Neurons for the SLP: How our Nervous System Communicates

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Outline

• Review of the Basal Ganglia
• Neuroanatomy Review
  • Nervous System
  • Neurons
• Neuronal Communication at the Cellular Level
• Neuronal Communication at the System Level
  • Motor System
• Clinical Application: Basal Ganglia
Learning Objectives

• Describe how neuronal anatomy relates to brain structures, including:
  • Gray and White Matter
  • Cortical and Subcortical

• Identify the parts and functions of a neuron

• Explain how neurons communicate at the cellular and system level
What word comes to mind when you hear *Basal Ganglia*?
Basal Ganglia

Movement, Mood, Emotions, Learning, and Cognition

Basal Ganglia

- Caudate Nucleus
- Putamen
- Globus Pallidus

Movement, Mood, Emotions, Learning, and Cognition

- Thalamus
- Internal capsule
- Globus Pallidus (ext. segment)
- Globus Pallidus (int. segment)
- Caudate nucleus (body)
- Caudate nucleus (tail)
- Substantia nigra
- Red nucleus
- Cerebral peduncle
Basal Ganglia – Motor Function

Initiating and Maintaining Smooth Movement

**Parkinson’s Disease**
- Hypokinetic Dysarthria
- Resting tremor
- Akinesia: impairment in the initiation of movement
- Bradykinesia: reduction in the velocity & amplitude of movement

**Huntington’s Disease**
- Hyperkinetic Dysarthria
- Ballismus: uncontrolled flinging (ballistic) movements
- Choreiform movements: generalized irregular dance-like movements of the limbs
- Athetoid movements: continuous writhing of the distal portions of the extremities
Anatomy Review
Central and Peripheral Nervous System

• Central Nervous System
  • Brain
  • Cerebellum
  • Brainstem
  • Spinal Cord

• Peripheral Nervous System
  • Connects the body (skin, muscles) to the Brain and Spinal Cord
  • Cranial Nerves!
Gray Matter vs. White Matter in the Brain

Coronal View

Sagittal View

Axial View
Gray vs. White Matter in the Spinal Cord

- Gray Matter
- White Matter
- NOTE: White Matter is Stained black

Dorsal (toward the back)

Ventral (toward the belly)
Parts of a Neuron

- **Cell body**
- **Dendrites**
- **Nucleus**
- **Myelin**
- **Axon**
- **Axon Terminal**
- **Synaptic Buttons**

Neurons can be up to 3 ft long!

There are 2 neurons between your brain and a muscle!
Let’s make a connection!

- **Grey Matter** = comprised of neuronal cell bodies
- **White Matter** = comprised of neuronal cell axons

- The cortex is the outermost layer of the brain, made up of cell bodies.
- The subcortical region of the brain has both.
  - White Matter = Tracts
  - Gray Matter = Nuclei (*usually*)
    - Nuclei = typically, clusters of cell bodies in the CNS
    - Ganglia = typically, clusters of cell bodies in the PNS
Neuronal Communication - Cellular Level
**Cell Body**

**Dendrites** = contain receptors that can bind Neurotransmitters

**Nucleus** = contains DNA

**Axon**

**Axon** = conducts electrical message (action potential)

**Myelin** = speeds up conduction of the action potential

**Axon Terminal** = contains proteins important for creating and packaging neurotransmitters

**Synaptic Buttons** = binds synaptic vesicles for release of Neurotransmitters
Neuronal Communication: The Synapse

Presynaptic Neuron

Postsynaptic Neuron

Direction of Communication
What is a Neurotransmitter?

Definition
• Molecules that are:
  • Synthesized within a neuron
  • Packaged w/in vesicles
  • Released from axon
  • Activate Receptors
  • Removed or Recycled

Examples
• Dopamine
• Serotonin
• Acetylcholine
• Glutamate = excitatory
• GABA = inhibitory
Types of Receptors

**Channel**

Neurotransmitter binds directly to channel protein and mediates the flow of ions across the membrane for a brief time.

**G-Protein Coupled Receptor**

Neurotransmitter binds to G protein-coupled receptor and activates a second messenger system – mediating the opening of ion channels for a longer period of time.
Neuronal Communication: The Action Potential

What happens in a Synapse?

Direction of Action Potential

Presynaptic Neuron

Postsynaptic Neuron

Depolarization

Repolarization

Resting potential

Membrane potential (mV)

Time (ms)

Threshold
Neuronal Communication: The Action Potential

- Intracellular space is Negative at rest
- NTs can have an excitatory or inhibitory effect
  - Action Potential = excitatory effect
The Role of Myelin

• Myelin is created by other cells
  • CNS: Oligodendrocytes
  • PNS: Schwann Cells

• Myelin creates saltatory conduction

• This speeds up the neural signal
Neuronal Communication - System Level
Messaging in the Motor System

- **Primary Motor Cortex**
  - Voluntary Movement (Force, extent, direction, speed)

- **Supplementary and Pre- Motor Area**
  - Motor planning of complex sequences

- **Primary Sensory Cortex**
  - Provides sensory/proprioceptive feedback for movement
Motor Neurons

• **Upper motor neurons (UMN)** = cell bodies located in the brain and synapse with a lower motor neuron
  • Fully located in the CNS
  • Damage = spasticity, hypertonia

• **Lower motor neurons (LMN)** = cell body located in the spinal cord, synapses onto the muscle
  • Directly responsible for stimulating the target muscle
  • Cell bodies in the CNS, but axons in the PNS
  • Damage = Flaccidity, hypotonia
Motor Pathways

- Corticospinal Tract (2 segments)
  - Innervates our Trunk and Limbs
  - Pathway: Primary Motor Cortex $\rightarrow$ corona radiata $\rightarrow$ internal capsule $\rightarrow$ brainstem (crosses in medulla) $\rightarrow$ ventro/lateral spinal cord
Motor Pathways

• Corticospinal Tract (2 segments)
  • Pathway: Primary Motor Cortex → corona radiata → internal capsule → brainstem (crosses in medulla) → ventro/lateral spinal cord
  • **Lateral Tract**: contralateral limb movements
  • **Ventral Tract**: bilateral innervation for trunk and neck
Motor Pathways

- **Corticobulbar Tract**
  - Innervate Face & Neck
  - Pathway: Primary Motor Cortex $\rightarrow$ corona radiata $\rightarrow$ internal capsule $\rightarrow$ cranial nerves in midbrain, pons, and medulla $\rightarrow$ Head and Neck

- Both receive input from the Corticostriatal pathway (Basal Ganglia!)
Clinical Application: Basal Ganglia Disorders
· **D1** - **DIRECT pathway:** INCREASE activity to the thalamus & EXCITATION of the cerebral cortex.

· **D2** - **INDIRECT pathway:** DECREASE activity of thalamus & DECREASE activity of the cerebral cortex.
Basal Ganglia

Corticostriatal Tract

Basal Ganglia (Caudate/Putamen)

Cerebral Cortex

D1 - DIRECT pathway: INCREASE activity to the thalamus & EXCITATION of the cerebral cortex.

Damage = hypokinesia

Globus Pallidus

Thalamus

Brainstem

Spinal Cord
Basal Ganglia

- **Basal Ganglia** (Caudate/Putamen) D1 D2
- **Thalamus**
- **Globus Pallidus**
- **Cerebral Cortex**

**Corticostriatal Tract**

**Brainstem**

**Spinal Cord**

- **D2 - INDIRECT pathway:**
  - DECREASE activity of thalamus & DECREASE activity of the cerebral cortex.

- **Damage = hyperkinesia**
Pharmacological Treatments Target Dopamine Levels

Treatment for Parkinson’s
• Levodopa (L-Dopa)
  • Enzyme converts it into dopamine
• Carbidopa
  • Prevents L-Dopa from being broken down before it reaches the brain

Treatment for Huntington’s
• Xenazine (tetrabenazine)
  • Prevents uptake into synaptic vesicles
  • Leads to depletion of dopamine in the neuron
Thank you for listening! Questions?