

HUMAN PHYSIOLOGY (normal)

LECTURE 9. Higher Nervous Activity

Lyubomyr Vovkanych

Department of Anatomy & Physiology

LSUPhC

Higher Intellectual Functions

Also called **higher brain functions**, **higher cortical functions** or **higher nervous activity**

The **gray matter** in **cerebral cortex** is responsible for higher intellectual functions

The **higher brain functions** are:

- Learning
- Memory
- Conditioned reflexes
- Speech
- Emotions

Learning

Process by which **new information is acquired**

Is **classified** into two types:

Non-associative learning

- **Habituation** (when a person is exposed to a stimulus repeatedly it is habituated to the stimulus and ignores it)
- **Sensitization** (if the same stimulus is combined with another type of stimulus, which may be pleasant or unpleasant, the person becomes more sensitive to original stimulus)

Associative learning

- Involves learning about **relations between two or more stimuli** at a time
- Classic example of associative learning is the **conditioned reflex**

Memory

- Memory is the **ability to recall** past experience or information
- Memory **is stored** in brain by the **alteration of synaptic transmission** between the neurons involved in memory
- **Storage** of memory **may be facilitated or habituated** depending upon many factors, such as neurotransmitter, synaptic transmission, functional status of brain, etc.
- **Short-term Memory** is based on the development of new neuronal circuits by the facilitation of synaptic transmission
- **Long-term Memory** is based on the **consolidation** and **encoding** of information
- **Hippocampus** and **Limbic System** are the main sites of memory encoding

Memory

- **Memory engram** is a process by which **memory is facilitated** and stored in the brain by means of structural and biochemical changes
- **Molecular mechanism of facilitation** involves the increase of the release of **serotonin**, which facilitates the synaptic transmission to a great extent, leading to memory storage
- **Memory consolidation** is the process by which a short-term memory is transformed into a long-term memory
- **Consolidation** causes **permanent facilitation** of synapses
- It is possible by **rehearsal mechanism**

Classification of Memory

- **Explicit memory (declarative memory** or recognition memory) is defined as the memory that involves **conscious recollection of past experience**. The information stored may be about a particular event that happened at a particular time and place. Involves **hippocampus** and medial part of **temporal lobe**.
- **Implicit memory (non-declarative memory** or skilled memory) is defined as the memory in which past experience is utilized **without conscious awareness** (cycling, driving, playing tennis, dancing, typing, etc.).

Classification of Memory

Depending upon **duration**, memory is classified into three types:

- **Sensory memory**
 - the ability to retain **sensory signals** in sensory areas of brain
 - signals **are replaced** by new sensory signals in **less than 1 second**
 - the **initial stage** of memory
- **Primary memory**
 - memory of facts, words, numbers, letters or other information retained for **few minutes** at a time
- **Secondary memory**
 - storage of information in brain for **hours, days, months or years**. It is also called fixed memory or permanent memory.

Abnormalities of memory

- **Amnesia** - loss of memory
 - **Anterograde amnesia** - failure to establish **new** long-term memories (lesion in hippocampus)
 - **Retrograde amnesia** - failure to recall **past** long-term memory (occurs in temporal lobe syndrome)
- **Dementia** - is the progressive deterioration of intellect associated with loss of memory. Most common cause of dementia is **Alzheimer disease**
- **Alzheimer disease** is a progressive neurodegenerative disease (caused by the loss of function and death of neurons in many parts of brain, particularly cerebral hemispheres, hippocampus and pons)

Conditioned Reflexes

- **Acquired reflex** that requires learning, memory and recall of previous experience
- They are acquired **after birth** and it forms the **basis of learning**

Conditioned reflex	Unconditioned reflex
Acquired after birth	Inborn reflex
Individual	Species-specific
Needs previous experience	Does not need previous experience
Can be elicited by any stimulus (preconditioned), influenced on any receptive field	Can be elicited only by particular adequate stimulus, influenced on particular receptive field
Temporal reflex arc	Stable anatomical reflex arc

Conditioned Reflexes Formation

Conditions

- Repeated **combination** of Unconditioned stimulus with the Neutral stimulus
- A Neutral stimulus must be introduced **just before** the Unconditioned
- Proper **functional state** of the CNS
- **Absence** of other types of activity
- **Over-threshold intensity** of the stimuli

Stages of formation:

- Unconditioned Stimulus (Food) > Unconditioned Response (Salivate)
- Neutral Stimulus (Metronome) > No Conditioned Response

Conditioning procedure: trials of the combination between Neutral Stimulus (Metronome) and Unconditioned Stimulus (Food)

The **Neutral** Stimulus becomes **Conditioned** Stimulus

- Conditioned Stimulus (Metronome) > Conditioned Response (Salivate)

Classification of Conditioned Reflexes

Classical (Pavlov's) conditioned reflexes (are established by a conditioned stimulus, followed by an unconditioned stimulus)

Positive or excitatory conditioned reflexes

- **Primary** conditioned reflex (one unconditioned stimulus and one conditioned stimulus)
- **Secondary** conditioned reflex (first conditioned stimulus and the second conditioned stimulus are applied)

Instrumental (operant or Skinner reflex) conditioned reflexes (are those reflexes in which the new response is formed, animal is taught to perform some task in order to obtain a reward or to avoid a punishment)

Difference Between Operant and Classical Conditioning



Classical conditioning	Operant conditioning
A conditioned stimulus before reflex	A reinforcement or punishment stimulus after the behavior
Arrange relationship between two stimuli	Arrange relationship between the response and the stimuli

Negative Conditioned Reflexes

External or indirect inhibition

- Reflex is inhibited **by extra stimulus**, which is quite different from the conditioned one (sudden noise, etc.) that evokes the investigatory reflex.
- If the extra (inhibitory) stimulus is repeated, its inhibitory effect gets weakened or abolished

Internal or direct inhibition

- **Extinction** (gradually decrease) of conditioned reflex (if the conditioned reflex is not reinforced by unconditioned stimulus)
- **Differential inhibition** (failure of conditioned reflex that occurs when the conditioned stimulus is altered, for example alteration in frequency of sound or intensity of light)
- **Conditioned inhibition** (the failure of conditioned reflex due to introduction new stimulus)
- Inhibition **by delay** (absence of response during some time period)

Speech

Language - ability to associate arbitrary symbols with specific meanings to express thoughts and emotions

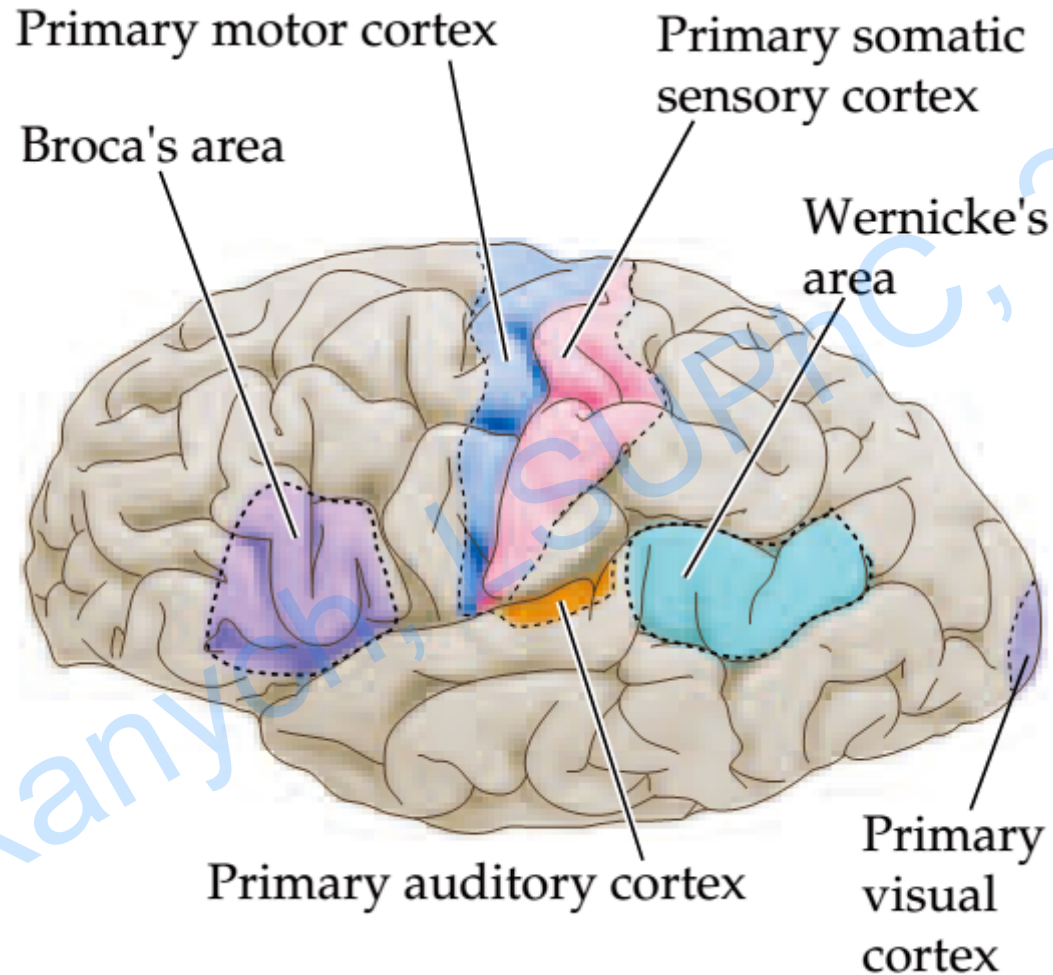
Speech (written or spoken) - expression of thoughts by production of some symbols or sounds, bearing a definite meaning

- **speech** - a symbols are produced verbally
- **writing** – a words are expressed as visual symbols
- **reading** - visual symbols or written words are expressed verbally

Development of speech involves integration of three important areas of cerebral cortex:

- **Wernicke** area
- **Broca's** area
- **Motor** area.

Speech



The major brain areas involved in the comprehension and production of **language**

Role of Cortical Areas in Speech

Cortical areas	Function
Broca's area: Areas 44 and 45 (lower part of lateral surface of prefrontal cortex)	controls the movements of structures involved in vocalization (tongue, lips and larynx)
Upper frontal motor area (paracentral gyrus)	controls the coordinated movements involved in writing
Secondary auditory area: Area 22 (superior temporal gyrus)	interpretation of auditory sensation and storage of memories of spoken words
Secondary visual area: Area 18 (angular gyrus of the parietal cortex)	interpretation of visual sensation and storage of memories of the visual symbols
Wernicke area (upper part of temporal lobe)	Interpretation of auditory sensation; responsible for understanding the auditory information about any word and sending the information to Broca area

Emotions

Emotions - subjective **feelings** and associated **physiological states** (happiness, surprise, anger, fear, sadness)

All emotions **are expressed** through both

- **visceral** motor changes (changes in heart rate and blood pressure, changes in cutaneous blood flow (blushing or turning pale), piloerection, sweating)
- **somatic motor responses** (especially movements of the facial muscles)
- Emotion states are coordinated by **group of the higher nervous centers**:
 - **limbic system**,
 - **amygdala**,
 - orbital and medial aspects of the **frontal lobe**

Integration of Emotional Behavior

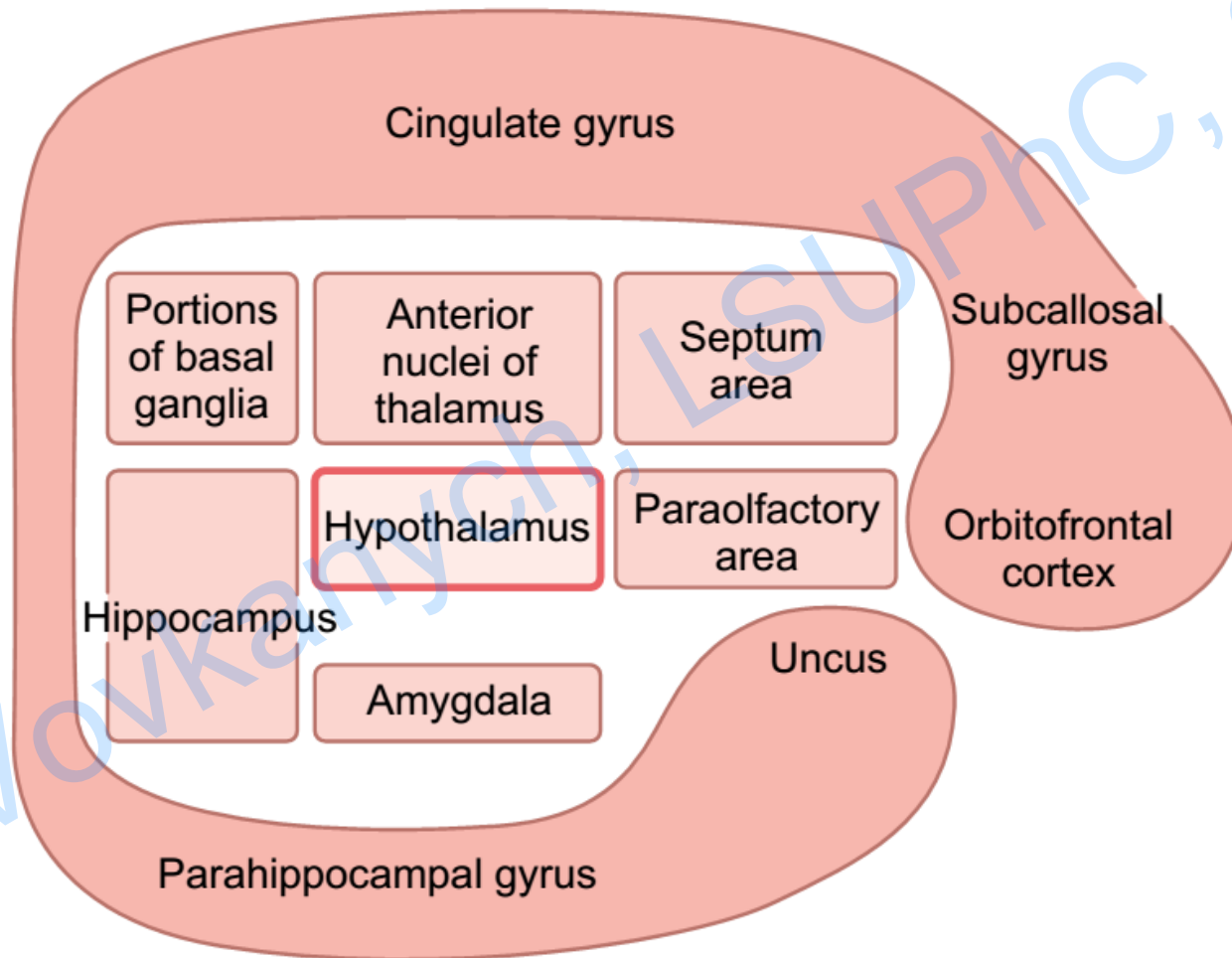
The **source** of emotion:

- **sensory drive** from muscles and internal organs
- **complex of stimuli** mediated by the **forebrain**

The **CNS structures**, involved in emotional behavior:

- the **frontal lobe** (connections with amygdala)
- important centers in the forebrain are considered part of the **limbic system**
- **hypothalamus** as a critical center for coordination of both the visceral and somatic motor components of emotional behavior
- the major targets of the hypothalamus is the **reticular formation** of the brainstem

Limbic system

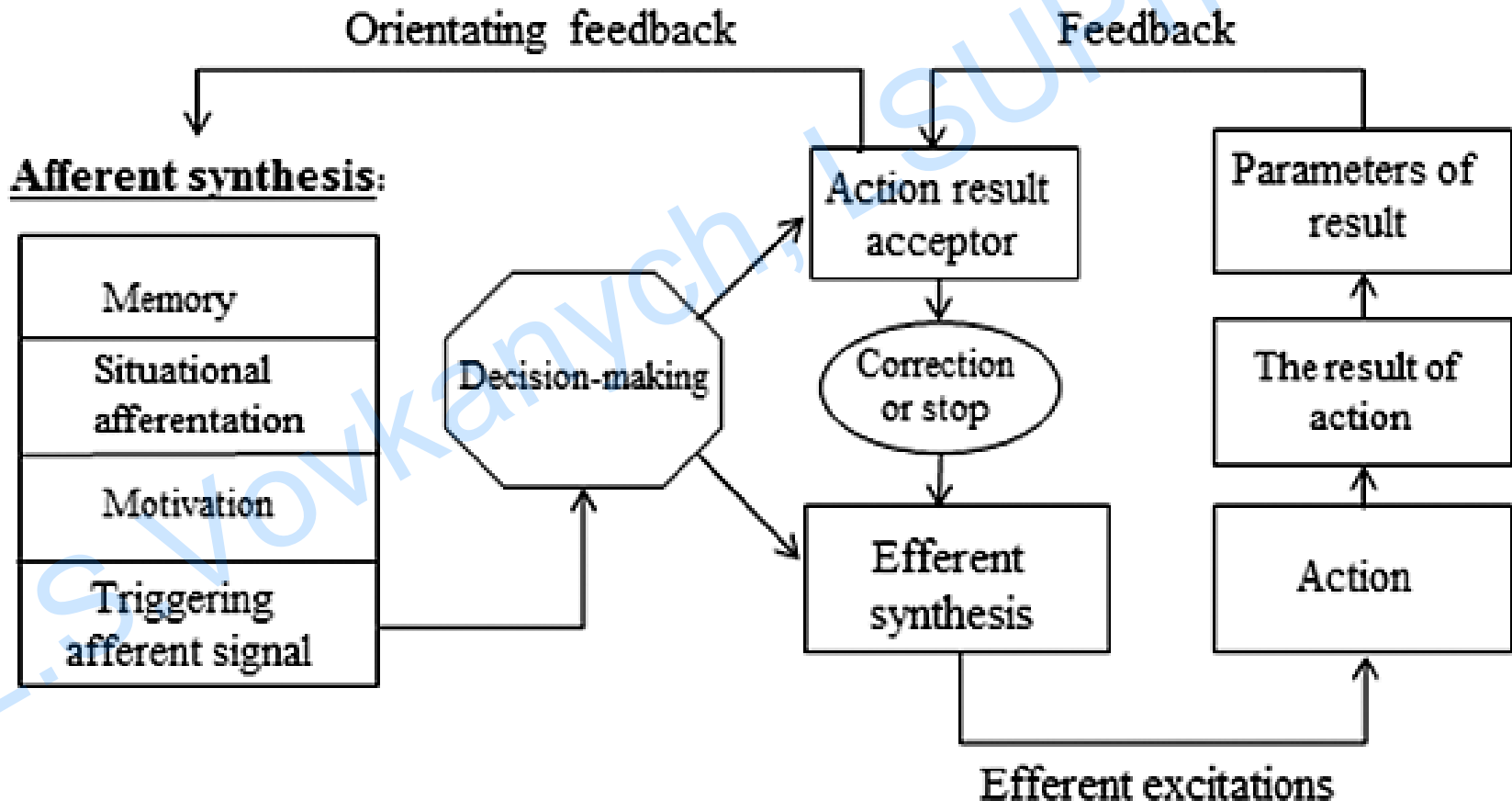


Integration of Emotional Behavior

- Forebrain circuit for the control of emotional expression (**limbic system**): cingulate gyrus, parahippocampal gyrus, mammillary bodies, orbital and medial prefrontal cortex, ventral parts of the basal ganglia, the mediodorsal nucleus of the thalamus, **amygdala**
- **Amygdala** mediates neural processes that invest sensory experience with emotional significance
- **Amygdala** emerges as a **nodal point** in a network that links together the cortical (and subcortical) brain regions involved in emotional processing:
 - amygdala projects to the **thalamus**
 - amygdala has significant connections with several **cortical areas** in the orbital and medial aspects of the **frontal lobe**

Theory of Functional Systems

- **Established by** physiologist Pyotr Anokhin
- The **endpoints** of functional systems are not actions themselves but **adaptive results** of these actions



Stages of the Functional System Action

Afferent synthesis – brain analyzes the information from such a sources:

- **Motivation**
- **Memory**
- **Triggering signals** (start signals)
- **Situational afferentation** (environment etc.)

Decision-making

- Formation of **action result acceptor** (creating the **ideal image** of result)
- **Efferent synthesis** (the **program** of the action, while the action is programmed, it is not manifested externally)

Action (**execution** of the program with the feedback obtaining)

Evaluation of the result of the action (comparison of the actual running with the ideal image of result)

Meeting the needs (correction or termination of action)

Pavlov's typology of higher nervous activity

Types of the nervous system (or types of higher nervous activity) are defined in the two ways:

- characteristic pattern of animal or human **behavior**
- complex of the **basic properties** of the nervous processes

The **Pavlovian types** of nervous system (TNS) are based on configurations of the **three properties** of the nervous processes of excitation and inhibition

- **strength**
- **mobility**
- **balance**

The **melancholic, choleric, phlegmatic** and **sanguine** temperaments are defined

The difference in behavior pattern



Choleric temperament



Phlegmatic temperament

The difference in behavior pattern



Sanguine temperament



Melancholic temperament

The basic properties of the nervous processes

Properties of nervous processes	Types of nervous system			
	Sanguine	Phlegmatic	Choleric	Melancholic
Strength	Strong			Weak
Balance	Balanced		Unbalanced	
Mobility	Mobile	Inert		



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