Basal Ganglia

Psychology 372
Physiological Psychology
Steven E. Meier, Ph.D.

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Basal Ganglia

• Does not have direct input or output to the spinal cord
• Receives information from the cortex
• Sends output to
  • Brain stem via the thalamus
  • Cortex

Past

• Had specific systems involved with movement
• Pyramidal
• Extrapyramidal
• Corticospinal
• Other structures including BG

Today

• Many more parts are involved
• Movement problems can also occur with problems in the
  • Brain stem
  • Red Nucleus
  • Cerebellum

Consists of Four Principal Nuclei

• Striatum
• Globus Pallidus (Pallidum)
• Substantia Nigra
• Subthalamic Nucleus

Striatum

• Has three important subdivisions
  • Caudate Nucleus
  • Putamen
  • Ventral Striatum (Includes Nucleus Accumbens)
• Mostly divided by the internal capsule
  • Are fibers that go from the cortex to the thalamus in both directions.
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Striatum

- Receives most of the fibers from the
  - Cortex
  - Thalamus
  - Brain Stem Structures
- Sends fibers to
  - Globus Pallidus
  - Substantia Nigra

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Striatum

- All areas of the cortex send excitatory (glutaminergic) fibers to the striatum.
- Also gets dopaminergic projections from the midbrain
- Finally gets serotonergic input from the Raphe Nuclei
- Contains mostly GABA neurons
- Has two separate parts (called patches)
  - Matrix
  - Striosome
- Both are separate and have different types of receptors

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Globus Pallidus (Pallidum)

- Lies medial to the Putamen
- Has two segments
  - External
  - Internal
- Use GABA as a NT.

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Substantia Nigra

- Lies in the midbrain on medial side of the internal capsule
- Has a compact zone (pars compacta)
  - Is a distinct nucleus
  - Contains
    - Many Dopamine neurons
    - Oxidized pigment from Dopamine
    - Neuromelanin (makes the structure dark)
    - Increases with age

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Subthalamic Nucleus

- Lies below the thalamus
- Lies above the substantia nigra
- Is closely connected to
  - Parts of the Globus Pallidus
  - Substantia Nigra
- Uses glutaminergic neurons
  - Are the only excitatory neurons in BG.
  - All others are inhibitory
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**Subthalamic Nucleus**
- **Input to the basal ganglia** is from the
  - Primary motor cortex
  - Substantia Nigra
- **Output of the basal ganglia** is to
  - Primary motor cortex
  - Supplemental motor area
  - Premotor area
  - Brainstem motor nuclei (ventromedial pathways)
- **Cortical Basal Ganglia Loop**
  - Frontal, parietal, temporal cortex send axons to caudate/putamen
  - Caudate/putamen sends axons to the globus pallidus
  - Globus pallidus sends information to the motor cortex via thalamic nuclei

**Functions**
- Past - Only motor related functions
- Today
  - Motor
  - Cognitive
  - Emotional
  - Motivated behavior

**Output from the BG**
- Output is very important
- Output neurons discharge at high frequency
- **Structures**
  - Internal Pallidal Segment
  - Pars Reticulata of Substantia Nigra
  - Both tonically inhibit target nuclei in the thalamus and Brain Stem
- Modulated by two parallel pathways
  - Indirect Pathway
  - Direct

**Indirect**
- Is purely Gabainergic
  - Goes first to external Pallidal Segment
  - Then goes to subthalamic nucleus
  - Finally goes to output nuclei in subthalamic nucleus
  - Contains excitatory glutaminergic neurons

**Direct**
- Striatum to Pallidum
- When activated shuts down the tonically active neurons
- Permits the thalamus and cortex to be activated

**Comparisons**
- Direct
  - Provides positive feedback
  - Activation disinhibits the Thalamus
  - Increases thalamus/cortical activity
  - Facilitates movement
- Indirect
  - Provides negative feedback
  - Activation inhibits the thalamus
  - Has opposing effect
  - Shuts down movement
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Dopamine
- Is very important
- Direct are D1 receptors are excitatory
- Indirect are D2 receptors are inhibitory
- Synaptic actions are different
  - Both decrease inhibition of thalamocortical neurons
  - Thus both facilitate movement
- Decrease dopamine in the striatum
  - Activity increases output nuclei increases
  - Output nuclei then inhibit thalamocortical neurons
  - Movement decreases

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Disorders
- Many different types
- Parkinson’s syndrome/disease
- Huntington’s Disease
- Most involve some sort of motor functioning problem.