LESSON THREE: Introduction to the Anatomy, Physiology, and Pathology of the Central and Peripheral Nervous Systems

Course: English for Speech and Language Pathology III
Program: Third-Year Bachelor's in Speech and Language Pathology (Orthophonia)
Duration: 90 minutes

Learning Outcomes

By the end of this lecture, students will be able to:

1. Describe the organization of the human nervous system.
2. Distinguish between the Central Nervous System (CNS) and the Peripheral Nervous System (PNS).
3. Identify the major anatomical structures of the brain and spinal cord.
4. Explain the physiological functions of the nervous system in speech, language, hearing, swallowing, and cognition.
5. Recognize common neurological disorders that affect communication.
6. Use appropriate English anatomical and neurological terminology.
7. Apply basic neuroanatomical knowledge to Speech and Language Pathology practice.

Lecture Outline

1. Introduction
2. Overview of the Nervous System
3. Anatomy of the Central Nervous System (CNS)
4. Anatomy of the Peripheral Nervous System (PNS)
5. Physiology of the Nervous System
6. Cranial Nerves Related to Speech and Swallowing
7. Common Neurological Disorders
8. Clinical Applications in Speech and Language Pathology
9. Essential Vocabulary
10. Practical Activities
11. Summary
12. Review Questions

1. Introduction

The nervous system is the body's communication and control network. It receives sensory information, processes it, and coordinates responses that allow humans to think, move, speak, hear, understand language, and swallow.

Speech-language pathologists work with individuals whose communication disorders are often caused by neurological diseases or injuries. Therefore, understanding the anatomy and physiology of the nervous system is essential for accurate assessment and effective intervention.

2. Overview of the Nervous System

The nervous system is divided into two major components:

A. Central Nervous System (CNS)

The CNS consists of:

- Brain
- Spinal cord

Primary functions

- Receives sensory information
- Processes information
- Controls movement
- Regulates speech and language
- Supports memory, learning, and cognition

B. Peripheral Nervous System (PNS)

The PNS consists of all nerves outside the brain and spinal cord.

It includes:

- Cranial nerves
- Spinal nerves
- Peripheral sensory nerves
- Peripheral motor nerves

The PNS connects the CNS to the rest of the body.

3. Anatomy of the Central Nervous System

A. The Brain

The brain is the body's control center.

It is composed of several major structures.

1. Cerebrum

The cerebrum is the largest part of the brain.

It is divided into two cerebral hemispheres.

Functions include:

- Speech
- Language
- Memory
- Intelligence
- Learning
- Voluntary movement
- Sensory perception

Cerebral Lobes

Frontal Lobe

Functions:

- Voluntary motor control
- Speech production
- Planning
- Problem solving
- Personality

Clinical importance

Contains **Broca's area**, which is responsible for speech production.

Parietal Lobe

Functions:

- Somatosensory perception
- Spatial awareness
- Integration of sensory information

Temporal Lobe

Functions:

- Hearing
- Language comprehension
- Memory

Clinical importance

Contains **Wernicke's area**, which is responsible for language comprehension.

Occipital Lobe

Functions:

- Vision
- Visual processing

B. Cerebellum

Functions:

- Balance
- Coordination
- Precision of movement
- Motor learning

Clinical importance:

Damage may lead to **ataxic dysarthria**.

C. Brainstem

The brainstem consists of:

- Midbrain
- Pons
- Medulla oblongata

Functions:

- Breathing
- Heart rate regulation
- Swallowing
- Reflexes
- Cranial nerve functions

Damage to the brainstem can result in severe speech and swallowing disorders.

D. Spinal Cord

The spinal cord connects the brain with the peripheral nerves.

Functions:

- Conducts nerve impulses
- Coordinates spinal reflexes
- Controls voluntary movement

4. Anatomy of the Peripheral Nervous System

The PNS is divided into:

A. Somatic Nervous System

Controls voluntary skeletal muscle movements.

Examples:

- Tongue movement
- Lip movement
- Jaw movement

B. Autonomic Nervous System

Controls involuntary body functions.

It includes:

Sympathetic Division

- Increases heart rate
- Prepares the body for stress ("fight or flight")

Parasympathetic Division

- Conserves energy
- Promotes digestion and recovery ("rest and digest")

5. Physiology of the Nervous System

The nervous system communicates through specialized cells called **neurons**.

Structure of a Neuron

- Cell body (soma)
- Dendrites
- Axon
- Myelin sheath
- Synapse

Neural Communication

1. A stimulus activates a sensory receptor.
2. Electrical impulses travel along neurons.
3. Information reaches the brain.
4. The brain processes the information.

5. Motor commands are sent to muscles.
6. Speech or movement occurs.

6. Common Neurological Disorders

Stroke (Cerebrovascular Accident)

Interruption of blood flow to the brain.

Possible communication disorders:

- Aphasia
- Dysarthria
- Apraxia of speech
- Dysphagia

Traumatic Brain Injury (TBI)

Damage caused by external force.

Possible consequences:

- Cognitive deficits
- Language impairment
- Memory problems
- Speech disorders

Parkinson's Disease

Progressive neurodegenerative disorder.

Communication characteristics:

- Reduced vocal loudness
- Monotone speech
- Imprecise articulation
- Reduced facial expression

Multiple Sclerosis

Autoimmune disease affecting myelin.

Communication effects:

- Dysarthria
- Fatigue
- Cognitive difficulties

Amyotrophic Lateral Sclerosis (ALS)

Progressive degeneration of motor neurons.

Communication effects:

- Severe dysarthria
- Dysphagia
- Loss of speech in advanced stages

Cerebral Palsy

Non-progressive neurological disorder caused by early brain injury.

Speech characteristics:

- Dysarthria
- Delayed language development
- Feeding difficulties

Brain Tumors

Depending on location, tumors may affect:

- Speech
- Language
- Swallowing
- Cognition

7. Clinical Applications in Speech and Language Pathology

Knowledge of neuroanatomy helps speech-language pathologists:

- Identify neurological communication disorders.
- Interpret neuroimaging reports.
- Select appropriate assessment tools.
- Develop individualized intervention plans.
- Collaborate with neurologists, neurosurgeons, and rehabilitation teams.

Clinical Example

A patient has difficulty producing fluent speech but understands spoken language.

Likely diagnosis:

Broca's aphasia

Probable lesion:

Left frontal lobe (Broca's area)

8. Essential Vocabulary

English Term	Definition
Central Nervous System (CNS)	Brain and spinal cord
Peripheral Nervous System (PNS)	Nerves outside the CNS
Neuron	Functional cell of the nervous system
Synapse	Junction between neurons
Cerebrum	Largest part of the brain
Cerebellum	Coordinates movement and balance
Brainstem	Connects the brain with the spinal cord
Spinal Cord	Main pathway for nerve impulses
Cranial Nerve	Nerve emerging directly from the brain
Motor Neuron	Carries impulses to muscles
Sensory Neuron	Carries information to the CNS
Aphasia	Language disorder caused by brain damage
Dysarthria	Motor speech disorder
Apraxia of Speech	Disorder of motor planning for speech
Dysphagia	Swallowing disorder
Neuroplasticity	The nervous system's ability to reorganize and adapt after injury

9. Practical Activities

Activity 1 – Match the Structure with Its Function

Structure **Function**

Cerebellum _____

Frontal lobe _____

Temporal lobe _____

Brainstem _____

Hypoglossal nerve _____

Activity 2 – Multiple Choice

1. Which part of the brain is primarily responsible for speech production?

a) Occipital lobe

b) Temporal lobe

c) Frontal lobe

d) Cerebellum

2. Which cranial nerve is responsible for hearing?

a) V

b) VII

c) VIII

d) XII

3. Which nervous system controls voluntary movement?

a) Autonomic

b) Somatic

c) Sympathetic

d) Parasympathetic

Activity 3 – Fill in the Blanks

Use the following words:

- cerebellum
- neuron
- vagus
- spinal cord
- cerebrum

1. The _____ is the largest part of the brain.
2. A _____ is the functional unit of the nervous system.
3. The _____ nerve plays an essential role in voice and swallowing.
4. The _____ transmits information between the brain and the body.
5. The _____ coordinates balance and motor control.

Activity 4 – Case Study

A 70-year-old man suddenly develops right-sided weakness and difficulty speaking. He understands spoken language but produces short, effortful sentences.

Questions

1. What neurological condition is most likely?
2. Which communication disorder is suggested?
3. Which brain region is most likely affected?
4. Which healthcare professionals should be involved in his rehabilitation?

Summary

The nervous system is the foundation of human communication, coordinating speech, language, hearing, swallowing, cognition, and motor control. The Central Nervous System processes information, while the Peripheral Nervous System connects the brain and spinal cord to muscles and sensory organs. Knowledge of neuroanatomy and neurophysiology enables speech-language pathologists to understand the neurological basis of communication disorders, interpret clinical findings, and design effective rehabilitation programs for individuals with neurological conditions.

Review Questions

1. Define the Central Nervous System (CNS).
2. Define the Peripheral Nervous System (PNS).
3. Name the four lobes of the cerebrum and describe one function of each.
4. What is the role of the cerebellum?
5. What are the primary functions of the brainstem?
6. Describe the structure of a neuron.
7. Explain how nerve impulses travel through the nervous system.
8. Name four cranial nerves involved in speech and swallowing.
9. What is the function of the vagus nerve?
10. Distinguish between the somatic and autonomic nervous systems.
11. Describe the communication disorders commonly associated with stroke.
12. How does Parkinson's disease affect speech?
13. What is neuroplasticity, and why is it important in rehabilitation?
14. Explain the relationship between Broca's area and speech production.
15. Why is knowledge of neuroanatomy essential for speech-language pathologists?

Recommended Reading

1. Seikel, J. A., King, D. W., & Drumright, D. G. (2023). *Anatomy and Physiology for Speech, Language, and Hearing* (6th ed.). Cengage Learning.
2. Brookshire, R. H., & McNeil, M. R. (2022). *Introduction to Neurogenic Communication Disorders* (9th ed.). Elsevier.
3. Duffy, J. R. (2020). *Motor Speech Disorders: Substrates, Differential Diagnosis, and Management* (4th ed.). Elsevier.
4. Kandel, E. R., Koester, J. D., Mack, S. H., & Siegelbaum, S. A. (2021). *Principles of Neural Science* (6th ed.). McGraw-Hill.
5. American Speech-Language-Hearing Association (ASHA). Clinical Resources on Neurogenic Communication Disorders and Dysphagia.