CNS
Doctor 2021

Physiology

Modified (1)

Writer: Sana Al-Sokhon
Corrector: Rama aldaqqa
Doctor: Fatima Ryalat

Receptor اعتبر حالك
واحكي بسم الله وابدأ

Neurophysiology

Introduction

Fatima Ryalat, MD, PhD

Assistant Professor, Department of Physiology and Biochemistry
School of Medicine, University of Jordan

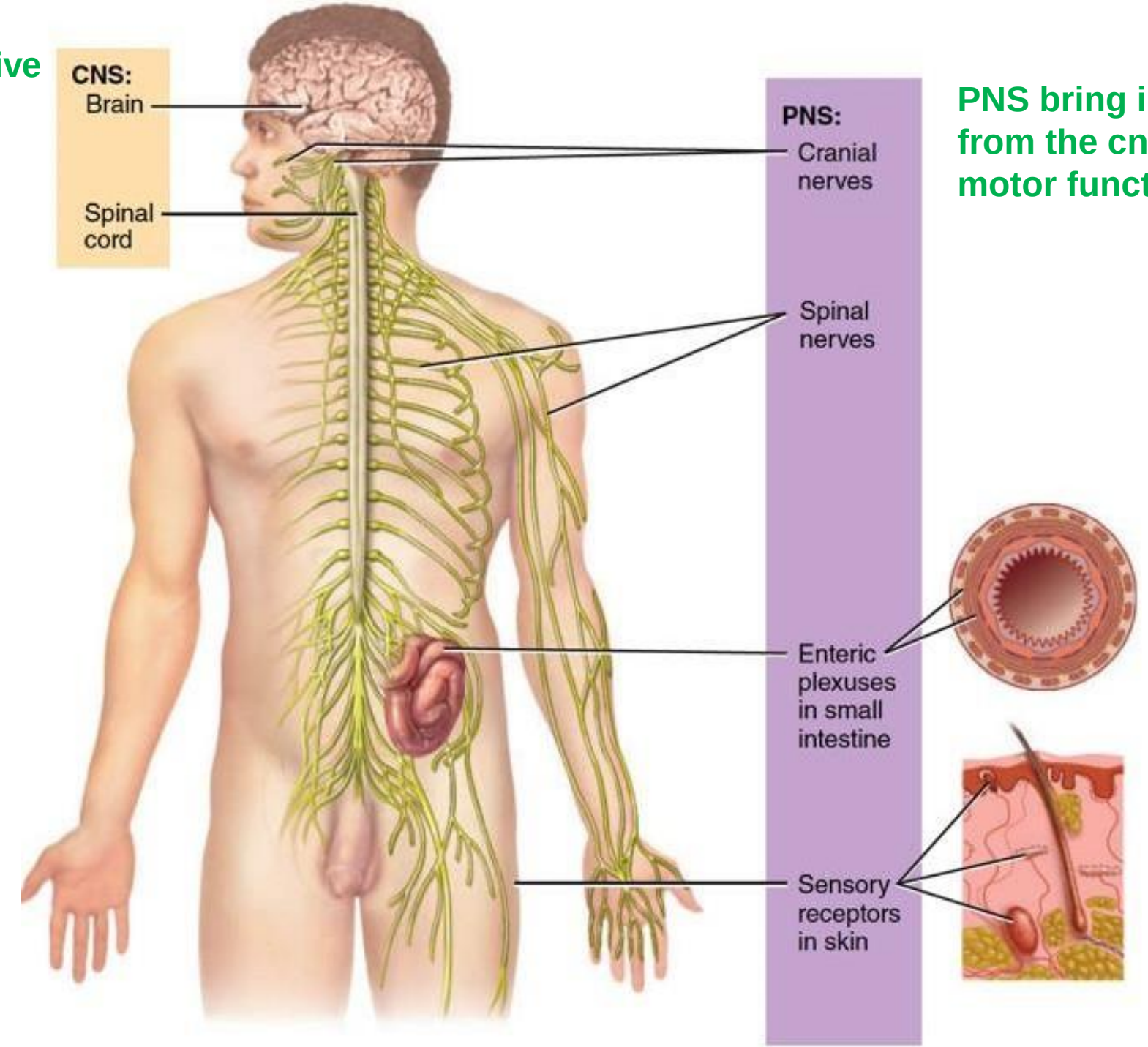
Functions of the nervous system

- **Sensory function**: sensory receptors detect internal or external stimuli. The sensory information is carried to the CNS through cranial and spinal nerves.

- **Integrative function**: process sensory information by analyzing it and making decision for appropriate responses. By brain and spinal cord

- **Motor function**: activation of effectors (muscles and glands) through cranial and spinal nerves.

CNS has integrative functions



PNS bring information to and from the cns (sensory and motor function)

Divisions of nervous system

Central nervous system (CNS)	• Brain • Spinal cord
Peripheral nervous system (PNS)	• Somatic system (SNS) • Autonomic system (ANS) • Enteric system (ENS)

Sensation

- **Sensation** is the conscious or subconscious awareness of changes in the external or internal environment.

-We don’t consciously aware about changing of blood pressure because its processing done in subcortical region (in the brain stem).
-While the conscious sensation is integrated by cerebral cortex.

- **Perception** is the conscious interpretation of sensations and is primarily a function of the cerebral cortex.

-Somatic sensation like touch, vibration ,pressure and itch can reach cerebral cortex that is why you consciously aware about them.

Perception

- Is the world, as we perceive it, reality?

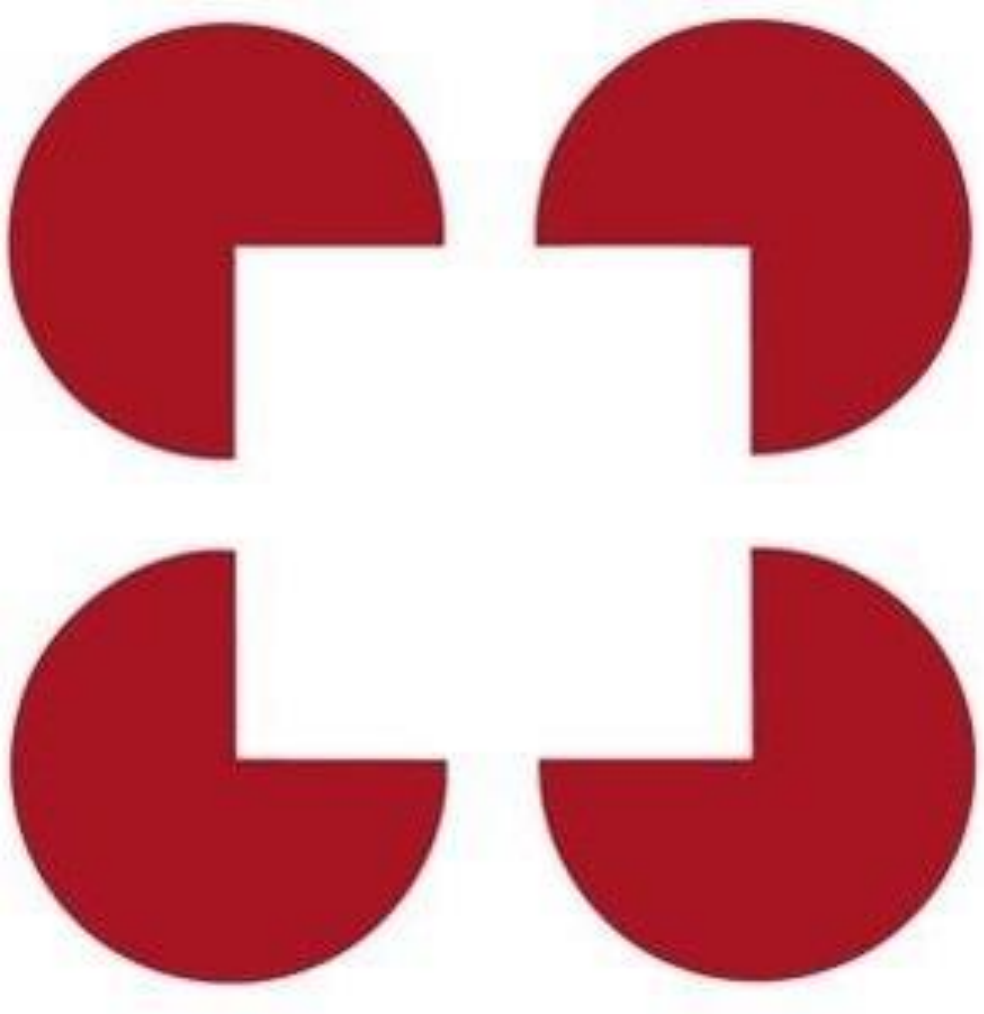
No ,for 3 reasons :

1- sensory receptors detect limited part of the whole range of stimulus (limited ability for receptors)

For Ex: we can perceive only 200-400 nanometer from the whole electromagnetic field ,Also we sound certain waves from large waves.

2- in the pathway between the sensory receptors up until the cerebral cortex so many changes can occur for ex, we have so many neural circuits it can be inhibitory or stimulatory so that it may inhibit certain stimuli or increase the stimulus intensity.

3- limited previous experiences which help the brain in making decisions.



The process of sensation

1. Stimulation of the sensory receptor.

For the receptor to get stimulated it should be sensitive for the stimulus which must be also found in their receptive field

A receptor may be either (1) a specialized ending of the afferent neuron or (2) a separate receptor cell closely associated with the peripheral ending of the neuron.

All receptors for a special senses are separate cells except the olfactory receptors(they are part of sensory neuron itself).

Each type of receptor is specialized to respond to one type of stimulus: **Differential sensitivity.**

Sensory modalities

- **Sensory modalities** are divided into **general senses and special senses**.

1- General senses are further divided into:

A- Somatic senses: include tactile, thermal and pain sensations.

B-Visceral senses: provide information about conditions within internal organs.

2- Special senses include smell, taste, vision, hearing, and balance.

Receptor potential

Because the only way afferent neurons can transmit information to the CNS about stimuli is via action potential propagation, receptors must convert these other forms of energy into electrical signals.

The stimulus can be electromagnetic , sound , pressure , vibration , mechanical whatever the type of energy of the stimulus , it will be converted into electrical energy (receptor potential) and we call this process transduction.

Stimulation of a receptor alters its membrane permeability, producing a **receptor potential**.

(it is a graded potential and that means whatever the stimulus , if it reaches the receptive field and it is selective for the receptor it will cause stimulation for this receptor and induce receptor potential , but this change may not reach the CNS because it is not strong enough to reach the threshold in this sensory neuron so that there is no action potential and no propagation of impulse to reach the CNS)

The process of sensation

- 1. **Stimulation of the sensory receptor**.

- 2. **Transduction of the stimulus**. A sensory receptor converts the energy in the stimulus into a graded potential.

The process of sensation

- 3. **Generation of nerve impulses**. When a graded potential in a sensory neuron reaches threshold, it triggers one or more nerve impulses, which then propagate toward the CNS.
- 4. **Integration of sensory input**. A particular region of the CNS receives and processes the sensory nerve impulses. **How?**

By comparing the received information with the previous ones , accordingly our CNS is making decisions , so maybe give an order to do motor function by fast neurons (either muscles contraction or glands secretion) or simply storing information.
After that we need a feedback system by comparing between the order and the actual movement to do it better next time.

***The brain assistant is the spinal cord through 2 things:**
1- its reflexes which consider the simplest behaviors produced by cns .
2- propagation of nerve impulse from periphery to the brain.

Receptive Field

- Each sensory neuron responds to a stimulus only within a specific region surrounding it, this region is called its **receptive field**.

مثلا لو كنت مسؤول عن تسجيل الحضور والغياب في شعبة 1 ما رح تعرف الغياب بشعبة2 وهون نفس المبدأ كل receptor مسؤول عن منطقة محددة ليشعر فيها (receptive field)

- The size of a receptive field varies inversely with the density of receptors in the region.

لو فرضنا أنه وضعنا 4 طلاب لإحصاء الحضور والغياب بسكشن فيه 200 طالب رح يقسموا بينهم الطلاب ليكون كل حدا فيهم مسؤول بس عن 50 طالب وبالمقابل وضعنا طالب واحد بس لإحصاء الغياب بسكشن فيه برضه 200 طالب رح يكون مسؤول لحاله عنهم كلهم

-So that if the receptors increased in one region their receptive field will be decrease

- The smaller the receptive field is in a region, the greater its acuity or discriminative ability: **2 point discrimination**

مكملين بمثالنا لما وضعنا 4 طلاب لسكشن واحد دقة المعلومات حتكون أكبر بالمقابل معلومات الطالب المسؤول عن سكشن لحاله حتكون أقل دقة.

At receptor level that gives localization for the stimulus in other words the stimulus will be more precise when its receptive field is small

Somatic sensory receptors distribution

- Receptors are **distributed unevenly**.

- The areas with the highest density of somatic sensory receptors are the tip of the tongue, the lips, and the fingertips.

In contrast , the density of somatic receptors for touch are less on the patients' back ,so the receptive field will be large as a result the localization of stimulus will be less.

فمثلا لو عملنا تجربة الفرجار على يد المريض رح يحس فيه بشكل أكبر ويميز إنهم وخزتين بإيده لكن بظهره ممكن يحس بوخزة وحدة بس من الفرجار

Lateral Inhibition

- To facilitate localization and sharpen contrast, lateral inhibition occurs within the CNS.

- With lateral inhibition, each activated signal pathway inhibits the pathways next to it by stimulating inhibitory interneurons that pass laterally between ascending fibers serving neighboring receptive fields.

- The most strongly activated pathway originating from the center of the stimulus area inhibits the less excited pathways to a greater extent than the weakly activated pathways inhibit the more excited central pathway.

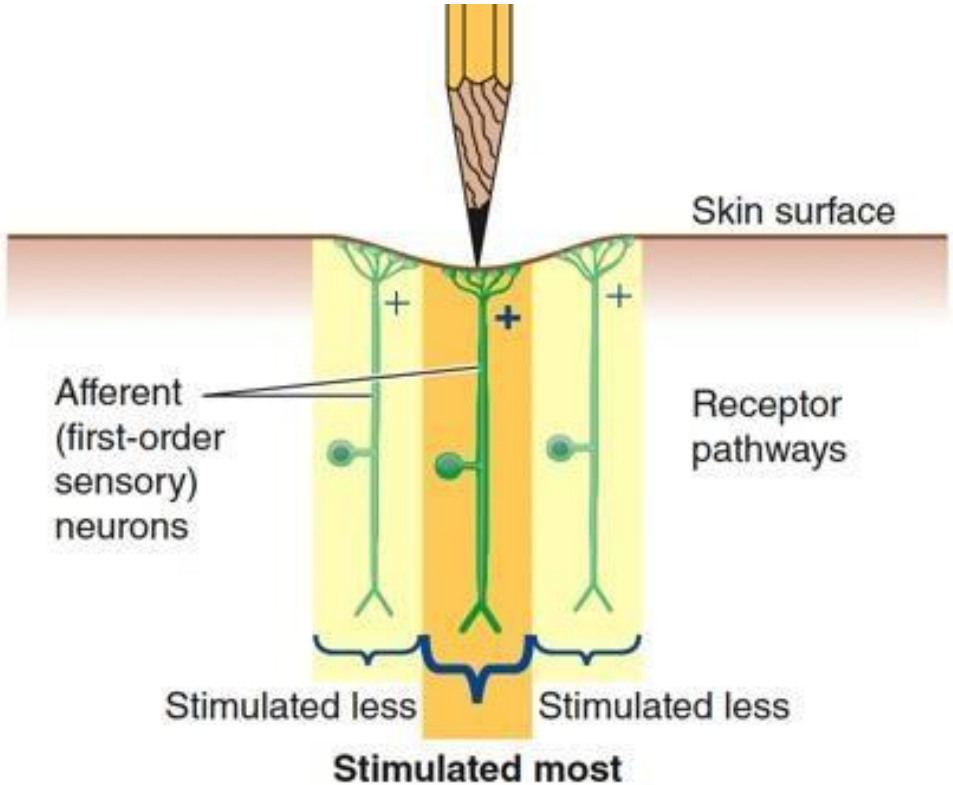
Lateral Inhibition

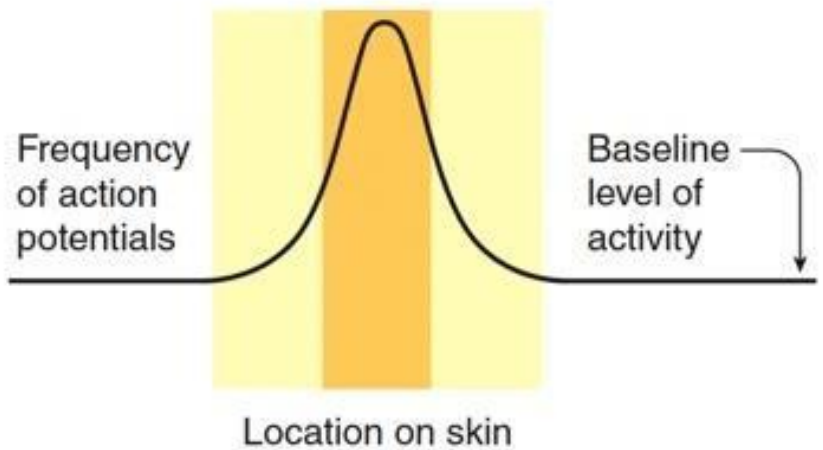
- Blockage of further transmission in the weaker inputs increases the contrast between wanted and unwanted information so that the stimulus precisely localized.

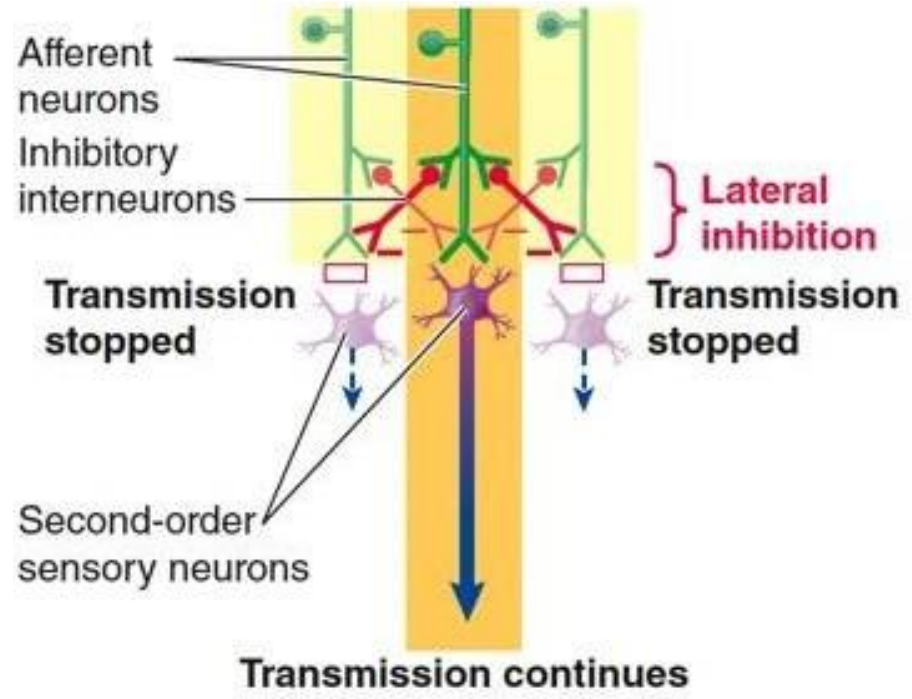
- The extent of lateral inhibitory connections within sensory pathways varies for different modalities. Those with the most lateral inhibition:

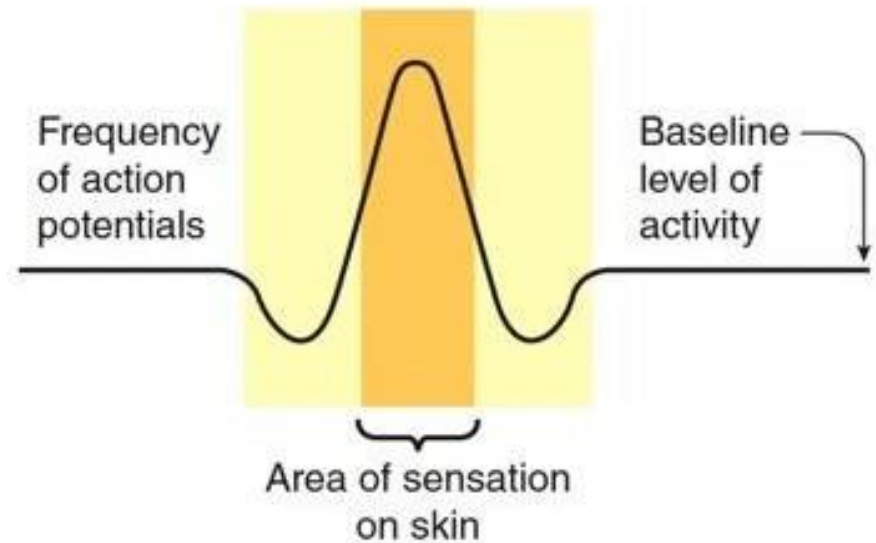
Fine touch and vision **(to get accurate signal)**

The type of stimulus is mechanical pressure and it will activate mechanoreceptor by deformation









***The picture on the right side :**

The deformation is strong mainly in the center and less deformation (stimulation) on the sides ,so that the strongest action potential (with higher frequency) come from the sensory neurons located in the center.

***The picture on the left side :**

Certain sensory pathways have inhibitory interneurons communicating with adjacent sensory neurons (which have similar modality of sensation) for lateral inhibition by secreting inhibitory neurotransmitters to inhibit adjacent parts so that the only pathway that reaches the CNS is the maximum stimulus from the middle area.

-Lateral inhibition doesn’t obtain on all sensory modalities.

Stimulus intensity

- The intensity of the stimulus is reflected by the magnitude of the receptor potential. **(the stimulus comes from many receptors)**
- The larger the receptor potential, the greater the frequency of action potentials generated in the afferent neuron.
- A larger receptor potential cannot bring about a larger action potential but it can induce more rapid firing of action potentials.

Stimulus intensity

- Stimulus strength is also reflected by the size of the area stimulated: Stronger stimuli usually affect larger areas, so correspondingly more receptors respond.

- **Temporal and spatial summation**.

***Temporal summation : is the frequency of stimulus from the same sensory receptor**
Like when I press strongly by my finger on your hand at the same area, so that the number of nerve impulses will be increased from the same receptor.

***spatial summation :the stimulus comes from many sensory receptors**
Like when I press by my wrist on your hand, stimulation area is larger ,so that the stimulated receptors increased .

True or false

- Stimuli of the same intensity always result in receptor potentials of the same magnitude in the same receptor.

False , because the adaptation in sensory receptors (it is important mechanism in our body because it helps the CNS not to be over worried with useless information)

-Exactly like when you forget that you are wearing a watch after a while of wearing it because of adaptation

Adaptation in sensory receptors

- A characteristic of most sensory receptors is **adaptation**, in which the receptor potential decreases in amplitude during a maintained, constant stimulus.

- Because of adaptation, the perception of a sensation may fade or disappear even though the stimulus persists.

- Receptors vary in how they adapt and how quickly they adapt (tonic vs phasic).

Sensory receptors differ between each other by :
1- how they adapt
2- extent of adaptation
3- speed of adaptation according to the function of these receptors (for ex: pain receptors ,they are slowly adapting receptors because pain is important stimulus that alarm us about tissue destruction , however smell receptors have rapid adaptation

- **Tonic receptors :receptors have slowly adaptation.**
- **Phasic receptors :receptors have rapid adaptation.**

Labeled Line Principle

- Even though all information is propagated to the CNS via the same type of signal (action potentials), the brain can decode the type and location of the stimulus.

- **Labeled Line Principle:** A particular sensory modality detected by a specialized receptor type is sent over a specific afferent and ascending pathway to excite a defined area in the somatosensory cortex **(somatosensory cortex the place where the processing takes place)**

  By the labeled line principle, the CNS determine the stimulus type as well as the location of stimulus because the somatosensory cortex reflects many parts of the body.

- Thus, different types of incoming information are kept separated within specific labeled lines between the periphery and the cortex.

اللهم احفظ أرواحهم وأبناءهم وردهم إلى ديارهم مردًا كريمًا آمنًا. اللهم يامن لا يهزم جنده ولا يخلف وعده، ولا إله غيره، كُن لأهلنا في غزة وإدلب ولكل المسلمين عونًا ونصيرًا .
اللهم انصر أهل فلسطين على من عاداهم. اللهم صوب رميهم وثبت أقدامهم وانصرهم نصرًا عزيزًا.

Thank you