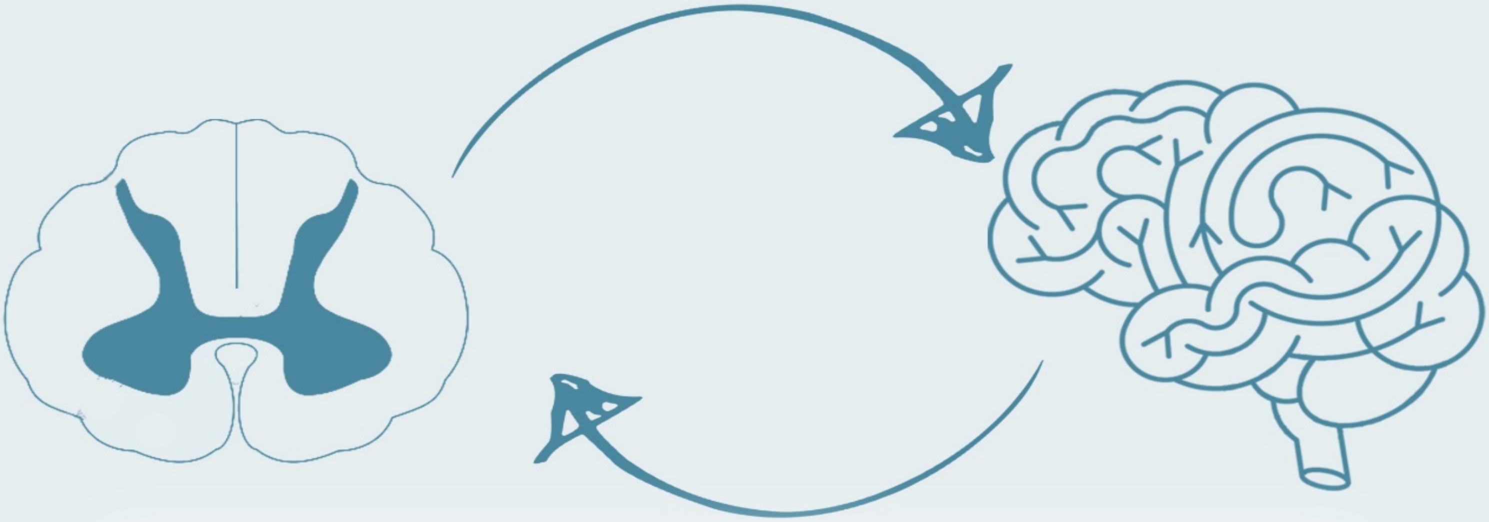

CNS

physiology

slides sheets

▶number	18
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Motor areas in the cerebral cortex

At this point of the course you're familiar with the general principle of areas in the cortex as they can be primary, secondary, or association areas.
Some areas which are related to motor functions were mentioned before and we are discussing them again:

1- Primary motor cortex; area number 4

2- Secondary motor cortex; area number 6 (generally called premotor cortex, but recently area number 6 is subdivided into premotor cortex and supplementary motor cortex)

In the contextof sensory pathways, a lesion in the primary sensory area caused loss of that sensation, for example, a lesion in the **primary**olfactory cortex results in **loss** of olfaction (anosmia).
Anda lesion in the **secondary** olfactory cortex results in inability to recognize odors despite a normally functioning olfactory system (olfactory **agnosia**).

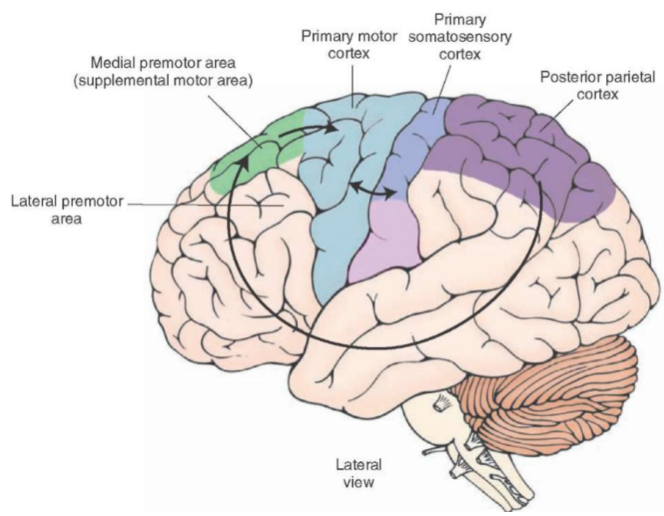
From the example above you can predict the functions of the different areas:
1- The info first reach the primary sensory cortex and undergo initial processing
2- Then they are sent to the secondary sensory cortex where the info are further processed and compared with the memory stored in that area to interpret meanings

In motor pathways it's the opposite!
1- The thought of the movement starts from one of the association areas (for example prefrontal cortex)
2- Then it's sent to the secondary motor cortex, where calculations are made to figure out what is required to do in order to achieve that movement
3- Then requirements are sent to the primary motor cortex and from there orders are sent to the spinal cord (in minority of the cases, orders are sent directly from secondary motor cortex to the spinal cord).

According to this sequence of functions; a lesion in the **primary** motor cortex results in **paralysis** and muscle weakness in the related muscles, whereas a lesion in the ***secondary*** motor cortex results in inability to do complex movements although the muscles are fully functional, this is due to the fact that complex movement require a lot of processing from the secondary motor cortex, so the patient won't be able to brush their teeth, do shirt's buttons, write, or play piano, because these are complex movements, this situation is called ***apraxia***.

The secondary motor cortex is wide and a lesion usually affects a small part of it, so the **disability is related to the affected site**; some lesions affect the coordination between the two hands, here the patient can properly perform movements that require one hand but can't perform complex movements that require the two hands. Other lesions might affect the hand only and spare the rest of the upper limb, or affect the coordination between eye and hand

The posterior parietal lobe (areas 5 and 7) is involved in sequential movements, so a lesion there also results in ***apraxia*** and the patient becomes unable to do complex movements that include a **sequence** (especially if the lesion is in the left hemisphere which is the dominant one in right-handed people).



The idea of a sequential movements starts from an association cortex and goes to secondary and posterior parietal cortices; to the secondary for processing related to strength and force, and to the posterior parietal for processing related to timing and sequencing, then orders from the two areas are sent directly to the spinal cord or more commonly indirectly through primary motor cortex then spinal cord.

Language

Language is one of most complex behaviors of ours, that's why many areas of the cortex are involved in its receiving, understanding, and production. Basically it's divided into two parts:

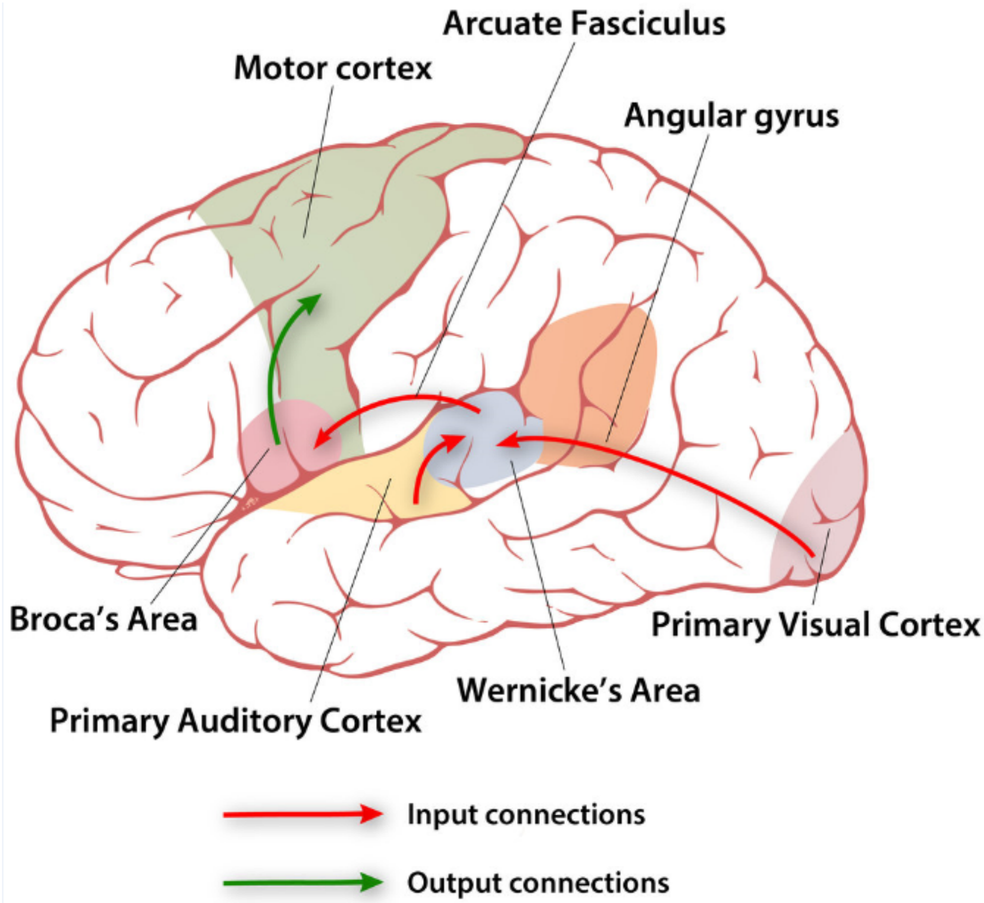
1. **Receiving and understanding** of language: which is the part related to sensory modalities and pathways:

A. Primary sensory areas (auditory or visual) receive input and process it to letters
B. Secondary sensory areas further process this info to words and maybe interpret some meanings
C. Then association area of languageunderstanding **(Wernicke's area)**combines the processed info to understand what is said or written.

2. **Production** of language: this part is concerned with motor orders to tongue, lips, and vocal cords to produce spoken language. It also sends motor orders to facial muscles to produce expressions and to the hands to produce sign language and written language.

Motor orders of language production is not haphazard, it's based on the received language.
For example, you see a word, this word is recognized as a word in the secondary visual area, then orders about the word are sent to the area of language production (Broca's area) to produce orders that move the tongue, lips, and vocal cords in a specific manner to read this word. This pathway doesn't actually produce language because it didn't pass over the area of language understanding.

Another example (look at the figure below):
- Your friend is talking, you receive his voice, expressions, and lips movement
- Eventually all these info are processed and sent to the association area of language understanding (Wernicke's)
- Based on what you have understood, info goes to the area of language production (Broca's) so you can choose words to reply, proper order of those words, and the facial expression
- Then orders are sent to the secondary then primary motor cortices, and from there to the spinal cord to perform the movements and produce language.



So Broca's area receives input from Wernicke's and then sends orders to motor cortex to produce language.

A lesion in the **primary** motor cortex that controls tongue, lips, and vocal cords results in their **paralysis** and the patient becomes unable to move them, whereas a lesion in the***secondary*** motor cortex results in ***apraxia***; the tongue, lips, and vocal cords are not paralyzed and the patient is still able to move themwith full strength, yet the patient is unable to use them to do complex movements that produce some letters (زي الراء والغين), and without those letters the patient can't speak properly and clearly.

If the lesion is in the association areas of language, the patient is able to move their tongue, lips, and vocal cord, and do complex movements with them to produce all the letters since primary and secondary motor areas are intact (NO paralysis, NO apraxia), **yet the patient is unable to produce proper and clear language** and this case is called ***aphasia***.

Expressive Aphasia - Sarah Scott - Teenage Stroke Survivor:
https://www.youtube.com/watch?v=1aplTvEQ6ew

Sarah was in an English class reading out loudly when she suddenly felt tingling in the right upper and lower limb and became unable to read. In the hospital they discovered that she had a **stroke in the area of language production (Broca's)**.

Since the area of language understanding is intact, Sarah is able understand what she and other people say, that's why when she mispronounced her name as "Scott" she realized she said it wrong and then corrected it to "Sarah Scott".

When asked about her age, the only answer Sarah had is "I can't", she couldn't say it so she tried to write it instead, but again she couldn't.
Even though she knows that her age in 19, she's still **unable to express it**.
With stroke in Broca's area, Sarah became completely unable to express some things (including her age), that's why even after the doctor told her that she's 19, Sarah only replied with "yeah" and a smile.

Association area of language production is in the inferior part of the frontal lobe of the dominant hemisphere (usually the left, between prefrontal and premotor cortices), it's includes three gyri the most important two of them are **pars opercularis** and **pars triangularis**(Brodmann's areas **44** and **45**).

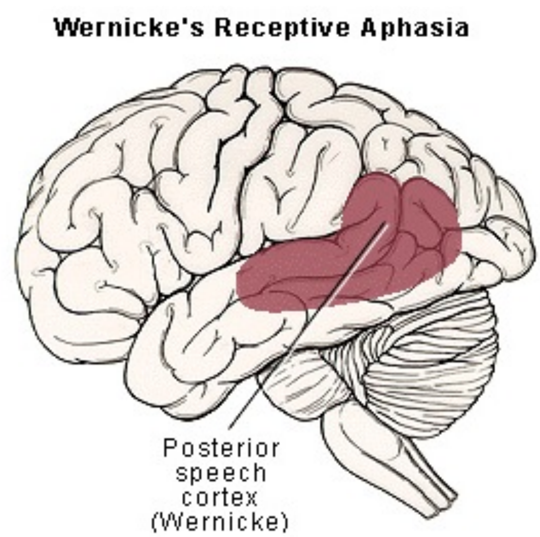
The first well-known case of stroke in the association area of language production was a one of Dr. Broca's patients, this patient lost almost the whole area after a stroke and lived 15-20 years with the only sound being able to produce is "tan", and he was unable to learn any word again, and can't learn sign language as well.

Note: *if a patient could use sign language in the past, they will lose this language or part of it if a stroke happened in Broca's area.*
This happens because Broca's area is responsible for language production by any means of communication; talking, signs, or writing, so they're all lost, and the loss of ability to produce written language is termed***agraphia.***

Note:a lesion in the secondary visual cortex will result in losing the ability of reading and identification of words and written language (word agnosia or alexia), but this patient will retain the ability of writing, because the memory of the language is still intact (the receptive area of the language is normal), so the patient can use this memory in writing.(If the patient see what he/she wrote after a while, they will not be able to read it, because the secondary visual area is defected). For more details, refer to the previous lecture.

So a lesion in the area of language production results in **Broca's aphasia** or **expressive aphasia**.

Wernicke's aphasia



It results after a lesion in the area of language understanding which is located almost at the tempo parietal junction, it includes parts of the visual and auditory cortices represented as Brodmann's areas 22, 39, and 40.

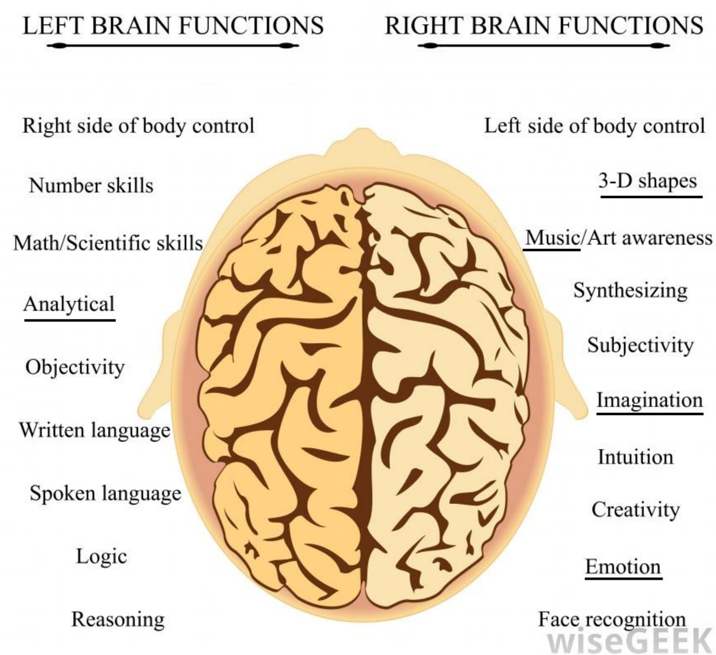
Wernicke's aphasia is also called **receptiveaphasia**; "receptive" since the patient is unable to understand what they <u>hear or read</u>**especially if it includes complex sentences or multi orders**, and "aphasia" because language production is dependent on understanding (as discussed before), so these patients are **unable to produce meaningful sentences**although they're able to say or write so many words.

In expressive aphasia, the patient knows exactly what to say but is unable to express it, whereas in receptive aphasia, the patient depends on a defective source to decide what to say so they end up saying words and sentences that lack meaning.

In severe cases of receptive aphasia, the order of sounds in each word is not correct, making the words sound like nothing but **meaningless voices**.
And the worst thing about Wernicke's aphasia is the fact that **patients cannot analyze and understand what they say!** So they produce meaningless sounds instead of sentences, and don't correct their speech because they're not aware about what they've just said.

Wernicke's Aphasia Interview with Amelia Carter:
https://www.youtube.com/watch?v=mxo0GDE6szs

Are there Broca's and Wernicke's areas on the other (right) hemisphere?
There are areas with similar yet different functions (but they're not called Broca's and Wernicke's), and the reason behind difference in functions is brain asymmetry.



Areas 44 and 45 on both hemispheres are association areas of language production, on the left (dominant) hemisphere it's **larger** and involved in spoken, written, or sign language production (called Broca's area), while on the right hemisphere, it'*ssmaller* and involved in the tone of speech and emotional part of it (not called Broca's).

Same thing applies for area of language understanding; areas 22, 39, and 40 on the right hemisphere (opposite to Wernicke's) are involved in understanding of tone, facial expressions, and emotions.

Note: tone and emotional part of speech allow us to differentiate between:
“You won?” – Question
“You won.” – Statement
“You won!” – Excitement
Even though the three lines have the exact same words, letters, and sequence (Wernicke’s area doesn’t differentiate between the three).

Note: Amelia was able to complete the song because this is the function of areas of language on the right hemisphere, which is intact. And part of rehabilitation of patients with Wernicke’s aphasia is the utilization of the other intact area on the right side by transforming words into tones and melodies (tone therapy).

Prosody of speech

It’s the ability to talk with the appropriate tone and emotion and utilize facial expressions, which is mainly the function of language areas on the **right** hemisphere.
A lesion in the language areas on the right hemisphere doesn’t result in aphasia, instead it results in ***aprosodia***.
It’s **receptive** aprosodia if the lesion is in areas 22,39,40 on the right, or **expressive**(productive or constructive)aprosodia if the lesion is in areas 44 and 45 on the right hemisphere.

Prefrontal cortex

This part starts with a short video: selective attention test:
https://www.youtube.com/watch?v=vJG698U2Mvo

Why you didn’t see the gorilla from the first time? Because all your attention was on the white team players and this is the simplest way to demonstrate the function the prefrontal cortex.

The prefrontal cortex (the **most rostral** part of the frontal lobe) is the highest center in the brain and controls almost the whole brain, it works mainly by three principles:

1. **Planning**: deciding what you want to do. For example, I want to concentrate on the video and count how many times white team players pass the ball.
2. **Inhibition**: deciding what functions are less important and fade them away. For example, the video I want to count in is received as visual input, but I don't need auditory input so inhibit it temporarily.
3. **Selection**: deciding which input to focus on and which to neglect. For example, selecting white color to have extra **processing** and neglect black color in order to count the number of passes accurately (and that's why you didn't see the gorilla)

It's possible that you notice the gorilla during the video, here the prefrontal cortex need to decide again, wither to pay attention to this new thing or not, then it decides to neglect it and continue counting, but during that time of decision you'd miss few passes. If someone noticed the gorilla and counted the number of passes accurately then they have good multitasking.

Since the prefrontal cortex is the place of selection and decision making, it is what defines the **personality**. And there, the **consequences of our behaviors** are saved to be used again in the coming decisions.

For example, the prefrontal cortex of an aggressive guy decides to punch someone who pissed him off to show that he's strong and brave, heart rate increases, face flushes, anger emotions dominate, and he punches, then this guy is sent to jail for few days.
Next time when someone pisses him off, the prefrontal cortex decides to stay calm because it has a memory about the bad consequence (jail) of punching.

Lesions in the prefrontal cortex results in:

1. **Lack of foresight**: the patient is unable to think about consequences of their actions, and they'll do whatever they want even if you tried to convince them with the bad consequences of their actions
2. Frequent **stubbornness**
3. Inattentive and **moody**
4. **Lack of ambitions**, sense of responsibility, and sense of propriety(**rude**)
5. Less creative and unable to plan forthe future

The prefrontal cortex is the last part of the brain to develop, it needs almost 20 years to become fully developed, that's you're not advised to make big decisions in young age.

The case of Phineas Cage, he had an accident that caused injury to his head, he had his prefrontal cortex surgically removed. After two weeks he came back to his job fully functional, but with huge changes in his personality.

Enjoy a this inspirational video of Sarah Scott, thank you ☺
https://www.youtube.com/watch?v=yh3cUe4BVrI