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Basal Ganglia

M1 – CNS Sequence
Peter Hitchcock, Ph.D.
The topic of today’s lecture is the basal ganglia.

I. Fundamental concepts of basal ganglia structure and function.
II. Nuclei of the basal ganglia
III. Axonal connections of the basal ganglia.
   a. afferent connections
   b. intrinsic connections
   c. efferent connections
   d. direct and indirect pathways
IV. Neurotransmitters of the basal ganglia
V. Diseases of the basal ganglia
VI. Models of anatomy and function of basal ganglia
The basal ganglia: organizing principles.

1) The basal ganglia is a collection of interconnected subcortical nuclei that functions as a central link in the part of the motor system that translates the desire to move (mentation) into action.

2) The basal ganglia integrates representations of sensory inputs, motor programs and ‘internal states’ and selects the appropriate, context-dependent learned behavior.

3) The basal ganglia are involved in higher order movements, particularly those with a cognitive component and damage to or disorders of the basal ganglia result in disruption of movements and may also cause significant deficits in other neural function such as cognition, perception and mentation.

4) The basal ganglia do not make direct or indirect connections with the motor neurons in the spinal cord or brainstem; rather it regulates the output of the cerebral cortex.

5) The basal ganglia contains 4 parallel, anatomically separate loops that originate in cortex, pass through the basal ganglia and project back to cortex via the dorsal thalamus. Each loop corresponds to a particular behaviorally relevant movement. The four loops are:
   - somatic motor loop: somatomotor control of voluntary movements
   - oculomotor loop: control of eye movements
   - frontal loop: cognitive functions
   - limbic loop: emotional and visceral functions
The basal ganglia: organizing principles, cont'd.

6) The basal ganglia receive inputs from all of the cerebral cortex and may be involved in all cortical functions.

7) The basal ganglia function primarily through disinhibition (release from inhibition) of thalamocortical circuits.

8) Diseases of the basal ganglia can be described as disruptions of the neurotransmitter interactions between components of the basal ganglia.

This lecture will deal only with the somatic-motor loop (motor channel) of the basal ganglia that is involved in regulating voluntary, somatic movements.
The neostriatum is the primary afferent-receiving structure of the basal ganglia.
ventral striatum: olfactory tubercle, nuc. accumbens

caudate
putamen

ventral globus pallidus: substantia inominata

internal capsule

globus pallidus
dorsal thalamus

putamen

subththalamic nuc.
amygdala
substantia nigra
-pars compacta
-pars reticulata
caudate
putamen
globus pallidus
internal capsule
-posterior limb
dorsal thalamus
This schematic diagram illustrates the nuclei of the basal ganglia and the three components of the major anatomical connections: afferent connections, intrinsic connections, efferent connections.
PD results from the degeneration of neurons in the substantia nigra

HD results from the degeneration of neurons in the neostriatum
Function of indirect and direct pathways in the BG

DIRECT LOOP
(INCREASES THALAMOCORTICAL EXCITATION)

Cortex → Striatum → GPI/SNr → Thalamus

(D1 RECEPTORS)
DA

NIGROSTRIATAL SYSTEM
(INHIBITS THE INDIRECT LOOP)

Cortex → Striatum → GPe → STN → GPI/SNr → Thalamus

(D2 RECEPTORS)
DA

INDIRECT LOOP
(DECREASES THALAMOCORTICAL EXCITATION)
Summary diagrams of the control circuits of the motor system.

A: basal ganglia
B: cerebellum
Blood supply to the basal ganglia

branches of anterior and middle cerebral artery
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