Control Movement and Posture

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How the Basal Ganglia and Cerebellum Work Together(One movement → one coordinated output)

BIG PICTURE (Before details)When you move (walk, dance, reach, speak):

Cerebral cortex = plans the movement

Basal ganglia = decides whether the movement should happen and how strongly

Cerebellum = makes the movement accurate, balanced, and smooth

Thalamus = the messenger that sends refined signals back to cortex
Spinal cord & brainstem = execute the movement

👉 Basal ganglia = selection & initiation👉 Cerebellum = timing, precision & error correction

They work in parallel, not in competition.

The IDEA OF MOVEMENT (Cortex)

A movement begins in the cerebral cortex:

Motor cortex → “I want to move”

Premotor / association cortex → “How should I move?”

Limbic cortex → “Do I want to move?” (motivation, emotion)

This cortical signal is sent at the same time to: Basal ganglia and Cerebellum

BASAL GANGLIA — “SHOULD WE DO THIS?”

Basal ganglia answer ONE main question:

Which movement should be allowed, and which should be suppressed?

They do NOT produce movement.

They select the correct movement.

The THREE Basal Ganglia Loops

1. Motor Loop (Movement execution)

Pathway: Copy code Motor cortex→ Putamen→ Gpi (Globus Pallidus internus) / SNr (Substantia Nigra pars reticulata) (MidBrain)→ Thalamus→ Motor cortex

Clinically relevant: Parkinson disease

Function: Facilitates desired movement Suppresses unwanted movements Makes movement smooth and efficient

Memory trick: Putamen = “put into motion”

2. Cognitive Loop (Planning & learning)

Pathway: Copy code Prefrontal cortex→ Caudate nucleus→ GPi / SNr→ Thalamus→ Prefrontal cortex

Function: Plans strategies Chooses the best motor plan Active during learning & practice

Memory trick: Caudate = cognitive

3. Limbic Loop (Motivation & reward)

Pathway: Copy code Limbic cortex→ Nucleus accumbens→ Ventral pallidum→ Thalamus→ Limbic cortex

Function: Motivation to move Emotional drive Reward after success

Key dopamine centers: ventral tegmental area (VTA) (midbrain) → reward dopamine Substantia nigra → motor dopamine

Clinically relevant: Damage ventral tegmental area (Depression and addiction)

Memory trick: Accumbens = reward

Result of Basal Ganglia Processing

✓ One clean motor plan is approved

✓ Competing movements are inhibited

✓ The cortex receives a refined “GO” signal

Cerebellar Functional Divisions (with pathways)

1. Vestibulocerebellum (Balance & posture)

Structures: Flocculonodular lobe and Vermis

Vestibular nuclei

Input: Vestibular system (inner ear) → Inferior cerebellar peduncle

Output: Vestibular nuclei Reticular formation → Vestibulospinal & reticulospinal tracts

Function: Head and eye position Trunk stability Balance while standing or dancing

Clinically related : Damage Flocculonodular lobe (Friederich's ataxia)

2. Spinocerebellum (Body & limb coordination)

Structures: Vermis (trunk)Intermediate hemisphere (limbs)Anterior lobe

Input (proprioception):Posterior spinocerebellar tract Muscle spindles Golgi tendon organs Joint receptors → Inferior cerebellar peduncle

Output: Anterior spinocerebellar tract Copy of motor command → Superior cerebellar peduncle

Function: Compares: Intended movement Actual movement Fixes errors instantly

Clinically relevant: Spinocerebellar ataxia

3. Cerebrocerebellum (Fine skilled movement)

Structures: Posterior lobe Dentate nucleus

Input: Copy code Cortex → Pons → Middle cerebellar peduncle

Output: Copy code Dentate nucleus→ Superior cerebellar peduncle→ Thalamus→ Motor cortex

Function: Precise hand movements Speech Dance coordination Timing and sequencing

Clinically related : Writing, Typing, Play music, using utensils, Buttoning a T shirt (Friedreich's ataxia, Spinocerebellar ataxia, Multiple system atrophy)

THALAMUS — “THE FINAL MESSENGER”

The thalamus: Receives output from :Basal ganglia Cerebellum Sends refined signals back to :Motor cortex Premotor cortex

Think of the thalamus as: The central relay that merges approval (BG) + precision (cerebellum)

Clinically Relevant: Thalamic stroke, Thalamic pain syndrome, thalamic aphasia

FINAL EXECUTION

(Spinal Cord) Motor cortex

sends commands: Corticospinal tract → limbs Brainstem nuclei → posture & tone

The result: ✓ Smooth✓ Balanced✓ Accurate✓ Purposeful movement