PSYC 223
Biological Psychology

Session 2 – THE NEURAL TRANSMISSION

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Session Overview

- The human nervous system is a made of cells. One of such cells is the neuron which has the primary function of transmitting signals from sensory organs to the brain and from the brain to organs and muscles so that the brain is able to control all functions in the body. In this session, the discussion will focus on how a neuron initiates signals, transmits the signal along to another neuron. We will also look at how the signal is carried across the space between neurons known as synapse by using a chemical mechanism.

Session Outline

The key topics to be covered in the session are as follows:

- Overview of Structure of a Neuron
- Resting Potential
- Action Potential
- Refractory Period
- Synaptic Transmission

Reading List

- Read Chapter Two of Biological Psychology 9th Edition by J. W. Kalat; pages 30 – 56 and
- Chapter 3 (pages 52 to 69)

- Read Chapter five of An Introduction to Brain and Behavior by Kolb and Wishaw.

Topic One

OVERVIEW OF THE STRUCTURE OF THE NEURON

STRUCTURE OF THE NEURON

- You will remember in the session that the neuron has some unique features – dendrite, soma, and axon.
- The neuron is covered by a *membrane*, a covering that is *selectively permeable*. This allows water and oxygen to pass through permanently but regulates the flow of *ions.*
- The *dendrite* receives signals from other neurons or organs and send them to the cell body.
- Signals are integrated at the cell body because they may becoming from more than one neuron.

STRUCTURE OF THE NEURON

- Signals are then resent from the *axon hillock* along the axon.
- When the signals arrive at the *terminal buttons*, its journey on the neuron is ended.
- A chemical process is needed to transmit the signal across the *synapse.*
- The *synapse* is a tiny gap between neurons.
- Note that transmission on the axon is through an *electrical* process and across the synapse it is a *chemical* process. These will be explained in detail

Topic Two

THE RESTING POTENTIAL

The Resting Potential

- Remember that the neuron membrane is selectively permeable
- The membranes have gates or channels. These gates or channels close or open for specific *ions* (charged particles)
- There are periods when sodium gates (Na^+) channels are closed, preventing Na^+ from entering the neuron
- During this same period, potassium (K^+) ions are also forced out although they leaked into the neuron in small amounts.
- This creates a negatively charged intracellular, (inside of the neuron) compared to extracellular.
- This is known as the *Resting potential.*

Resting Potential

- Electrical gradient
  - A difference in electrical charges between intracellular and extracellular
- Electrical Polarization
  - A difference in electrical charge between two locations
- Resting Potential
  - Difference in electrical potential

Resting membrane potential:
(things you need to know)

a. Concept of 'Selective membrane'

b. How permeable the membrane is to proteins, K+, and Na+

c. Na^{+}-K^{+} pump and its role in maintaining the membrane potential

Topic Three

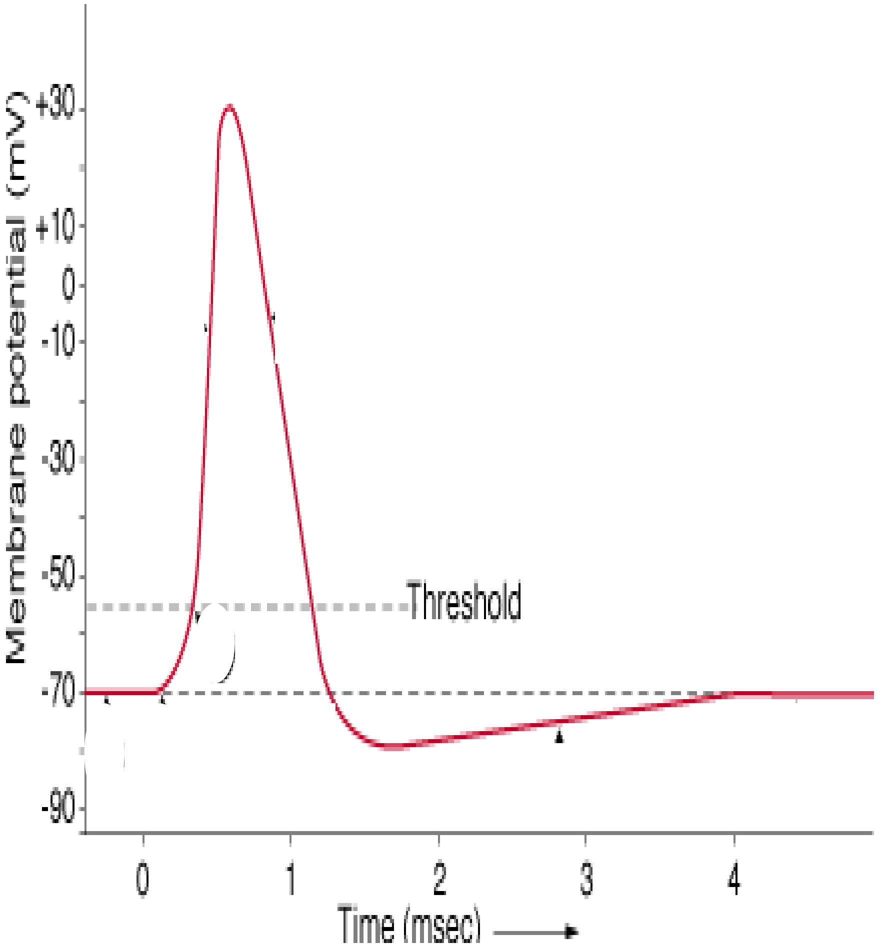
THE ACTION POTENTIAL

The Action Potential

- In the absence of external stimulation therefore, the neuron will be at rest
- A stimulation therefore causes a number of things to happen.
    1. Sodium and potassium gates open carrying positive charges in
    2. There is a reversal of potential making the inside more positive
    3. If the stimulation is strong, gates open long enough for the membrane to reach *threshold*. This stimulation is known as *Action Potential* to occur.
- <u>Threshold</u> is the point at which a neuron has received sufficient stimulation to trigger an impulse. Threshold is fixed for a neuron but may vary from neuron to neu

The Action Potential

- They are initiated in an all-or-none manner when the excitation of the neuron reaches or exceed threshold.
- Occurs upon alteration of the permeability of Na^+ and K^+ - i.e., stimulation results in opening of channels



The Action Potential

- A few terminologies you have to take note of.

1. Polarized

   The membrane is more negative and it is at rest (not stimulated)

2. Depolarized

   The membrane is stimulated and is more positive

3. Graded potential.

   This is any stimulation that leads to a depolarization. It may not be an action potential. Multiple graded potential however can lead to an action potential.

4. All-or-None Principle

   The principle that neurons only send an impulse if stimulus exceeds the threshold

5. Hyperpolarize

   Electrical potential becomes GREATER (more negative inside compared to outside of the neuron)

Topic Four

REFRACTORY PERIOD

Refractory Period

- Refractory period
  - Brief period immediately following action potential. The neuron is hyperpolarized.
  - This lasts for about 400 milliseconds.
  - During this period, a neuron is unable to send another impulse because both sodium and potassium are pumped out of the neuron.

Refractory Period

- The first 200ms is known as the *Absolute refractory period*. The neuron is hyperpolarized and cannot send another impulse.

- Between 200ms and 400ms (*Relative refractory period*), stronger than usual stimulation can trigger action potential but normally there is no action potential until the neuron becomes polarized (resting potential)

Topic Five

SYNAPTIC TRANSMISSION

Synaptic Transmission

- Remember that neurons are not fused. The gap between them is called a *synapse.*
- Therefore the electrical process explained previously does not apply here.
- There are chemicals in the neuron known as *neurotransmitters*.
- These neurotransmitters are either *excitatory or inhibitory.* An excitatory neurotransmitter initiates transfer of impulse from the synapse to the next neuron (*postsynaptic neuron*).

Synaptic Transmission

- Examples of neurotransmitters are:
  - Amino acids — e.g., glutamate, GABA,
  - Acetylcholine – A single class neurotransmitter
  - Monoamines – e.g., serotonin, dopamine, norephinephrine, epinephrine
  - Purines – e.g., adenosine
  - Gases – e.g., nitric oxide

  - **Please make it a point to read about the neurotransmitters and their most pronounced effects from the recommended textbook (Kalat, 2009; Chapter 3).**

Synaptic Transmission

- The arrival of an impulse at the synapse triggers the release of neurotransmitters from presynaptic neuron into the synapse.
- The chemicals *bind* with *receptors* on the postsynaptic membrane (receiving neuron).
- Chemicals and receptors function like a *lock* and *key.*
- Binding triggers a chemical reaction that causes depolarization of the postsynaptic neuron – causing transfer of signal to the postsynaptic neuron.

Summary of Chemical Events

The major events that allow communication between neurons across the synapse are as follows:

1. The neuron synthesizes (produce) chemicals that serve as neurotransmitters.
2. Neurons store neurotransmitters in axon terminals or transport them there.
3. An action potential triggers the release of neurotransmitters into the synaptic cleft.
4. The neurotransmitters travel across the synapse and attach to receptors on the postsynaptic neuron.

Chemical Events at the Synapse (cont.)

4. To end the transmission (so not to exaggerate the impulse) the neurotransmitters separate from the receptors.

5. The neurotransmitters are taken back into the presynaptic neuron (reuptake), diffuse away, or are inactivated by chemicals.

6. The last process is particular important for the same reason why there is refractory period.

Excitatory Postsynaptic Potential(EPSP)

- Releasing excitatory neurotransmitters causes *graded potential* leading to *EPSP.*
- EPSP is a “graded” potential
- Multiple EPSPs are integrated across space and time.
- The cell is depolarized & action potential occurs

Inhibitory Postsynaptic Potential(IPSP)

- This occurs when there is a series of events at the synapse that prevents the depolarization of the postsynaptic neuron.
- For example, the release of inhibitory neurotransmitters such as GABA.

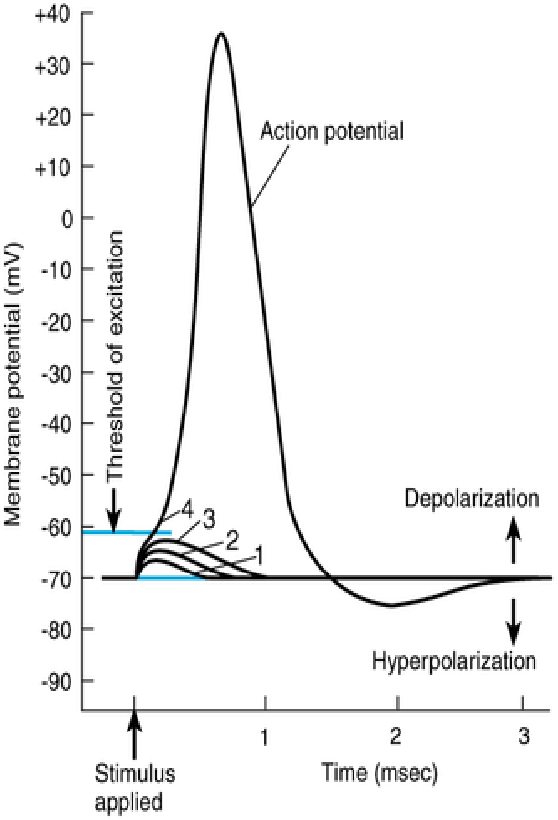
Integration of Graded Signals

- Many graded potentials can be generated simultaneously
  - Many receptor sites
  - Many types of receptors
  - Some graded potentials are depolarizations, some are hyperpolarizations
- *Spatial summation*
  - Graded potentials from different sites influence the net change
- *Temporal summation*
  - Graded potentials that occur at slightly different times influence net change

Assignment

- Identify the numbers 1, 2, 3, and 4. Describe briefly what these represent.
- Select three neurotransmitters and identify whether it is excitatory or inhibitory. Then describe its most pronounced behavioral effect.

▸ Action Potential as Seen on an Oscilloscope Screen



References

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