Central Nervous System

Sheet 10

Subject | Physiology

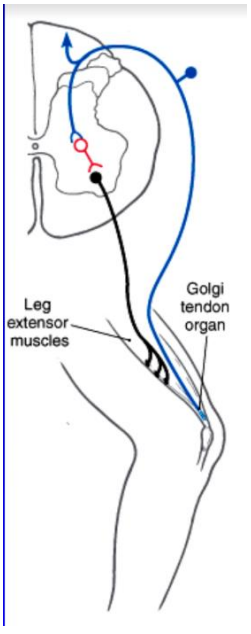
Done by | Bahaa Jaradat

Correction | ...

Doctor | Loai Al-Zghoul

This sheet is based on lecture 10 from section 1, the subjects covered: -
1-Golgi tendon organ, its reflex and withdrawal (nociceptive) reflex.
2-cortex functional classification and its clinical significance.
3-the concept of Agnosia and selective agnosia, in addition to brain lateralization.

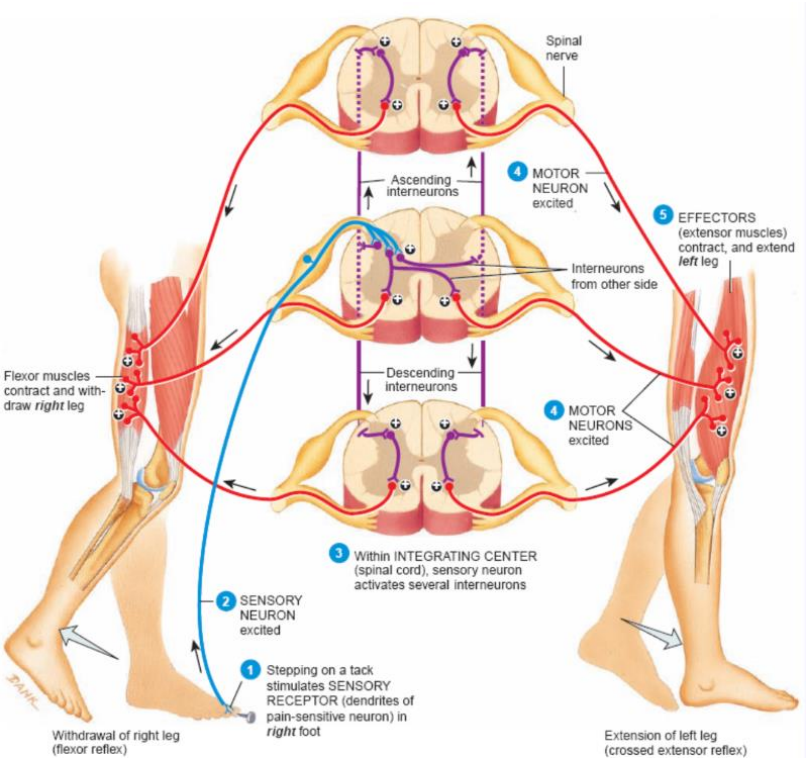
Last lecture talked about the first receptor within the muscle belly that is the muscle spindle which detects changes of the muscle's length, this lecture will start by talking about the other receptor found in the muscle-tendon structure, that is the Golgi tendon organ that detects the tension of the muscle.



-**Golgi tendon organ and its reflex**
the function of this reflex is to prevent muscle damage when tension is too high. The mechanism starts with a muscle contraction or external force, which increses the tentsion on the muscle tendon , if the tension in the tendon incresedd a lot, then golgi tendon organ will send impulses through its affaerant sensory fibers to the spinal cord, and inhibts the muscle leading to muscle relaxation. An examble is arm wrestling, when you arm wrestle with someone, your hand muscles are contracted trying to over come the force of your oponent, causing increase tension of the assoiciated tendons, but after certain tension which may harm the muscle, to prevent this harm the Golgi tendon organ will send sensory fibers to the LMN in the spinal cord causing inhibition of the muscle and relaxation.
-**Withdrawal reflex (nociceptive reflex)**

This is a spinal reflex, that represents a protective mechanism that gets you away from harm. For example if you touch a hot surface you must withdraw your hand as quickly as possible so that the

excessive heat won't kill you hand tissue, if this function was left to the cortex, it would take longer time allowing more damage to your hand, and that's why it's important for this reflex to be initiated at the level of the spinal cord. This reflex happens by activating flexors which are the muscles responsible of the withdrawal, and inhibition of extensors by a spinal reflex caused by the heat, pain..etc.
here are examples on this reflex:-
a-arm flexion after touching a hot surface.
b-knee flexion after stepping on a sharp object. Imagine you stepped on a Lego peace with your left foot, in this case the left knee will be flexed, but the right knee will be extended so that it can bear the weight over it since the right lower limb is flexed and is not bearing any weight, this opposite side extension is called **crossed-extension**.



-So note that the withdrawal reflex of the last example caused flexion of the left knee (by activating knee flexors and inhibiting knee extensors), it also cause a crossed-extension of the right knee (by stimulation of right knee extensors and inhibition of right knee flexors), and based on that you are expected to appreciate that the term "spinal reflex" is not necessarily a simple movement of one muscle, instead, it could be a complex interaction affecting different muscles of different functions on different sides of the body in different way.

-Corticospinal tracts

more details about its functions will be mentioned as we learn about cortical areas and their functions, but for now it's important to remember the following: -

1) its responsible for voluntary movements.

2) it's a crossed tract meaning that left cortex controls right side of the body and vice versa, the crossing of the fibers happens at the lower part of medulla oblongata forming the motor (or pyramidal) decussation.

Cortical classification

As we know, the cerebral cortex is the outermost part of the cerebrum with a thickness of 0.5-1.0cm. Its divided into the neo cortex and many other parts collectively called the allocortex. When we use the term cortex, then it's understood that we are talking about the neocortex as it's the most important part.

-the neocortex is divided into 6 layers, theses layers have

Note, some auditory sensations are sent to area 42, which is not classified as a primary cortex. This is an exception where our definition of a 1ry cortex doesn't apply, but you don't have to worry about it.

different functions, different shapes of neuron and different thicknesses. And the relative thickness of these layers is different along the neocortex itself. The neocortex is mainly associated with concuss awareness.

-**the functional classification of the cortex (the neocortex)**: - there are many systems and many ways to classify the neocortex, but we will be sticking to only one system to make things easier and more feasible to link with clinical aspects. the system that we will use classifies neocortex into:-

A-primary cortex:- this is the type of cortex that is connected with outside of CNS, and thus is the first part of the cortex to receive sensations from the periphery or send motor information to muscles, examples: 1ry visual cortex (area 17), 1ry somatosensory cortex (areas 1,2,and3) and 1ry motor cortex.

B-secondary cortex.(further explained later on)

C-association cortex.(further explained later on)

-As we said, this classification is useful because it enables us to easily understand the link between clinical signs and symptoms with the causative lesion, so for example, and since the 1ry cortex is the one to receive sensory information from the periphery, then a damage to a certain 1ry cortex will be associated with a loss of the associated sensation because there would be no cortex to receive the sensory input coming from the periphery.

so:

-Right 1ry somatosensory cortex damage leads to loss of somatosensation on left body.

-right and left 1ry olfactory cortex damage leads to loss of olfaction (this is called Anosmia).

****1ry cortex is the entry point of sensations, so damage of 1ry cortex of a certain sensation would lead to loss of the associated sensation****

-Vision sensation is the most complex sensation, thus 2ry visual cortex is the largest 2ry cortex.

-the smallest 2ry cortex is the gustatory (taste sensation).

-Now after the 1ry motor cortex receives the information, it carries out minor processing only , and the information will then be relayed from the 1ry cortex to other cortices for more processing and interpretation, the cortex that receives the information coming from the 1ry cortex is called the secondary cortex.

Functions of 2ry cortex:-

1-recives information from 1ry cortex.

2-further processing of the information.

3-each secondary cortex saves the memories associated with its corresponding sensation to be able to process it (remember, processing and memory are linked together). It's important to understand that different sensations have different levels of complexity, and the simpler the sensation is → the less processing it needs → less memory stored about this sensation in its 2ry cortex → the smaller the size of the 2ry cortex itself. Hence, in humans the smallest 2ry is for the gustatory while the biggest is for the visual area.

-Damage of 2ry sensory cortex is associated with loss of memories about the sensation that is usually processed at that 2ry cortex, thus the patient will receive the sensation, will be aware of it, but his 2ry cortex won't be able to process this sensation, so the patient will not be able to give it a meaning. For example if the 2ry olfactory cortex got damaged, then the patent will smell, but won't be able to differentiate is this a smell of a flower or of a chicken or stinky clothes…etc., in other words, the patients

will receive the smell because 1ry olfactory cortex is intact, but due to the damage in the 2ry olfactory cortex, then the patient will not be able to understand what he is smelling. Another example is if a patient has a lesion in his/her somatosensory cortex and you gave him an object to touch and then asked him to identify the object without looking at it, then he will grab the object, would appreciate its textures(soft,rough..etc.) but won't know what the object is. ***Such conditions that results from 2ry cortex lesions are called "Agnosia".***

-Agnosia: - inability to interpret and extract a meaning from sensations.

---now we will be talking about "processing of information"

There are main 2 different ways for processing, these are: -

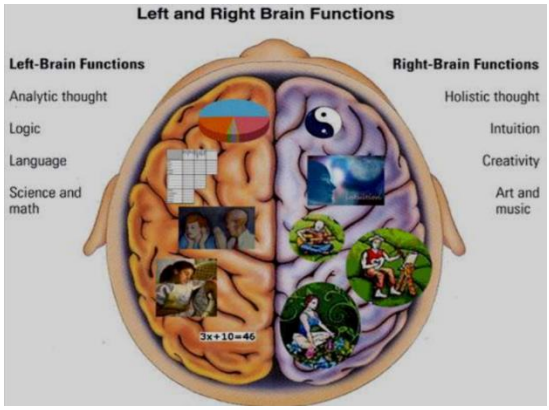
A-continuous processing:- in this type, the received information won't be separated, and will be processed on the same area to give a single outcome.
B-Parallel processing: - in this type of processing, the received information will first be separated from each other, sent to different places, get processed and then the outcomes are added up to produce the single final result of this processing, (e.g. parvo and magnocellular layers of lateral geniculate nucleus of visual sensation, remember we had two pathways, "what" and "where" pathways, the "what" pathway itself included different modalities like what's the shape, what's the size, the texture, the color..etc., but in the end, the final outcome is a single picture that is the summation of all different outcomes of different streams of processing).

-the two ways of processing (parallel and continuous) are used in our brains

-so we already said that damage to 2ry cortex will lead to agnosia due to loss of processing, now this is a true, yet it is a very general description that doesn't apply on all types of damage to 2ry cortex, so for example, if only one stream of parallel visual processing got damaged , this won't lead to complete Agnosia because the other streams are still functional, instead it will lead to what's known as "**selective agnosia".**

Normally, facial recognition area recognizes facial features like its oval shape, presence of ears, mouth, nose…and so on.
-there is a book called "The man who mistakes his wife for a hat" about a man who suffered from selective agnosia that he couldn't recognize his wife's face, and though it was a hat instead, his lesion was in the area prior to facial recognition are.

-examples on selective agnosia:-
1-selective visual agnosia for letters: the patient will know that this is writing but won't be able to specifically identify letters and words.
2-selective visual agnosia for faces **(prosopagnosia**):- this is one of the most common selective agnosia disorders , results from damage to the area of 2ry visual cortex that is responsible for facial recognition, it's also commonly known as face blindness.



-*Brain Lateralization*

We already know that the Rt 1ry somatosensory cortex and the left one are very simmer, and they both receive information form the contralateral sides of the body. We also said that in order for 2ry cortex to be able to process information, it needs to save the memory related to this information, so would these memories be saved in 2ry cortex of the left hemisphere only? Right

hemisphere only? or would both right and left 2ry cortices save their own memories? The answer is, if both right and left cortices saved memories, then this would mean wasting of the precious brain tissue and memory space by filling it with the same information over and over, thus to prevent this, memories are mainly saved in only one side of the brain depending on this type of memory, in other words, some types of memories are mainly saved on the right side of the brain, other types are mainly saved on the left side of the brain, so memories stored on the right side of the brain are different from those on the left side of the brain, which also means-since processing and memory are very related to the extent that they are useless without each other- that right side of the brain is mainly responsible for processing of certain types of information, and the left side of the brain is responsible for processing of other types, and that's what we call "Brain lateralization".
-some functions and certain types of memories are evenly distributed between right and left brines.

- Left brain:
  Logic.
  analysis.
  sequence.
  math.
- Right brain: -
  Emotions
  Feelings
  Art
  Music
  Tone
  3d-dimensions

Brain lateralization is reflected by the different sizes of different 2 cortex Areas between right and left brains.
-2ry cortices that saves more memories are larger in size. Since olfactory 2ry cortex on the right brain saves much more memories than the one of the left side ,then olfactory 2ry cortex is larger on the right brain compared to the left.
-In general, if a certain function or process is carried out mainly on the right brain, then its right 2ry cortex will be larger than the left one and vice versa. If the process is carried out on both right and left sides equally then the sizes of the right and left 2ry cortices will be almost the same.

-what are the clinical results of brain lateralization? To answer that lets take these examples:-
1- Olfaction sensation mainly depends on artistic processing like emotions and feelings and doesn't relay much on logical analysis or math and such things, so we expect the olfactory processing to be mainly carried out by the right brain, this of course means that olfactory memories are mainly saved in the 2ry olfactory cortex on the right side as well. So, if the left 2ry olfactory cortex got damaged, the olfactory processing won't be affected a lot since the left side does only a little amount of olfactory processing at the first place, thus left 2ry olfactory cortex will NOT lead to olfactory agnosia. But if the right 2ry olfactory cortex is damaged, this will lead to olfactory agnosia.
2-auditory sensation is processed on both right and left sides depending on the type of sound you are listening to, if you are hearing a song then the processing will be more dependent on the right cortex, but if you are listening to a lecture's recording then the left cortex is the one responsible for the larger share of processing than the right one, complex sounds that have many components will be processed by both sides with a potential shift to one side more than the other depending on the nature of the sound. This implies that damage to right 2ry auditory cortex will lead to auditory agnosia that is specific to emotional sounds leaving logical informative

-remember that auditory sensation from right ear goes to both right and left 1ry auditory cortices, olfactory sensation also goes to both right and left 1ry cortices, but don't let that confuse with the concept of lateralization, because lateralization is at the level of the 2ry cortex not the 1ry.

-2ry olfactory cortex is present at orbitofrontal area close to flavor area.

sounds almost non affected, whereas damage to left 2ry auditory cortex will cause an auditory agnosia that is specific to logical informative sounds leaving the emotional sound almost non affected, finally, damage to both right and left will lead to auditory agnosia affecting all types of sounds.

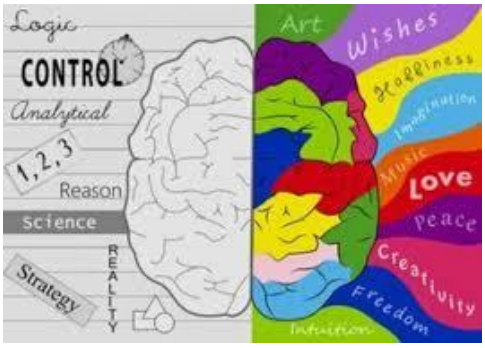
Very important:

1-sometimes a damage to 2ry cortex on one side is sufficient to cause agnosia if the damage was on the predominant side.
2-if the sensation processing is almost equally distributed on right and left sides, then damage to both right and left 2ry cortex is required to cause agnosia.
3-some time, a damage to the 2ry cortex on the predominant side won't cause agnosia due to many factors that enables the other side to take control and get better at the processing of the affected sensation even though it is not the predominant side under normal situations, these factors include young age, plasticity and therapy.

3-face recognition: - we already talked about prosopagnosia (face blindness), but now will go a step further by applying the concept of lateralization to prosopagnosia. Face recognition process has two aspects, one of them is a logical aspect where you look at the physical features of the face (distance between the eyes, the shape of the mouth, and so on) these features are processed in the left side of the brain. The process of face recognition also includes the artistic features of the face and emotions associated with certain person to recognize them, this information is processed in the right side of the brain. So, face recognition depends on both right and left sides, but is little more dependent on right side processing more than left. Depending on that: -
1- in most cases, prosopagnosia requires damage to both right and left 2ry cortices.

2-in less common scenarios, damage to right side of the cortex is sufficient to cause prosopagnosia.

3-in the very rare scenario, damage to left side of the cortex can be associated with prosopagnosia.
-cases 2 and 3 are due to normal variations that makes the processing of facial recognition information shifted more to the right or to the left, however the most common scenario, as we said is the first one where the processing is almost equal on both sides.



Sorry for any mistakes, feel free to reach me, thank you and good luck. The END.