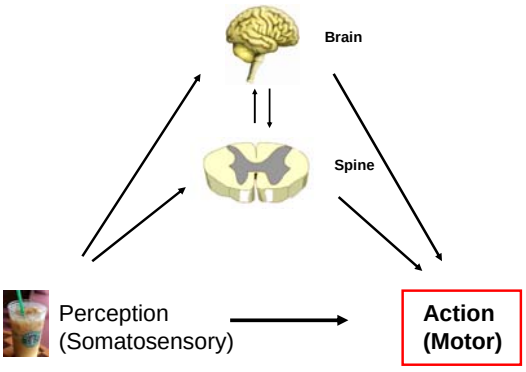
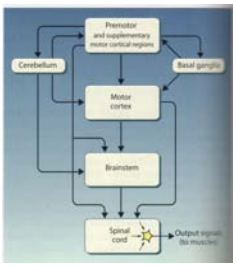
Motor Systems

The perception-action hierarchy



Motor Areas of the Brain

- **Subcortical and Cortical**
- **Hierarchical control**
  - Connection between areas with **multiple levels** of control
  - Higher levels: planning based on experiences and perceptions (lower level isolation leads to **simple reflex reactions**)

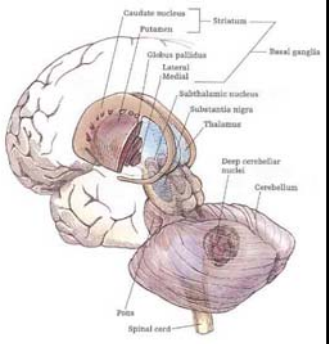


Motor areas of the brain

Subcortical

Cerebellum

Basal Ganglia



Motor areas of the brain

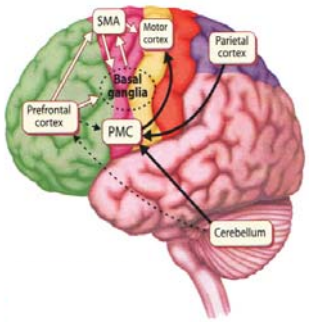
Cortical

Motor cortex

Premotor cortex

Parietal cortex

Supplementary motor area (SMA)

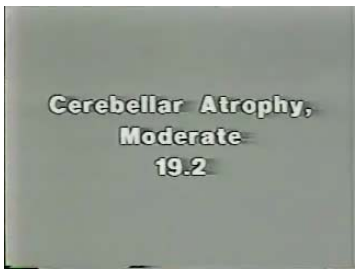


Subcortical Areas: Cerebellum

- 10% of brain mass, **more that 50% of neurons**
- Input from **primary & secondary motor cortex**
  - Motor feedback from vestibular and somatosensory systems
- Evaluates and corrects input for ongoing movements
- Major role in **motor learning**

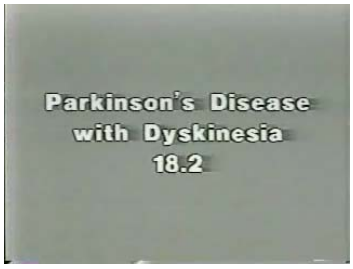
Damage to the cerebellum

- Trouble with rapid, ballistic movement sequences that require accurate aim and timing
  - e.g., tapping a rhythm, pointing to a moving object, typing, speaking, writing, playing a musical instrument
- Strength is preserved
  - e.g., grasping, lifting
- Difficulty in controlling the angle and distance of eye movements
  - executing saccades to particular location
- Symptoms resemble alcohol intoxication
  - clumsiness, slurred speech, inaccurate eye movements



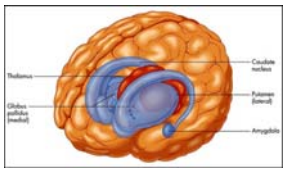
The finger-to-nose test

- Instructions:
  "*Hold one arm straight out and then, at a command, touch your nose*."
- Normally executed in 3 steps
  1. ballistic movement towards the nose
  2. hold (stop) finger just in front of nose
  3. slower movement to touch nose
- Diagnostic of cerebellar damage



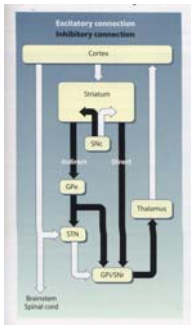
Subcortical: Basal Ganglia

- Consists of
  - **Putamen**
  - **Caudate nucleus**
  - **Globus pallidus (GP)**
  - **Substantia nigra**
  - **Subthalimic nuclei (SN)**
- Receives input from cortex and transmits back via **thalamus**
- Nuclei are not a single entity, but **interconnected network**



Basal Ganglia Pathways

- Striatum = **caudate + putamen**
- Two pathways: **Direct and Indirect**
- Direct pathway: **Increase** thalamic activity through direct inhibition of GPi
- Indirect pathway: can **increase** thalamic activation (through GPe) or **decrease** it (through STN)



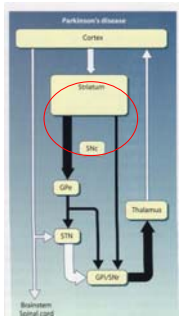
Parkinson's Disease

- Neurodegenerative disease
  - basal ganglia affected
  - gradual progressive death of neurons in substantia nigra
  - decreased dopamine release into the caudate and putamen
- Symptoms include
  - rigidity
  - muscle tremors
  - slow movements
  - difficulties initiating physical and mental activity

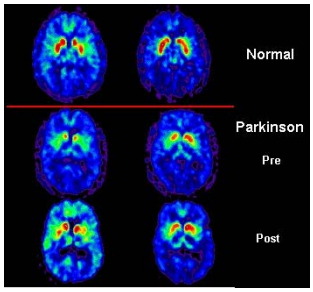
Parkinson's Disease

Effect of Parkinson's Disease

- **Loss of dopaminergic fibers** of substantia nigra (SNc)
- **Reduces inhibitory** activity along the direct pathway
- Increased **inhibition from the globus pallidus** (GPi/SNr) **to the thalamus**
- **Decrease in cortical activation** and movement



Pathology and treatment



- Treatment with L-Dopa, **a precursor** to dopamine (can cross the blood-brain barrier)

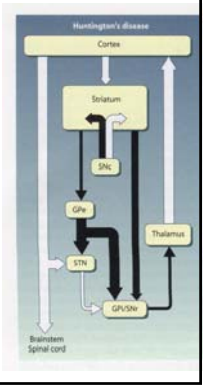
L-Dopa
- does not prevent loss of neurons
- produces side effects, including restlessness, sleep problems, delusions

Huntington's Disease

- Progressive degenerative disorder
- Clumsiness, balance problems and general restlessness (onset)
- Involuntary movements (**chorea**) gradually take over normal motor function
  - Contorted positions
- Patients develop **apraxia, aphasia or agnosia**

Effects of Huntington's Disease

- **Atrophy**: cell death
  - Basal ganglia: as high as 90% in striatum
- Atrophy leads to pathway changes in striatum
  - Affects **inhibitory neurons** of indirect pathway
  - Leads to **reduced output** from basal ganglia -> **excessive excitation** of thalamus -> uncontrollable movements



Changing view on Basal Ganglia and Cerebellum

- **Traditional view:** Both areas involved in motor control and motor learning
- **Emerging view:** Both areas are involved in motor and non-motor control functions (i.e. cognitive functions)