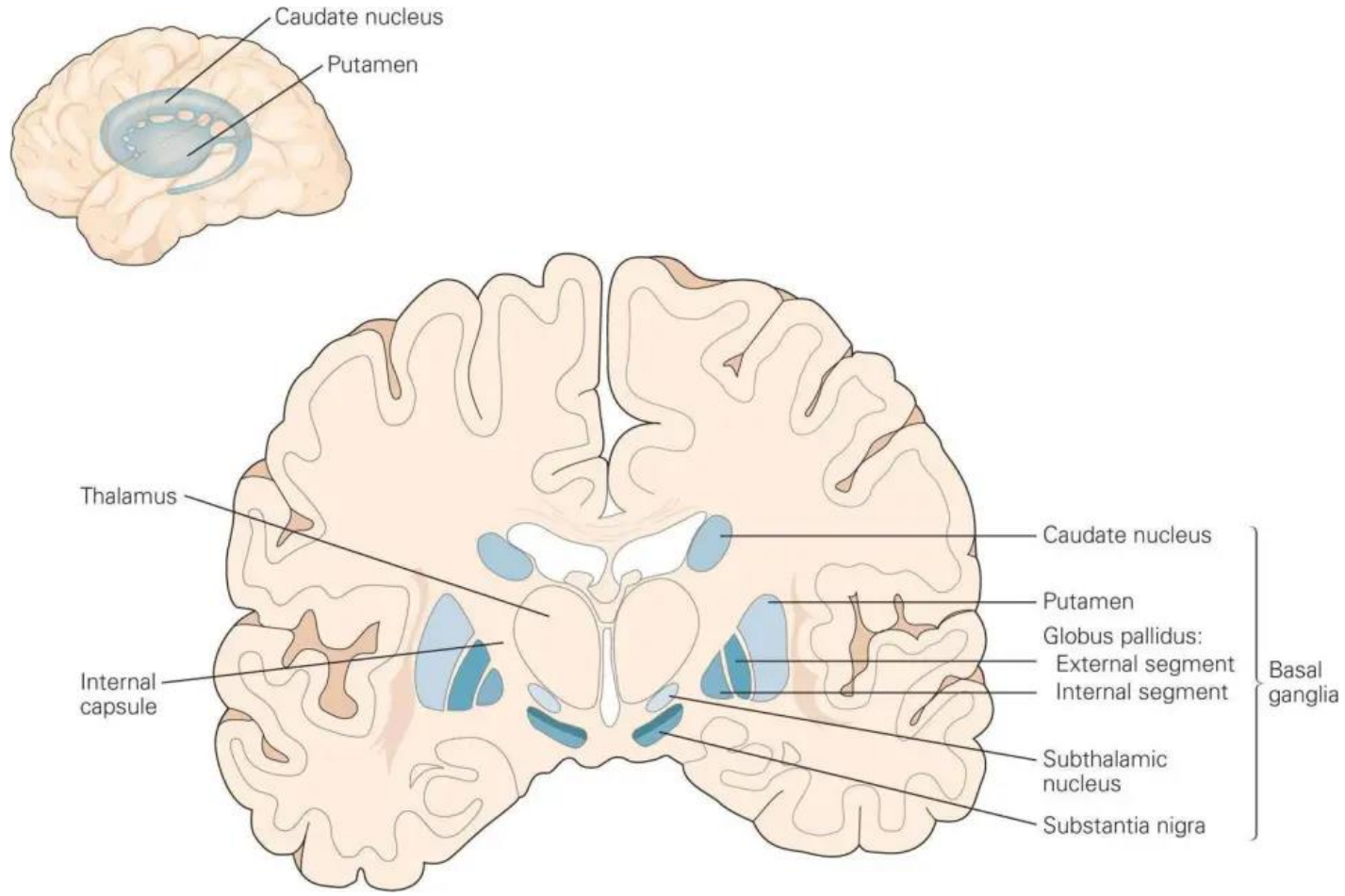
basal ganglia- functional neuroanatomy

- **subcortical structures**:
  - caudate nucleus
  - putamen
  - globus pallidus
  - subthalamic nucleus
  - substantia nigra /ventral tegmental area

- **Roles**:
  - to select between incompatible behaviors
  - to mediate reinforcement learning

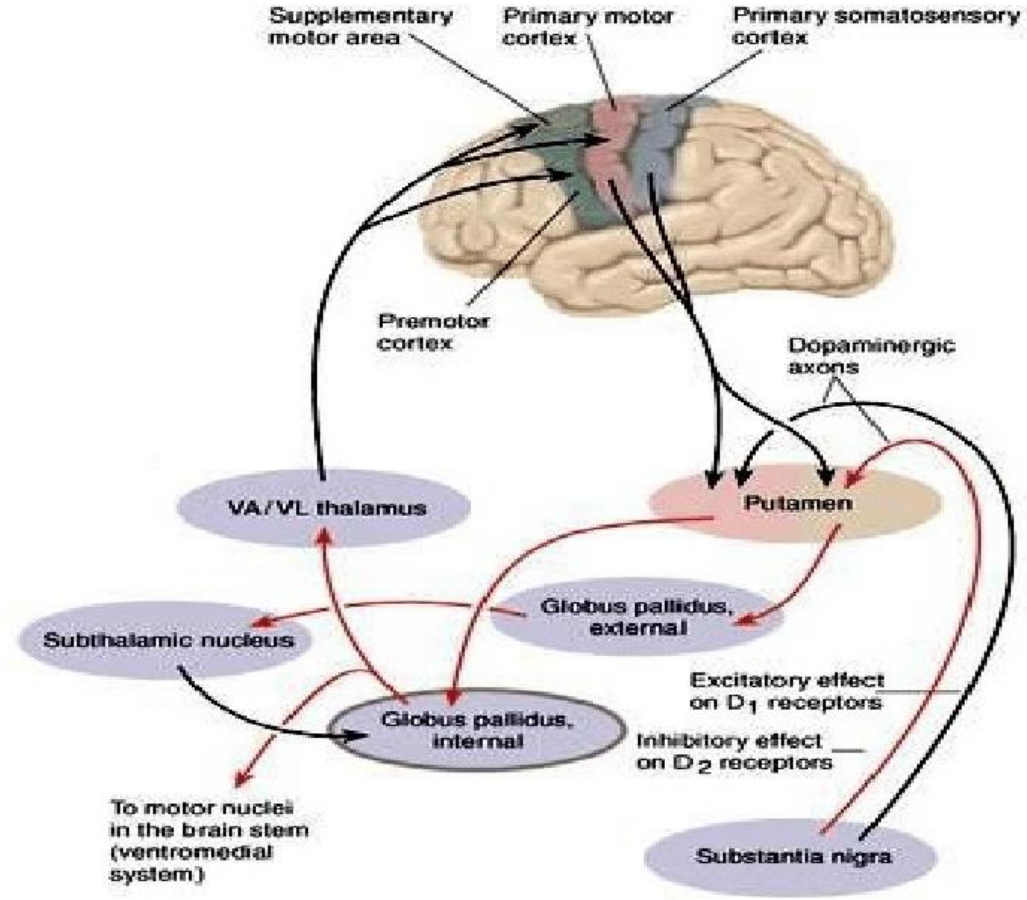


the basal ganglia network

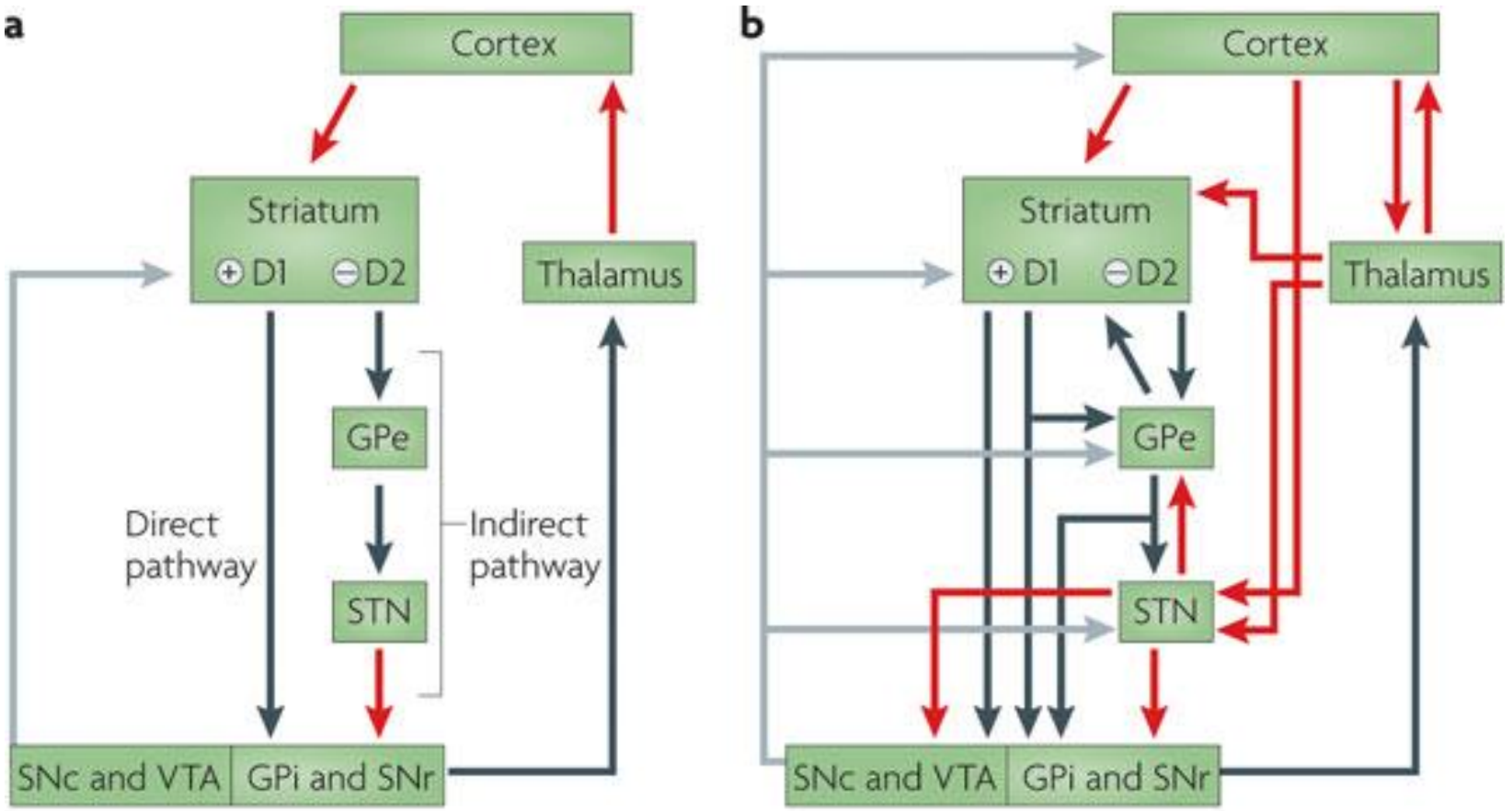
- 3 input nuclei:
  - striatum
  - sub-thalamic nucleus (STN)
  - substantia nigra pars compacta (SNpc)

- 2 output nuclei:
  - substantia nigra pars reticularis (SNpr)
  - internal part of globus pallidus (Gpi)

- one intrinsic nucleus:
  - external part of globus pallidus (Gpe)



The striatum receives excitatory corticostriatal and thalamic inputs. Outputs of the basal ganglia arise from the GPi and the SNr, which are directed to the thalamus, superior colliculus, and pedunculopontine nucleus (PPN). The striatum has two output pathways.



the direct pathway is formed by D1 dopamine receptor (Drd1a)-expressing medium spiny neurons (D1MSNs) that project to the GPi and SNr output nuclei. The indirect pathway originates from D2 receptor (Drd2)-expressing MSNs (D2-MSNs) that project only to the GPe, which together with the STN connects to the basal output nuclei. The direct and indirect pathways provide opponent regulation of the basal ganglia output interface

diseases of the basal ganglia may involve disorders of selection

- Parkinson disease
- Huntington disease
- Tourette syndrome
- OCD
- ADD
- Schizophrenia
- Many addictions

Parkinson’s disease

- 4 main characteristics of the disease:
- bradykinesia
- rigidity
- tremor
- gait & balance abnormalities

Parkinson's Disease Exam

- inspection:
  - ➢spontaneous movements reduced
  - ➢hands gestures while talking, usually reduced or absent
  - ➢resting tremor, usually affecting in the beginning one hand only

- examination: rapid alternating movements: as fast as possible and as big - 10 repetitions for each movement.
  - ➢finger tapping
  - ➢fist open close
  - ➢pronation/supination of the hand

MDS-Unified Parkinson's Disease Rating Scale (MDS-UPDRS)

- 4 sub-scales: covers mentation, behavior and mood. rates activities of daily living and clinician rating of the motor manifestations of PD
- Clinician motor hand manifestations:
  - bradykinesia
  - finger tapping
  - fist open close
  - pronation/supination of the hand
- rigidity - elbow and wrist
- Tremor
  - postural tremor
  - kinetic tremor : finger nose maneuver

finger tapping

- instructions to examiner: each hand is tested separately. instruct the patient to tap the index finger on the thumb 10 times as quickly AND as big as possible. rate each side separately, evaluating speed, amplitude, hesitations, halts, and decrementing amplitude.
- 0: Normal: No problems.
- 1: Slight: Any of the following: a) the regular rhythm is broken with one or two interruptions or
- hesitations of the tapping movement; b) slight slowing; c) the amplitude decrements
- near the end of the 10 taps.
- 2: Mild: Any of the following: a) 3 to 5 interruptions during tapping; b) mild slowing; c) the
- amplitude decrements midway in the 10-tap sequence.
- 3: Moderate: Any of the following: a) more than 5 interruptions during tapping or at least one
- longer arrest (freeze) in ongoing movement; b) moderate slowing; c) the amplitude
- decrements starting after the 1st tap.
- 4: Severe: Cannot or can only barely perform the task because of slowing, interruptions, or
- decrements.

anatomy of the Cerebellum

- 10% of the total brain volume but more than 50% of its neurons
- 3 functional areas:

➢ Vestibulocerebellum: vestibular and visual inputs

➢ Spinocerebellum: vermis+ parts of intermediate zone- Extensive inputs from spinal cord via the dorsal and ventral spinocerebellar tract

➢ Cerebrocerebellum: lateral hemispheres- connections to cerebral cortex

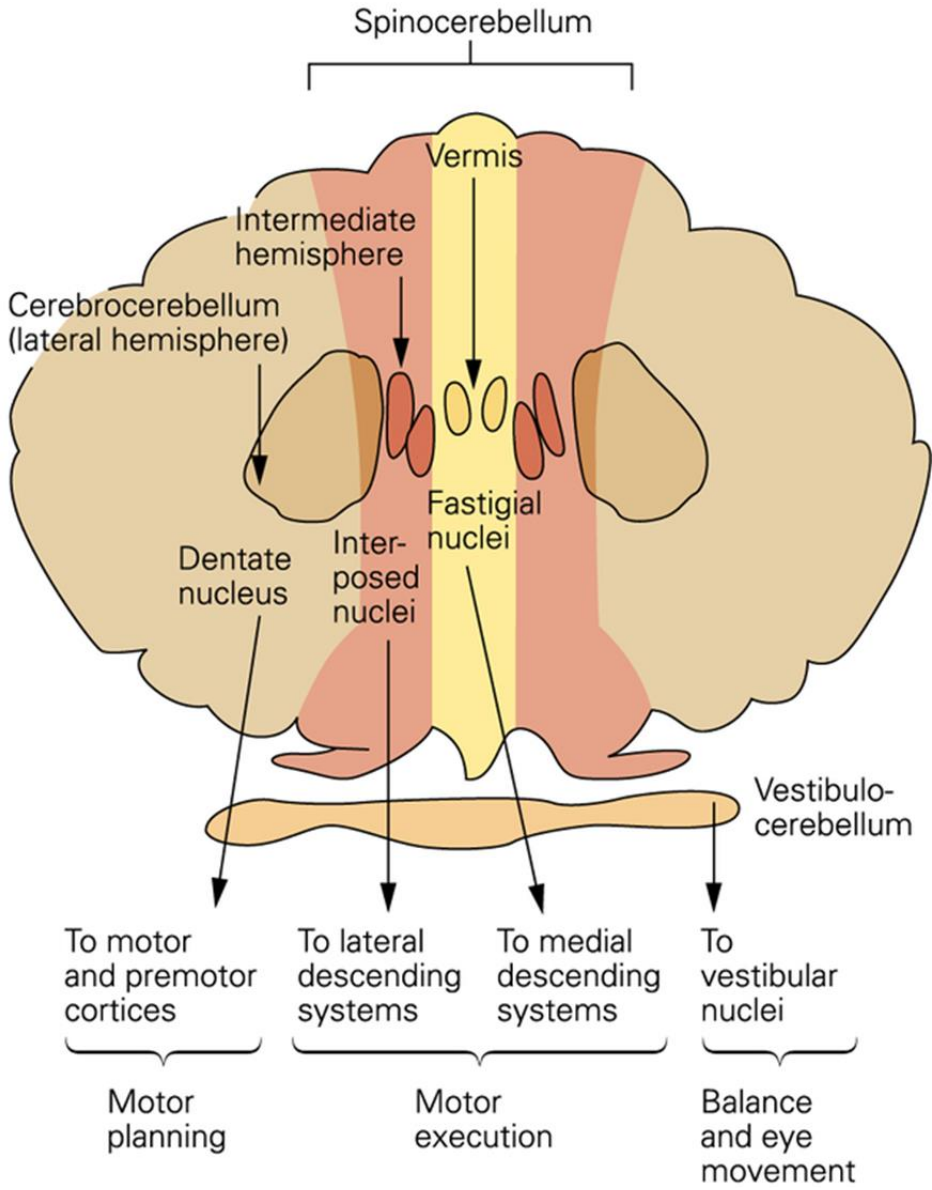
- 3 pairs of deep cerebellar nuclei : fastigial, interposed and dentate nuclei
- connected to the brainstem by 3 cerebellar peduncle on each side

➢ inferior cerebellar peduncle :inputs from spinal cord

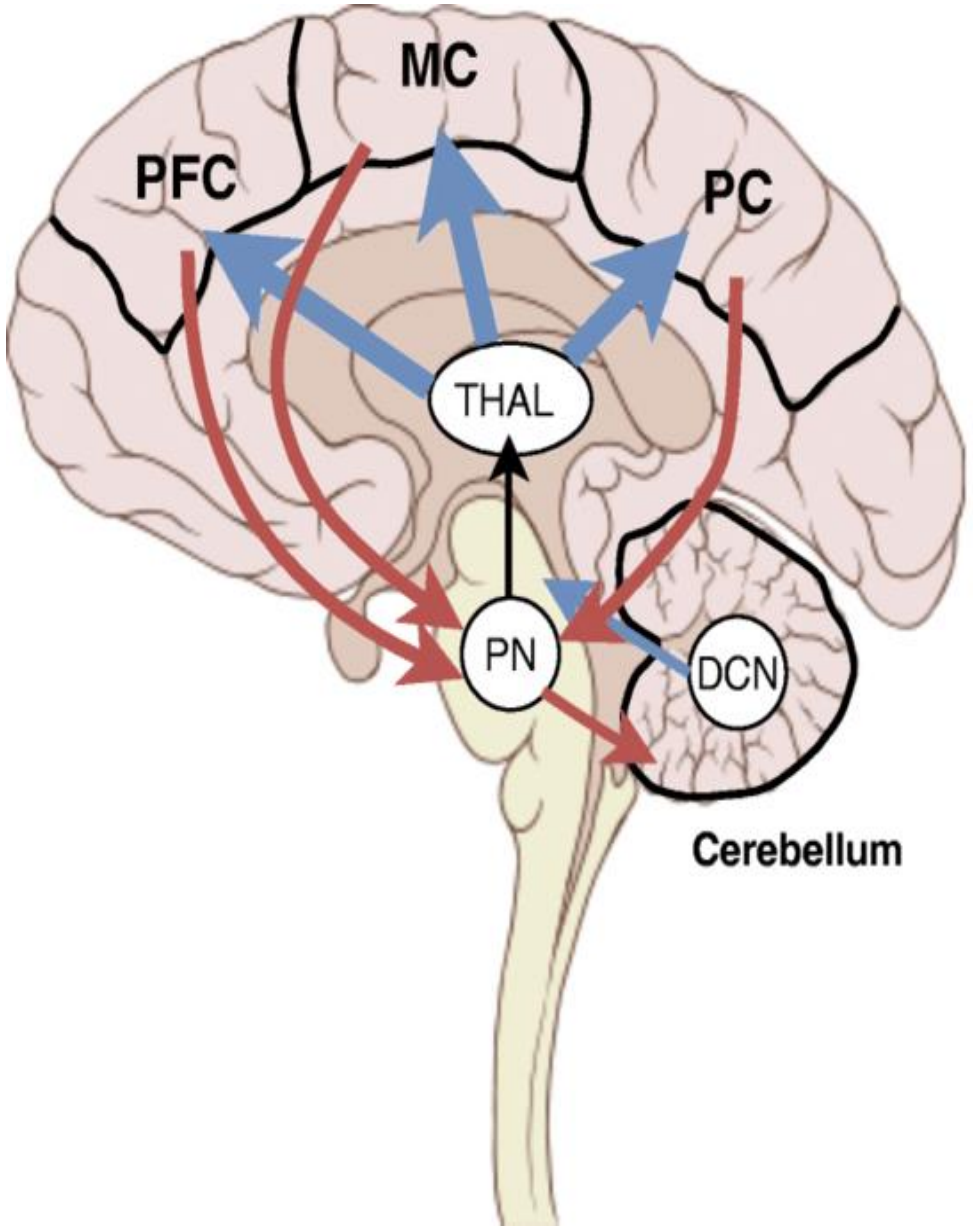
➢ middle cerebellar peduncle: inputs from cerebral cortex

➢ superior cerebellar peduncle : most of the efferents fibers

➢ Deep nuclei organized into somatotopic maps of limbs and joints



Cortex-cerebellum: reccurent loops

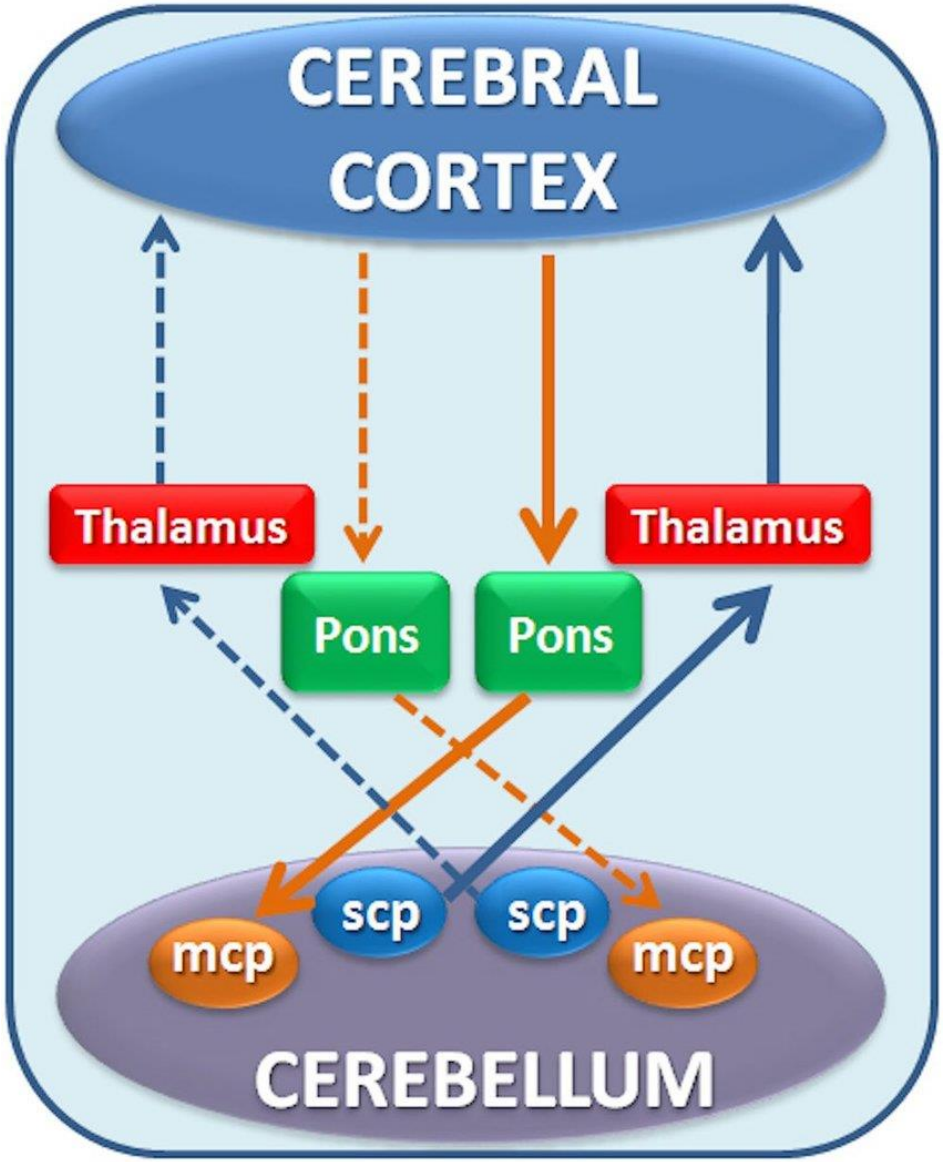


Key

DCN: Deep Cerebellar Nucleus
PN: Pontine Nucleus
THAL: Thalamus

Cerebellar efferents

Cerebellar afferents



clinical significance

- hypotonia
- ataxia
- intention tremor
- nystagmus
- dysarthria
- dysdiadochokinesia

scales for the clinical evaluation of cerebellar disorders

- ICARS: International cooperative Ataxia Rating Scale:
  - 100 points
  - 4 parts: limbs movements (52 points)

- SARA:Scale for the Assessment and Rating of Ataxia:
  - 40 points – 24 points for upper limbs movements
  - 8 items related to gait, stance, sitting, speech, finger-chase test, nose-finger test, fast alternating movements and heel-shin test.

- BARS: Brief Ataxia Rating Scale
  - 30 points – 8 points for upper limbs
  - 5 items: only finger nose for limb movement

the basal ganglia and the cerebellum

- 2 distinct subcortical systems with unique functional operations:

➢ BG: selection of movement program via inhibition of competiting programs

➢ Cerebellum: coordination and correction according to environmental changes

- The outputs of the basal ganglia and the cerebellum influence many of the same cortical areas but do so by projecting to distinct thalamic nuclei.
- thought to be independent and to communicate only at the level of the cerebral cortex.

- basal ganglia and the cerebellum are interconnected at the subcortical level:

➢ The **subthalamic nucleus** in the basal ganglia is the source of a dense disynaptic projection to the cerebellar cortex.

➢ Similarly, the **dentate nucleus** in the cerebellum is the source of a dense disynaptic projection to the striatum


Thank You