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Syllabus

02 Language and the brain

04 Speech perception

06 Word recognition

08 Language development

Week 2

Language and the brain

Human brain quiz

- What is the average weight of the human brain?

  1.3kg (3 pounds)

- How many interconnected neural cells are in the brain?

  About 100 billion

- Is it correct that movement and sensation on one side of the body are controlled by the hemisphere on the opposite side?

  Yes

Debate on human’ s brain

——What’ s the brain for?

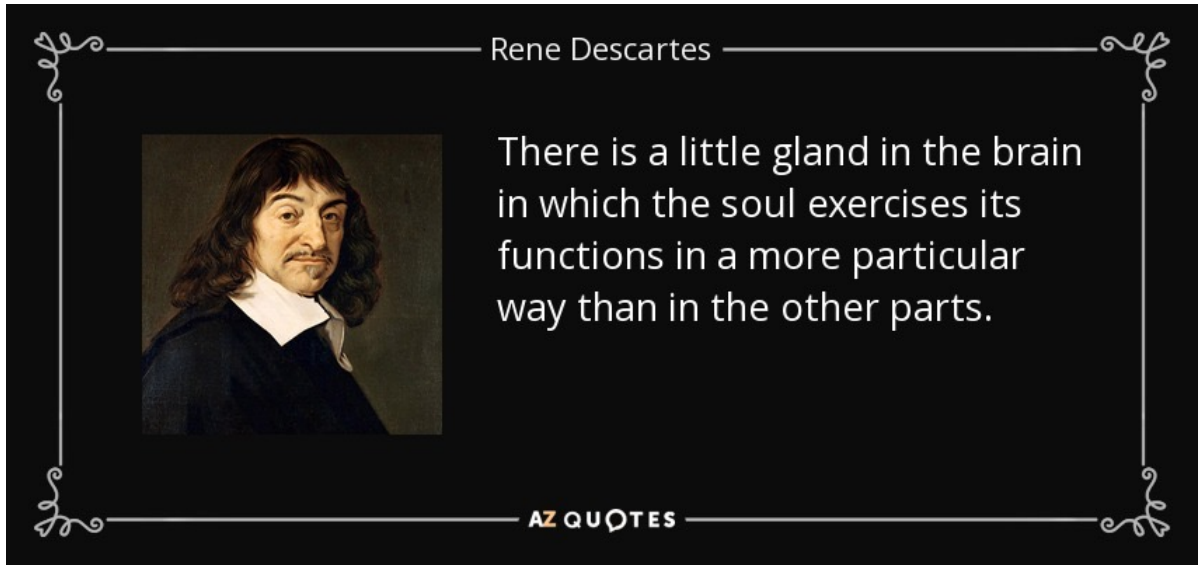
- Aristotle believed that the source of our consciousness was our heart, not our brain
    - “For the brain, or in creatures without a brain that which corresponds to it, is of all parts of the body the coolest. Therefore, as moisture turned into vapor by the sun. The heat is, when it has ascended to the upper regions, cooled by the coldness of the latter, and becoming condensed, is carried downwards, and turned into water once more…

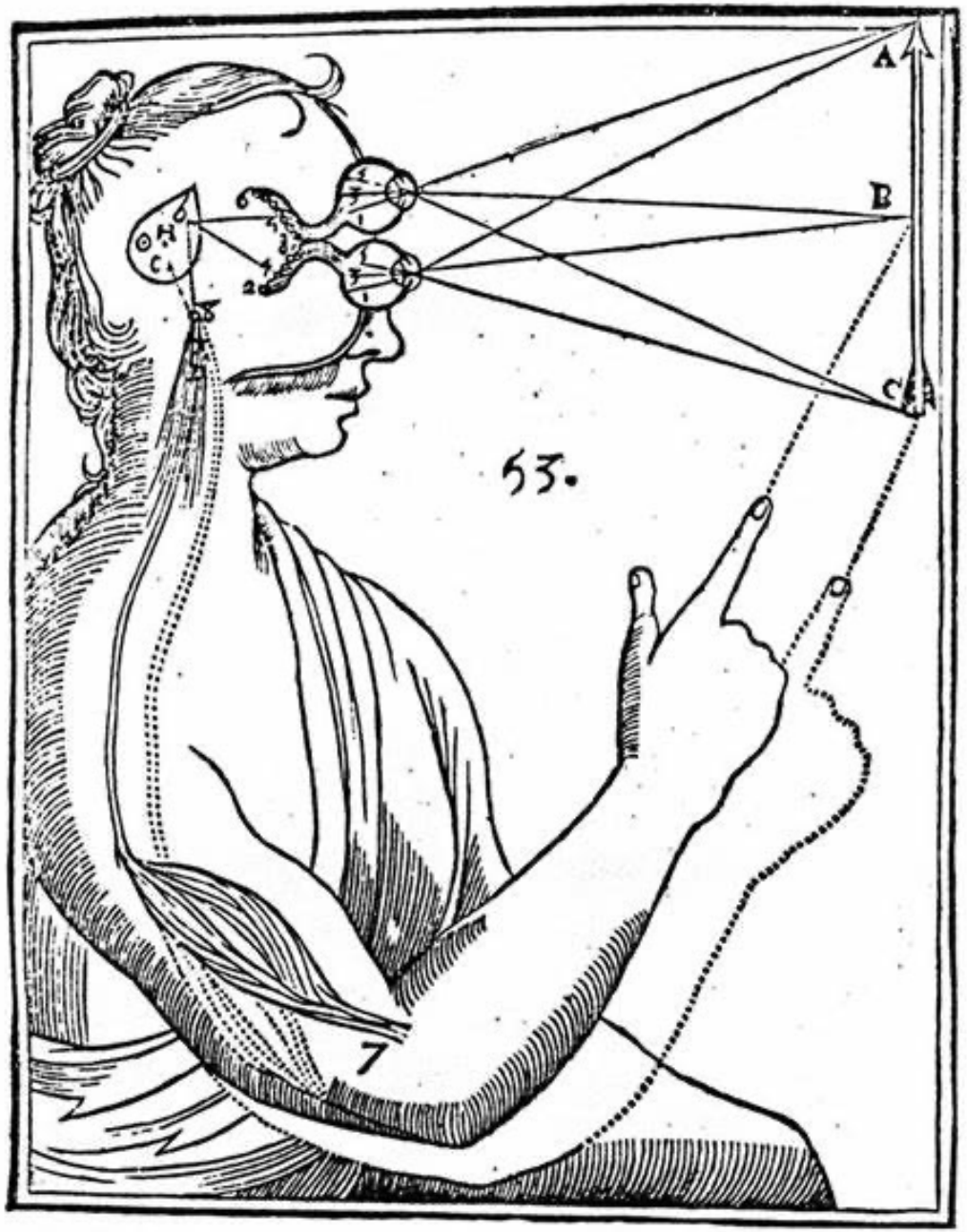
VS.

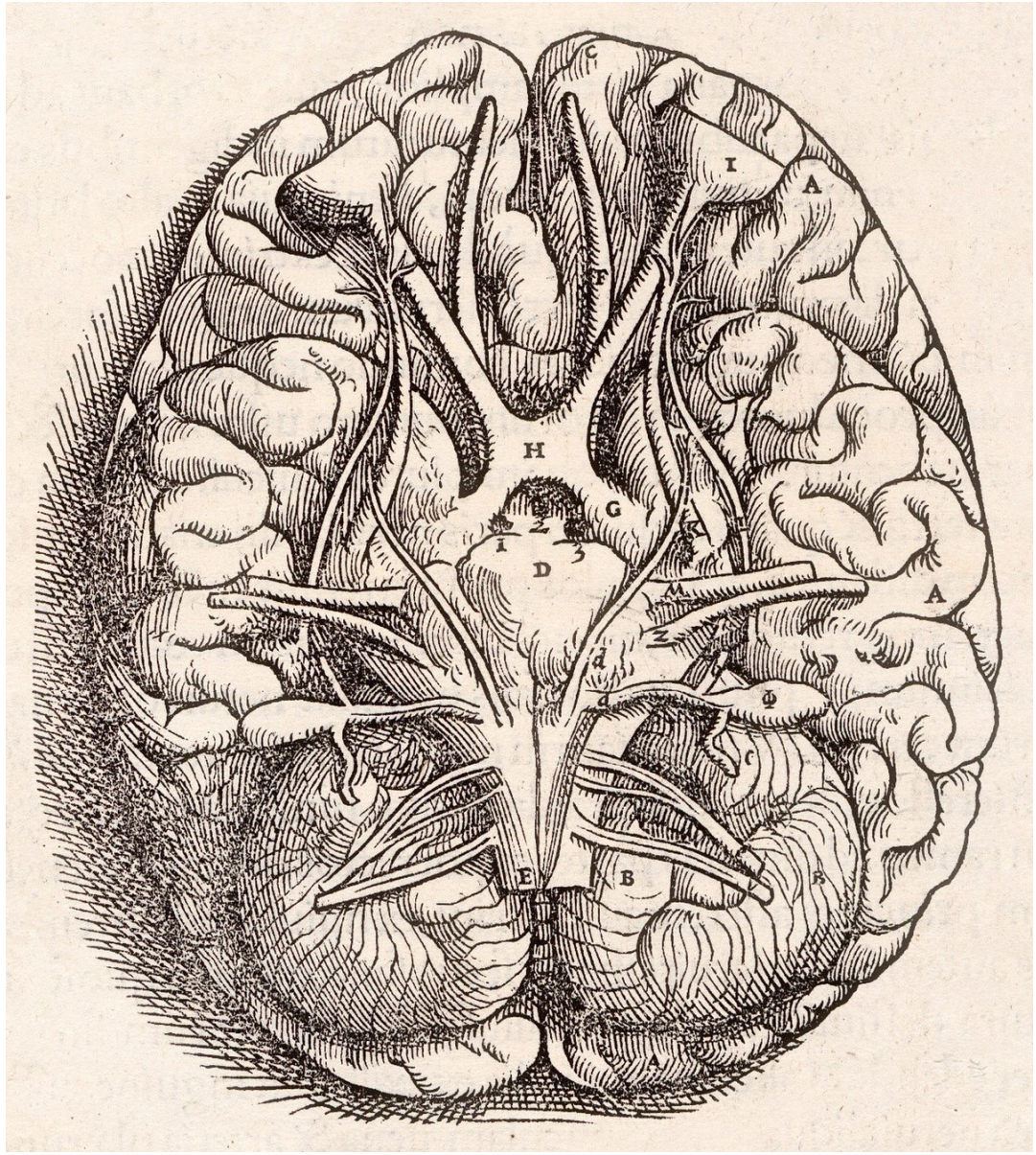
- Hippocrates believed that the brain was the seat of thought and emotions.
    - “Men ought to know that from nothing else but the brain come joys, delights, laughter and sports, and sorrows, ……And by the same organ we become mad and delirious, and fears and terrors assail us.…All these things we endure from the brain when it is not healthy…In these ways I am of the opinion that the brain exercises the greatest power in the man.”

- Philosopher René Descartes (1596–1650), proposed dualism, the idea that the mind and body are distinct entities, with the mind influencing the body through the pineal gland (松果腺)

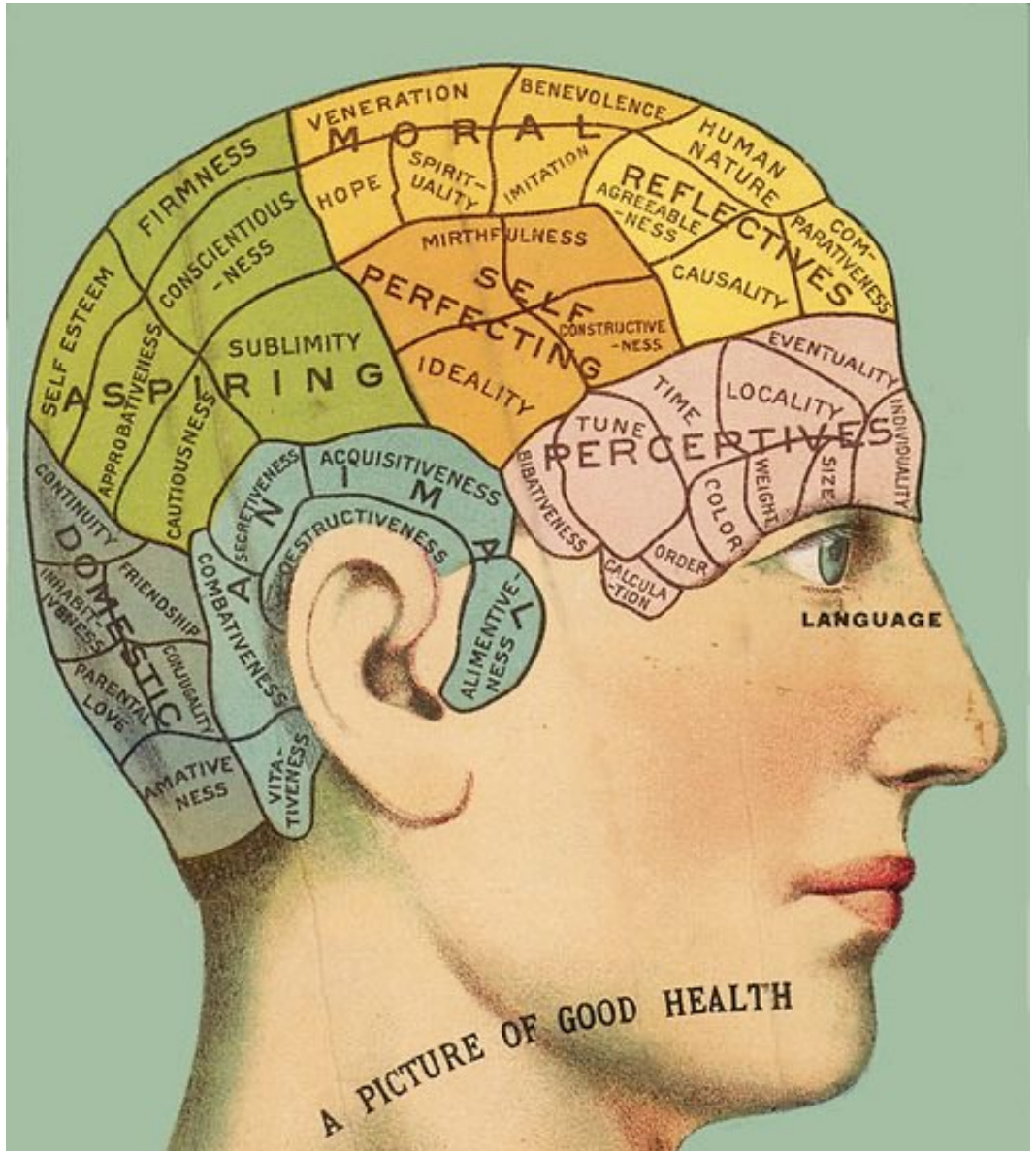
- He established a rational foundation for human knowledge in the intuition that, when one is thinking, one exists—expressed as “I think, I am”



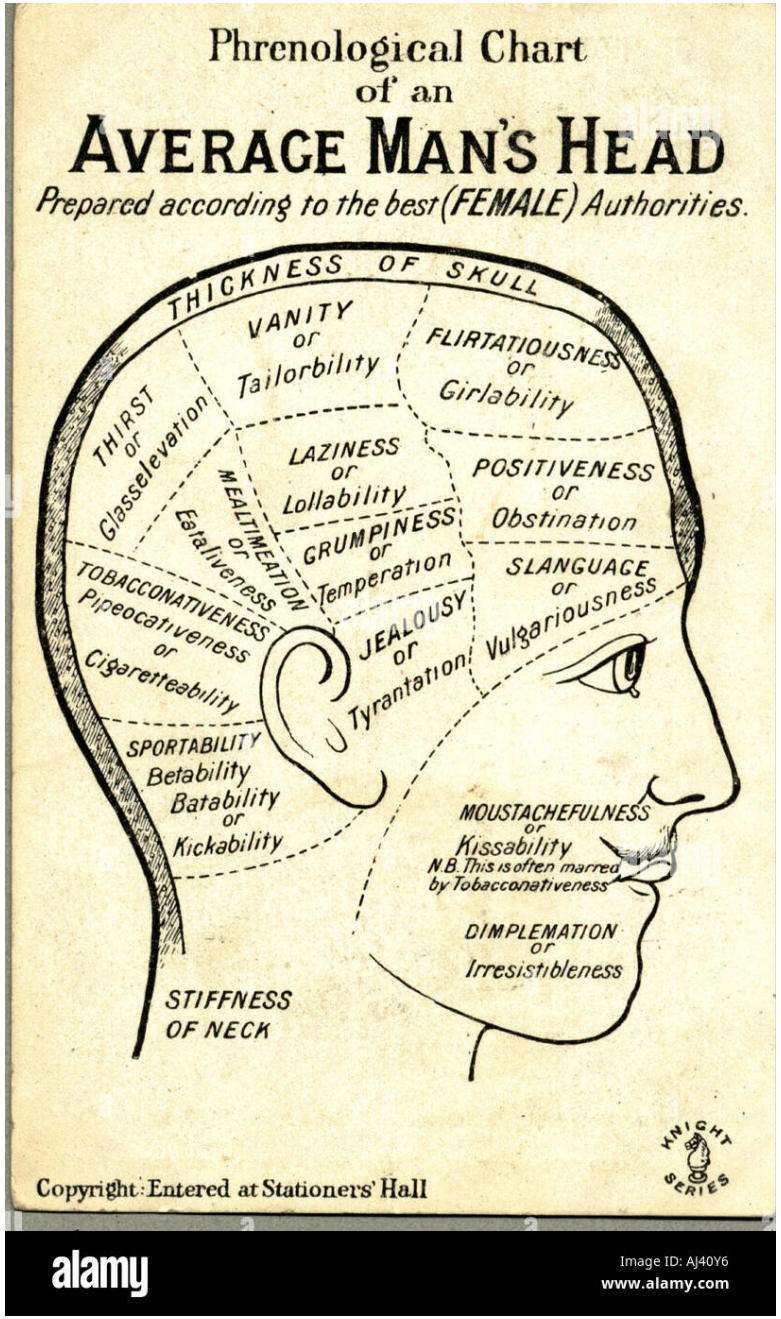




- In the 16th century, Belgian anatomist Andreas Vesalius created a highly detailed map of the nervous system.
- Andreas Vesalius (1514-1564) is considered the Father of Modern Anatomy
  - Gyrus
  - Sulcus



- In the 19th century, Phrenology (颅相学) is the pseudoscientific practice of studying the shape of the skull to infer mental traits and character.
- Franz Joseph Gall believed that the brain was made up of 27 individual organs that determined personality, the first 19 of these 'organs' he believed to exist in other animal species.



PHRENOLOGY CHARACTERS

GOOD WIFE

GOSSIP MONGER

WEAK SPIRITED

CRIMINAL

QUICK TEMPER

RESPECTABLE

Functional anatomy

——relationship between language and the brain

Early studies: evidence from damage to the brain

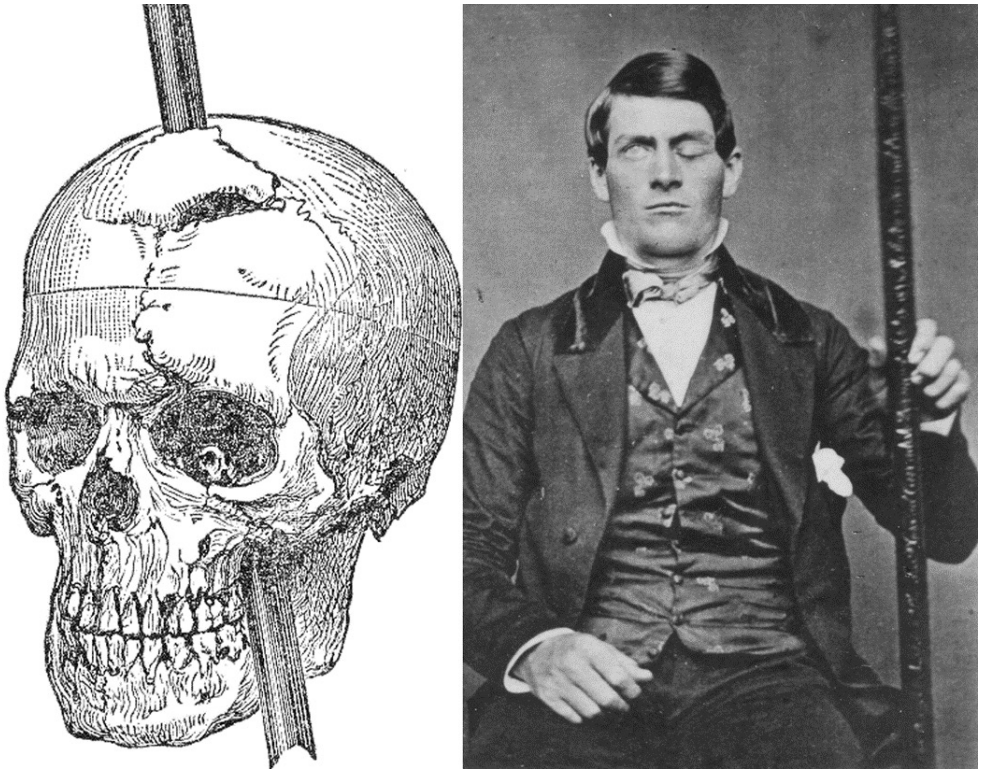
The case of Phineas Gage:

--- 1848, a 25-year-old railroad worker

--- Gage was the unfortunate victim of an accidental explosion that drove an iron rod into his left cheek and out the top head

--- most of his capacities intact, including language and motor functions

--- but personality changed

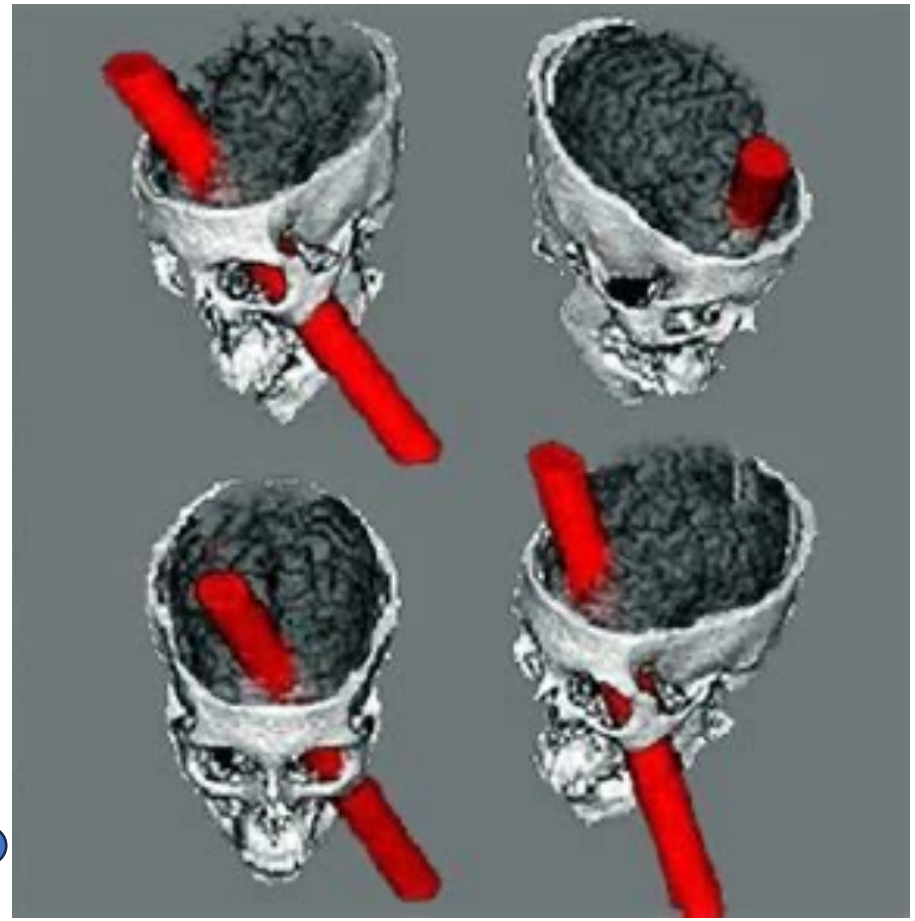


- Popular reports of Gage often depict him as a ***hardworking, pleasant*** man prior to the accident. Post-accident, these reports describe him as a changed man, suggesting that the injury had transformed him into an ***aggressive heavy drinker*** who was unable to hold down a job.

- In a 199 neuroim hineas Gage' ment of th

- Their nju to bo *l cort* (前额叶), w blems with emotional proc nd rational decision-making.

Based on this case, researchers inferred that the brain might be made up of a number of independent regions, each responsible for different functions



Broca’ s area

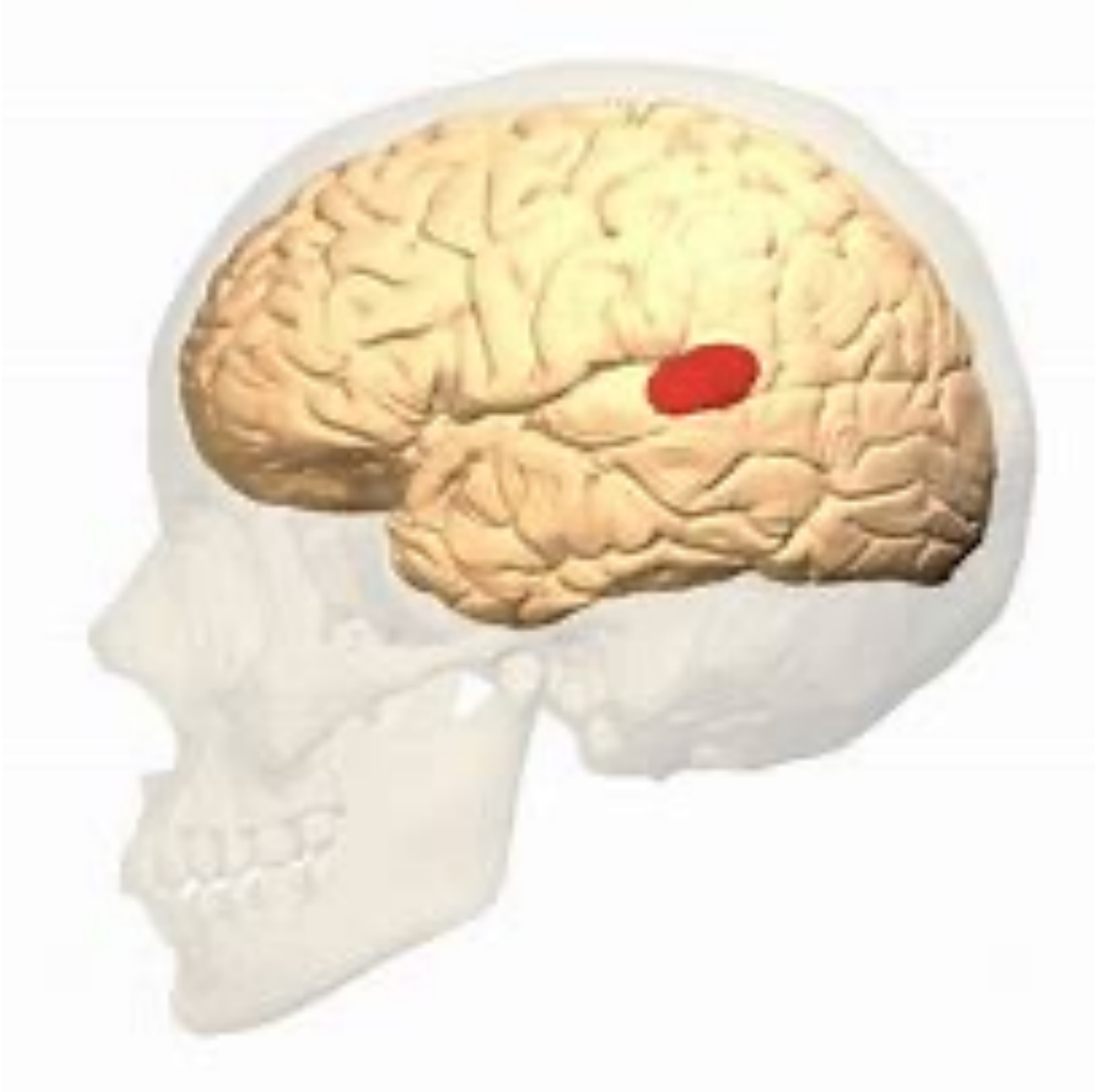
- This area, located in the ***frontal part (额叶)of the left hemisphere*** of the brain, was discovered in 1861 by French surgeon Paul Broca, who found that it serves a vital role in the generation of articulate speech.

- Damage to the frontal lobe can result in a speech disorder known as ***Broca aphasia***, which is characterized by deliberate, telegraphic speech with very simple grammatical structure, though the speaker may be quite clear as to what he or she wishes to say.

Wernicke’ s area

- The Wernicke area is located in the ***temporal lobe (颞叶)*** of the left hemisphere of the brain. This area was first described in 1874 by German neurologist Carl Wernicke.

- Damage to the temporal lobe may result in a language disorder known as ***Wernicke aphasia,*** which is characterized by impaired language comprehension. Despite this impaired comprehension, speech may have a normal rate, rhythm, and grammar.

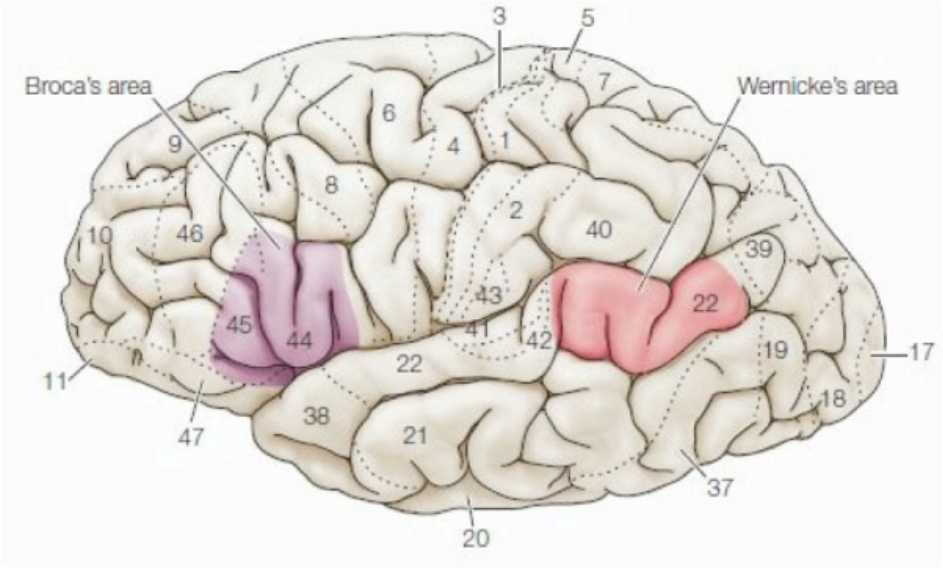



IT AFFECTS ME BOTH IN

Language localization: Broca and Wernicke

- Aphasia is a language disorder that affects how you communicate. Aphasia could be caused by stroke, infection, tumors, or dementia.

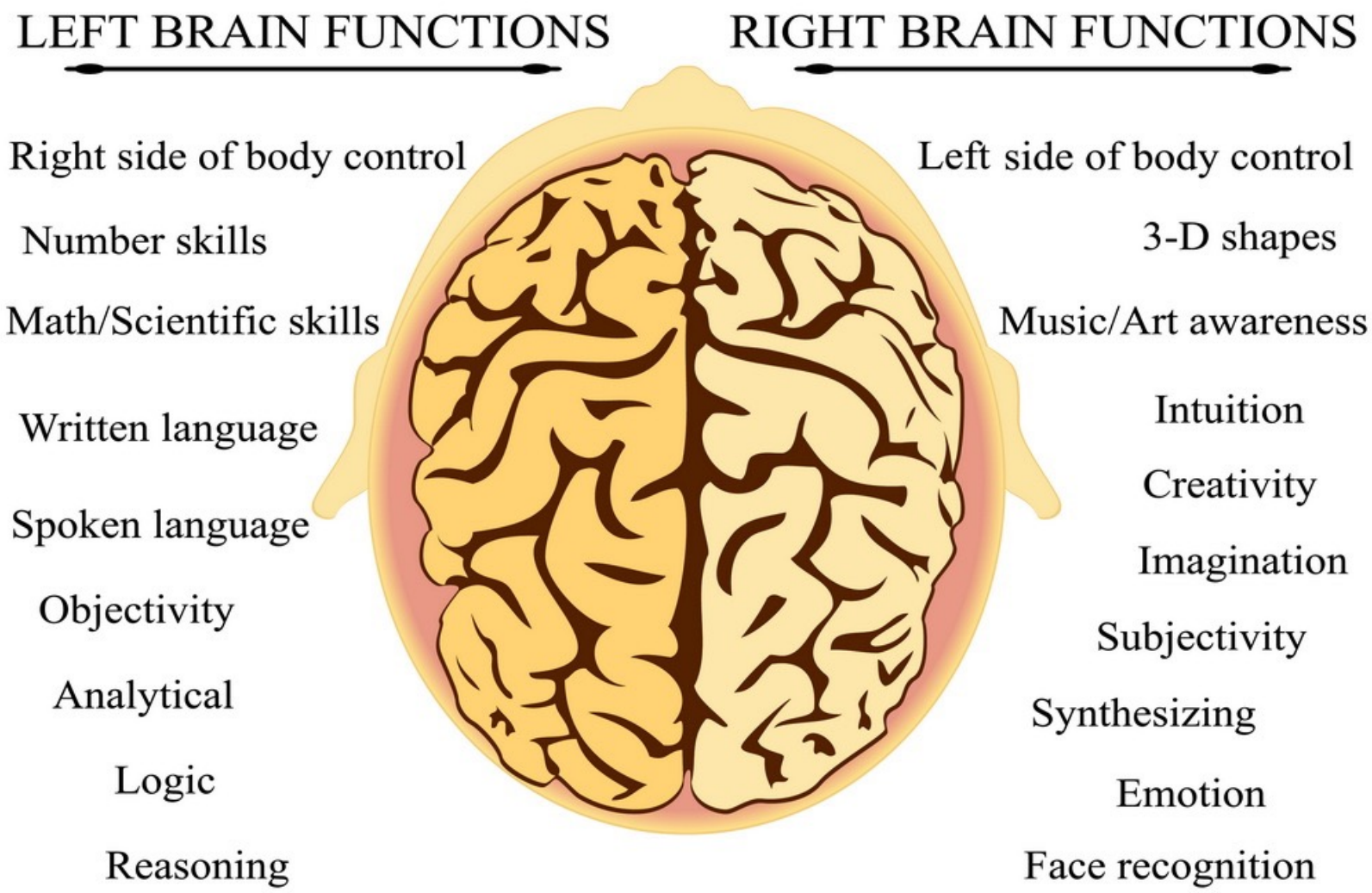
Broca' s area: frontal cortex
Broca' s aphasia: 1. expressive aphasia 2. no issue understanding speech 3. struggle to form complete sentences



Wernicke' s area: temporal cortex
Wernicke' s aphasia: 1. a form of receptive aphasia 2. difficulty understanding speech

What do they in common?

Brain lateralization 偏侧化

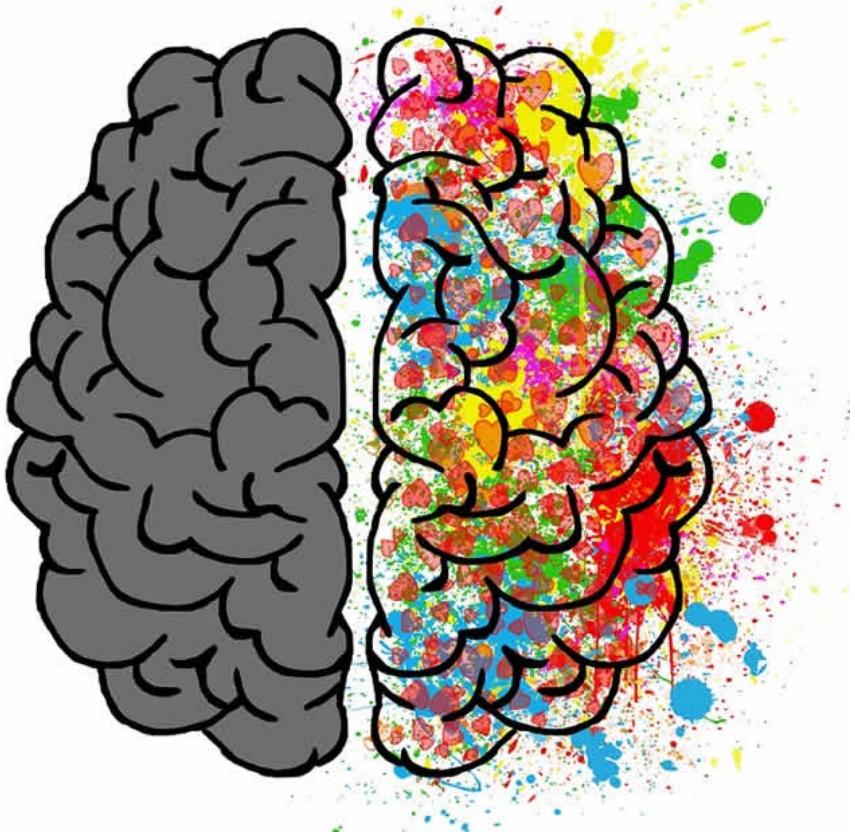


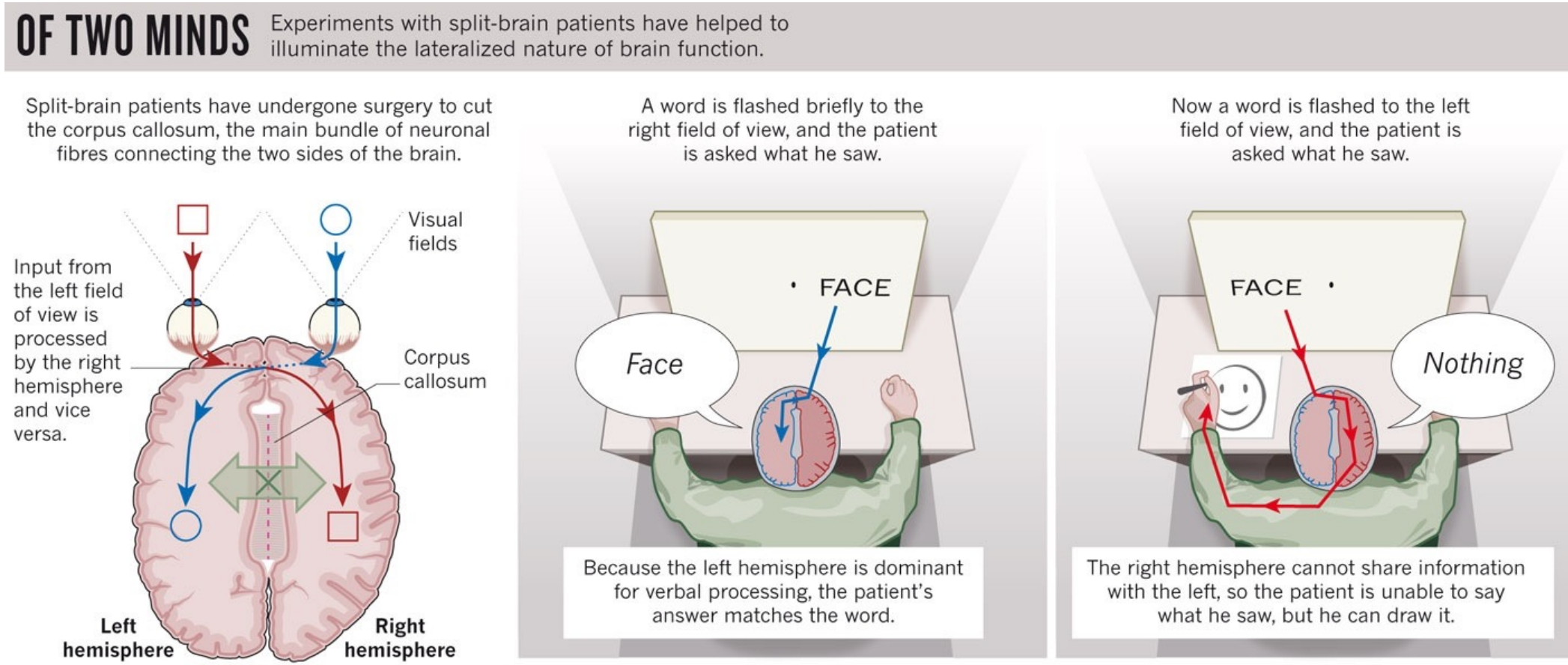
Structural & functional symmetry and asymmetry

- In a neuroscience perspective, the concepts of symmetry and asymmetry are closely tied to the two hemispheres of the human brain
- Two objects may show *mirror symmetry* with regard to shape and structure, although the *functions of the two are asymmetrical*.
- A similar distinction applies to the two cerebral hemispheres, which at least on the surface seems to be symmetrical mirror images, making up the left and right halves of the brain

Split brain experiment

- ***Roger Sperry*** performed experiments on cats, monkeys, and humans to study functional differences between the two hemispheres of the brain.
  - Sperry severed the **corpus callosum** (胼胝体) in cats and monkeys and he found that if hemispheres were not connected, they functioned independently of one another, which he called a ***split-brain***.
  - Later, Sperry tested the same idea in humans, and he found that the hemispheres in human brains had different functions



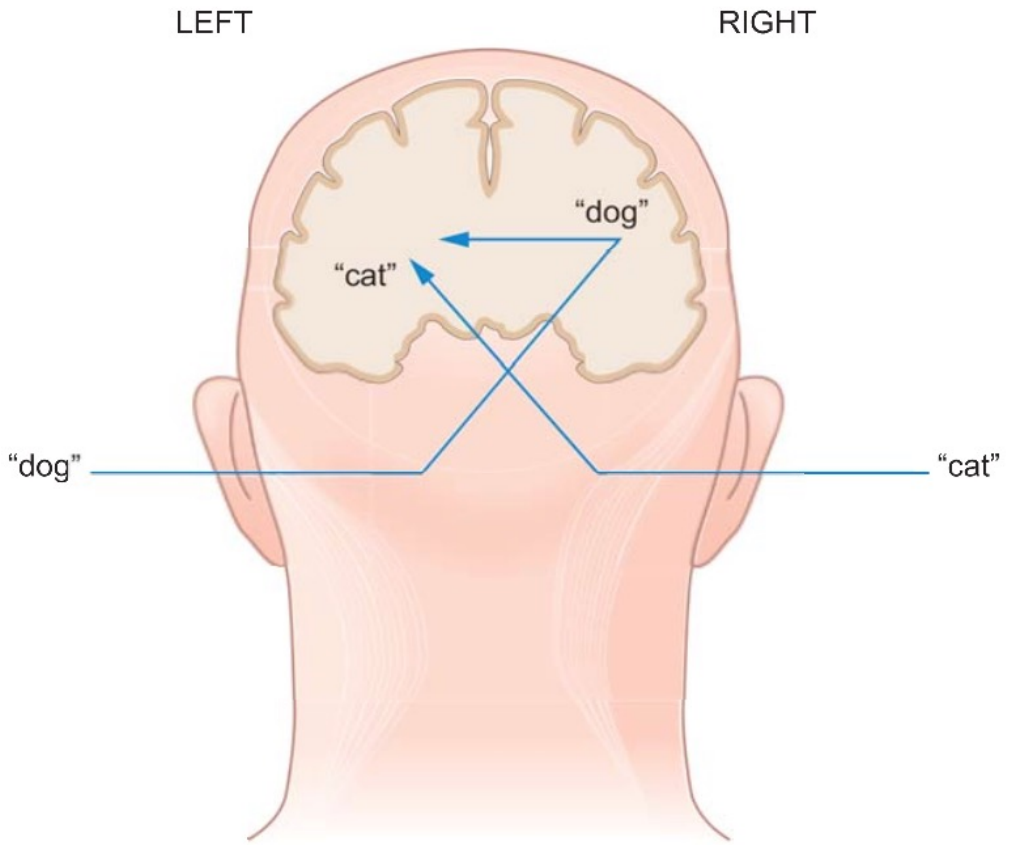


- When asked to report what they had seen on the screen the patients reported, to the surprise of everyone, that they had not seen anything when the words were projected in the left visual half-field, i.e. to the right hemisphere. There was however nothing wrong with their eyesight.
- When the words were projected in the right visual half-field, i.e. to the left hemisphere, the patients correctly reported the words shown.
- However, when asked to use his left hand, to pick up the corresponding item from the table, the patients invariably picked the item that corresponded to the word they reported having not seen.

Dichotic listening 双听技术，双耳分析法

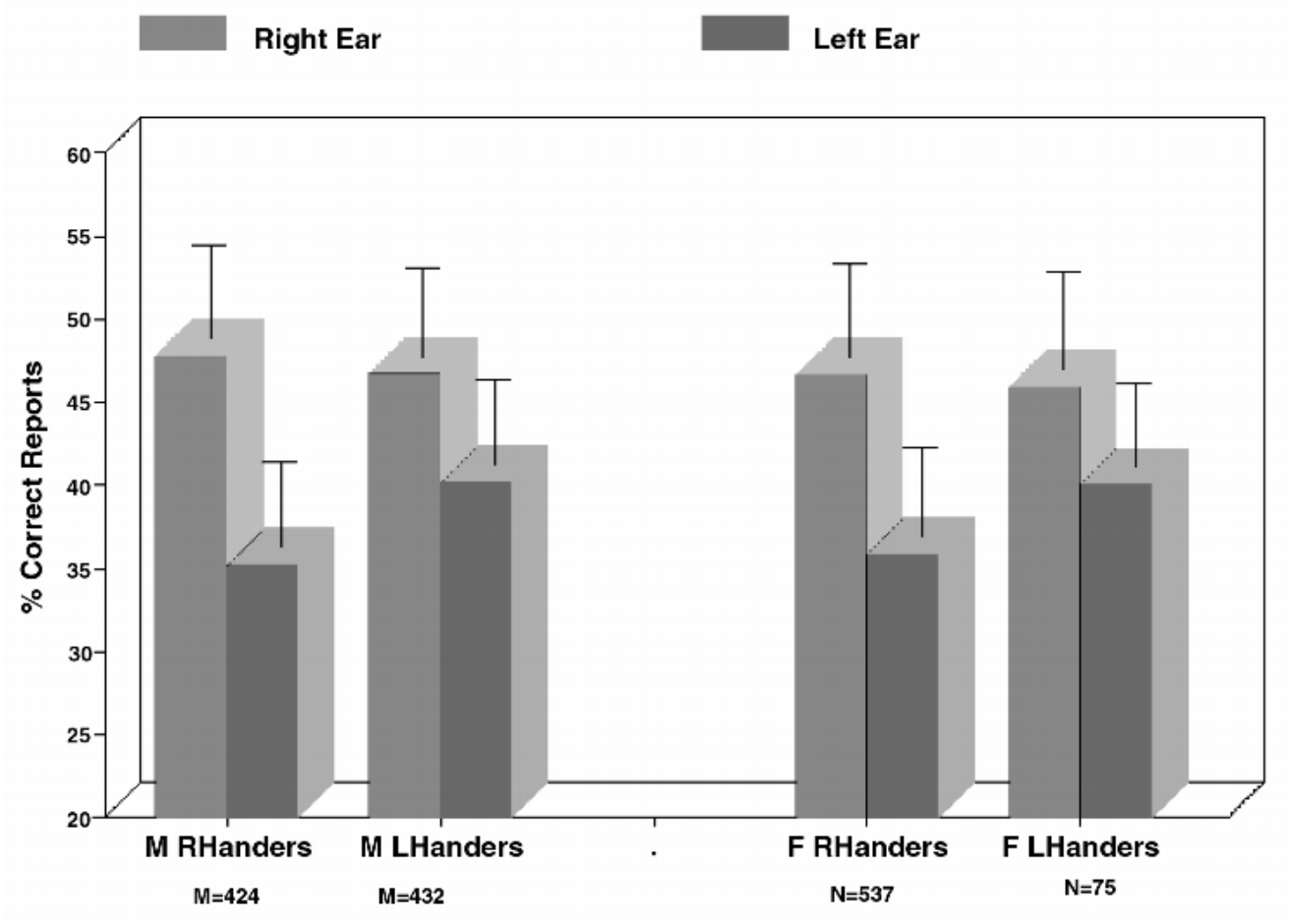
- Experimental tasks
  - Subject listen to spoken words over headphones
  - A different word spoken into each ear

- Findings:
  - One of the words seems more distinct than the other
  - Advantage of the right ear in processing language sounds
  - Why?



Handedness vs. brain lateralization

- Evidence shows that left-handers are indeed more likely than right-handers to have atypical lateralization for language around 30% of left-handers vs 5% of right-handers have atypical lateralization for speech.



Knecht, S., Dräger, B., Deppe, M., Bobe, L., Lohmann, H., Flöel, A., ... & Henningsen, H. (2000). Handedness and hemispheric language dominance in healthy humans. *Brain*, *123*(12), 2512-2518.

Szaflarski, J. P., Binder, J. R., Possing, E. T., McKiernan, K. A., Ward, B. D., & Hammeke, T. A. (2002). Language lateralization in left-handed and ambidextrous people: fMRI data. *Neurology*, *59*(2), 238-244.

Bottom-up vs. Top-down

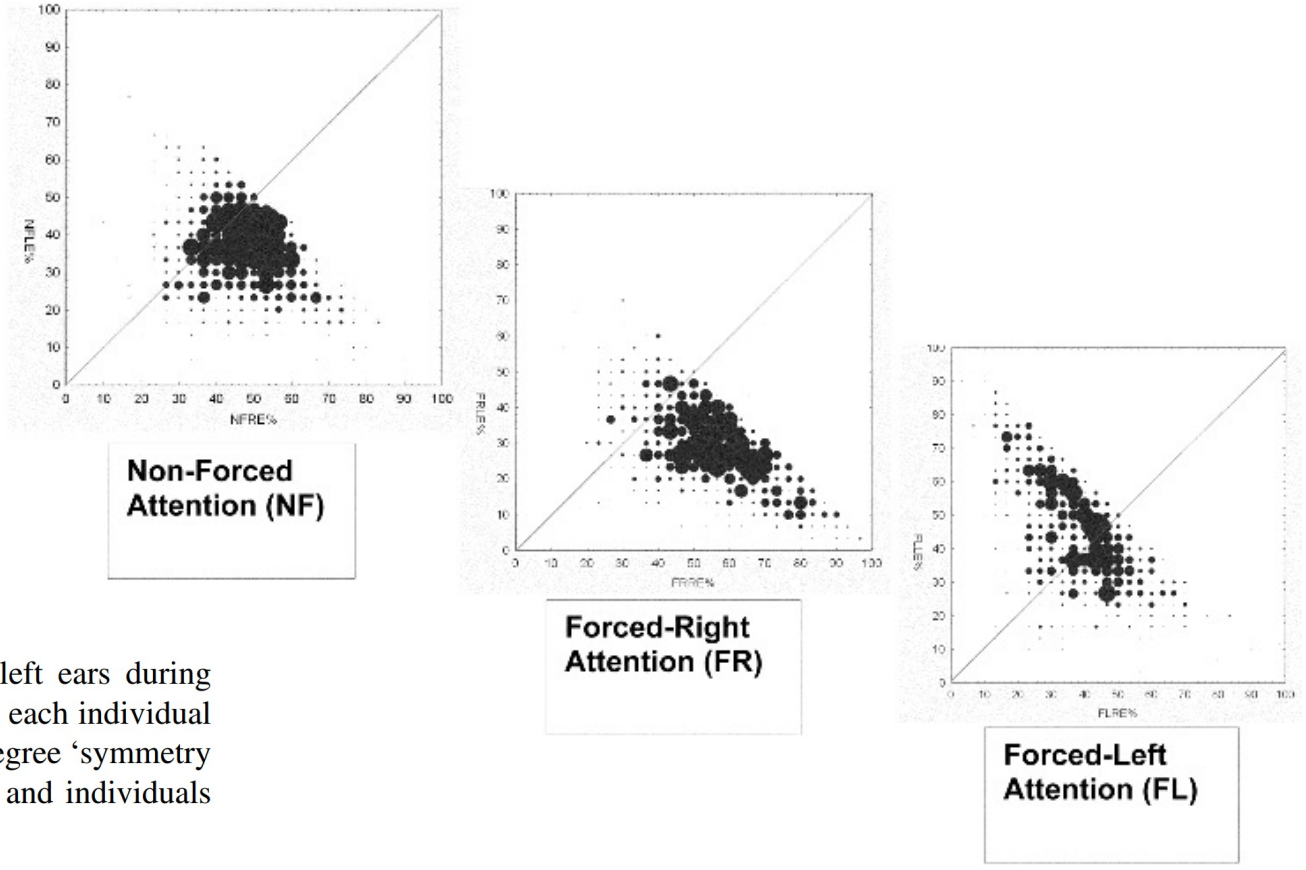
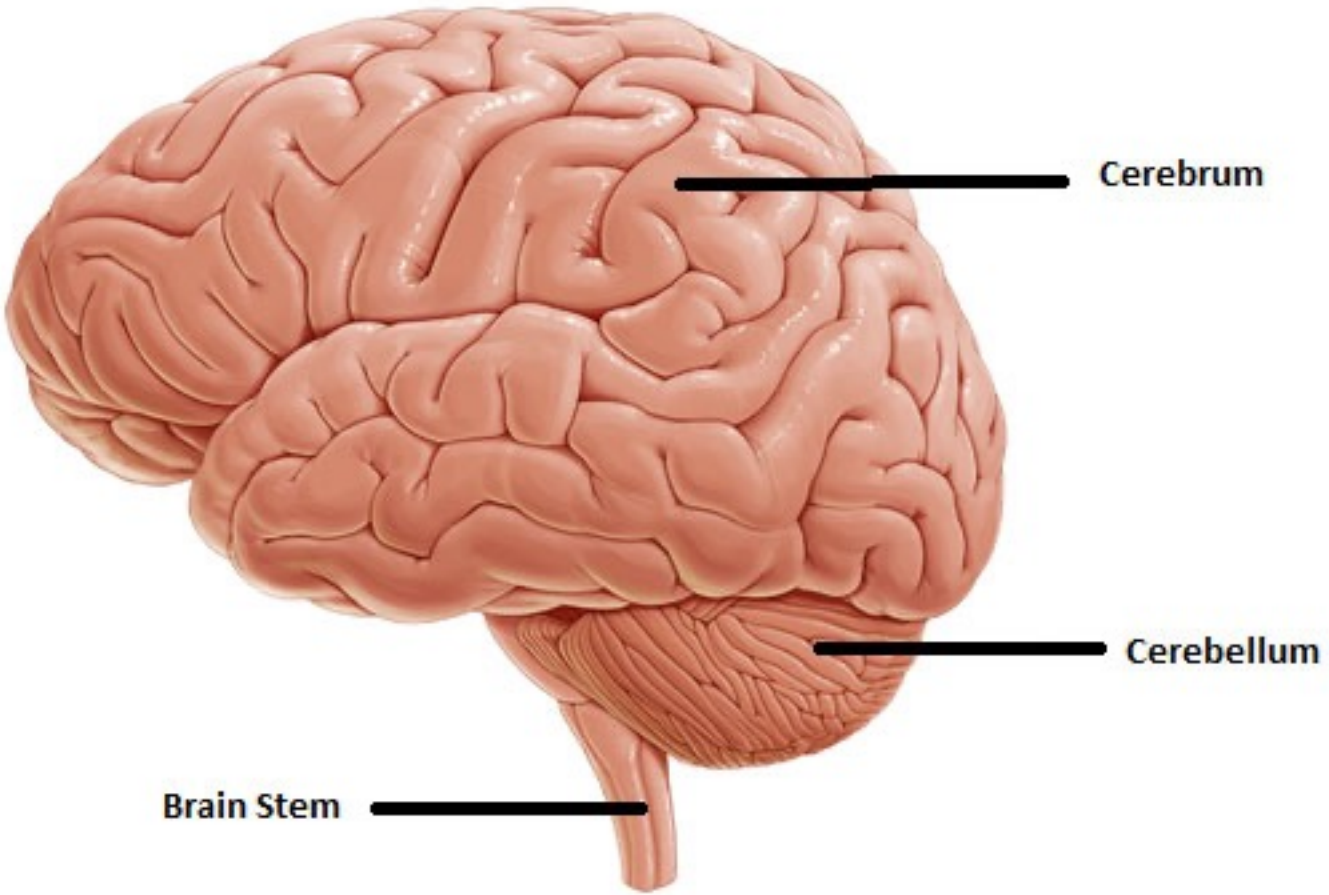


Figure 6. Mean percent correct reports from the right and left ears during divided attention (NF) and focused attention (FR and FL) with each individual plotted in the scatter plot. The diagonal line represents the 45-degree 'symmetry line', with individuals falling below the line showing a REA and individuals above the line showing a left ear advantage (LEA).

Hugdahl, K., Westerhausen, R., Alho, K., Medvedev, S., Laine, M., & Hämäläinen, H. (2009). Attention and cognitive control: unfolding the dichotic listening story. *Scandinavian journal of psychology*, *50*(1), 11-22.



- Largest and uppermost portion
- Emotion
- Executive function
- Language
- Motor
- Personality
- etc.

- Balance
- Coordination of brain and body
- etc.

- Involuntary actions
- Heart beat
- Swallow
- Breathing
- etc.

Cerebral Cortex = Outer Grey Matter Layer

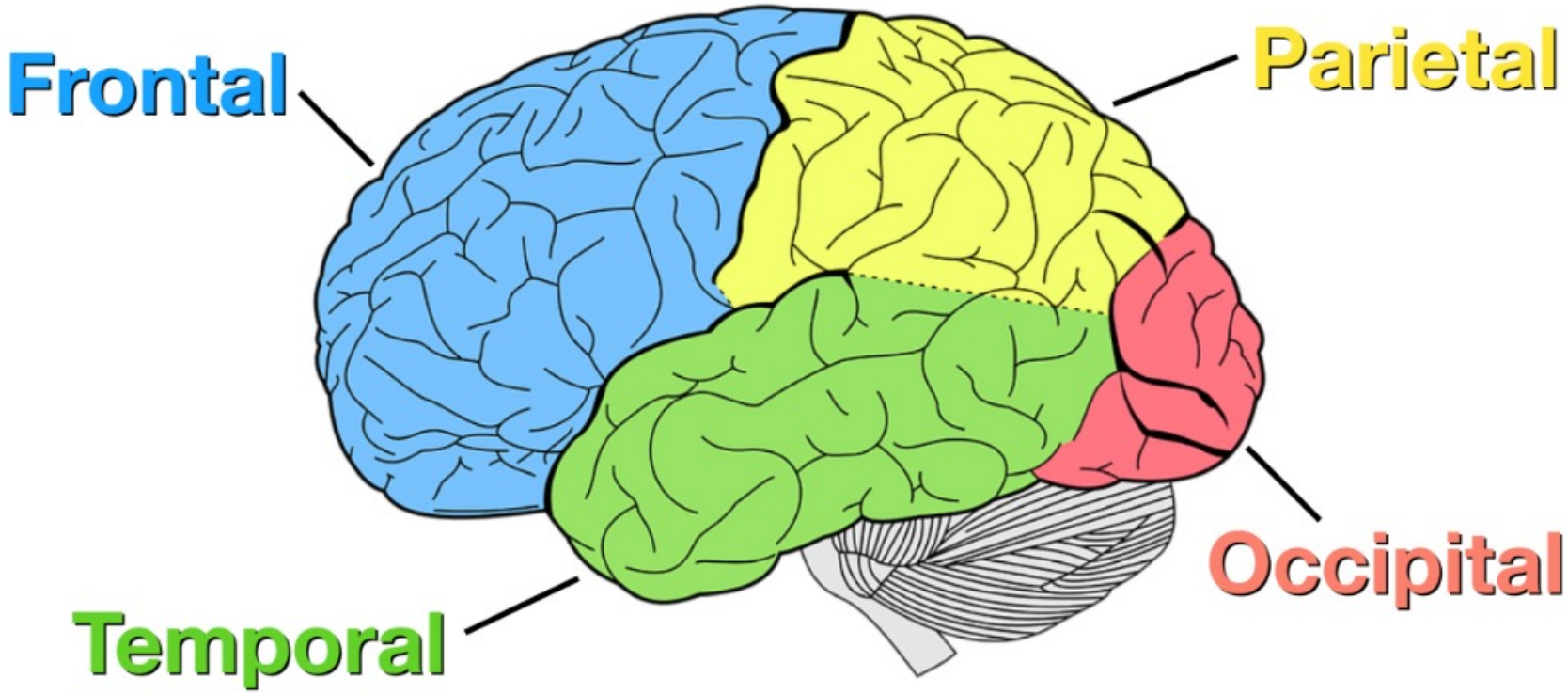
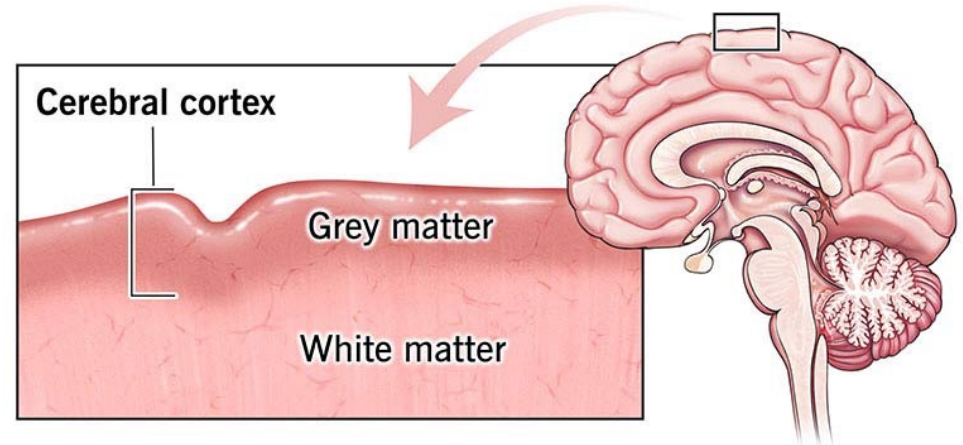


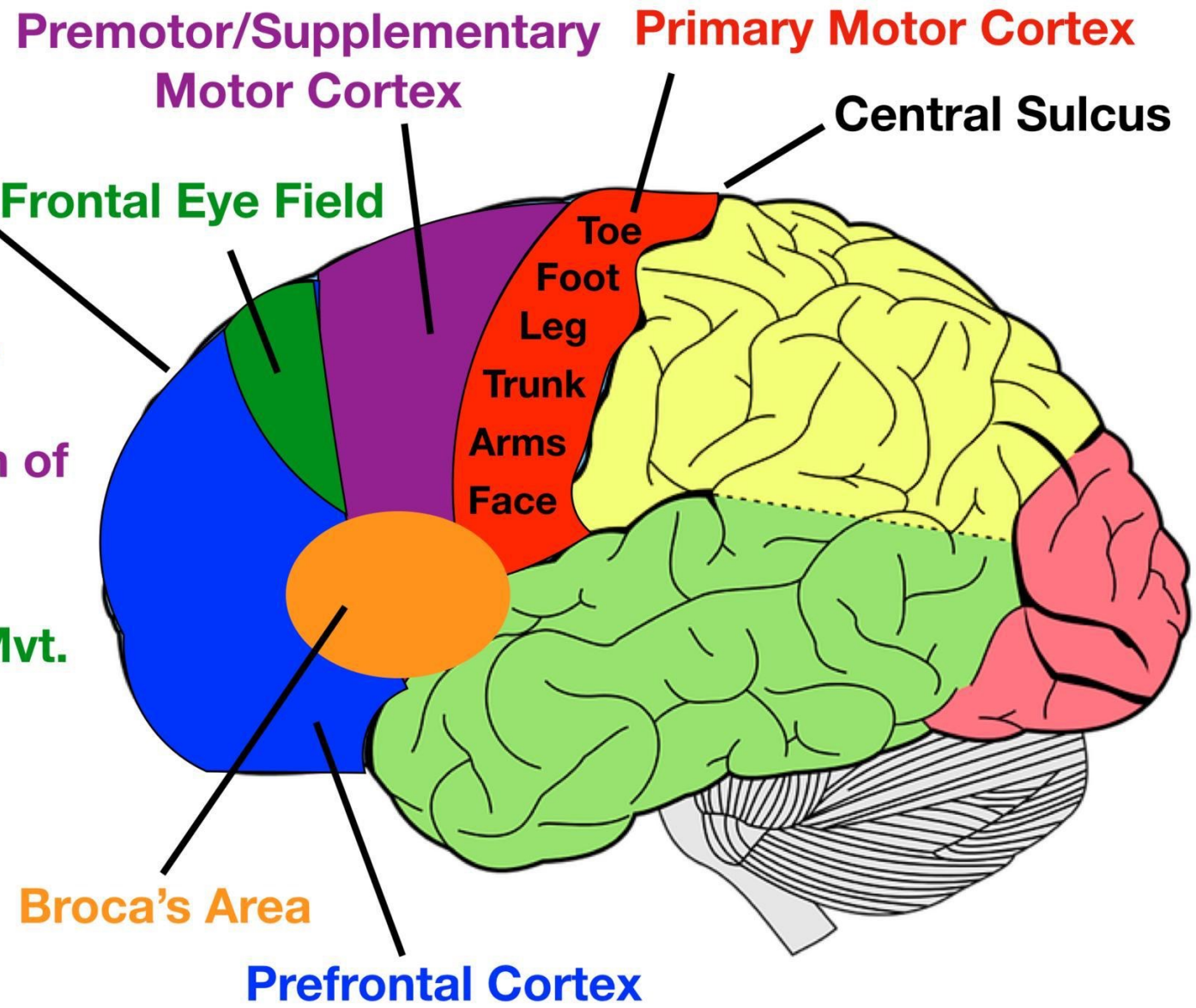
Image: The cerebrum is made up of an outer layer of grey matter, known as the cerebral cortex, which surrounds the inner white matter layer. The cerebral cortex has 4 main lobes: frontal, parietal, occipital, and temporal.



Frontal

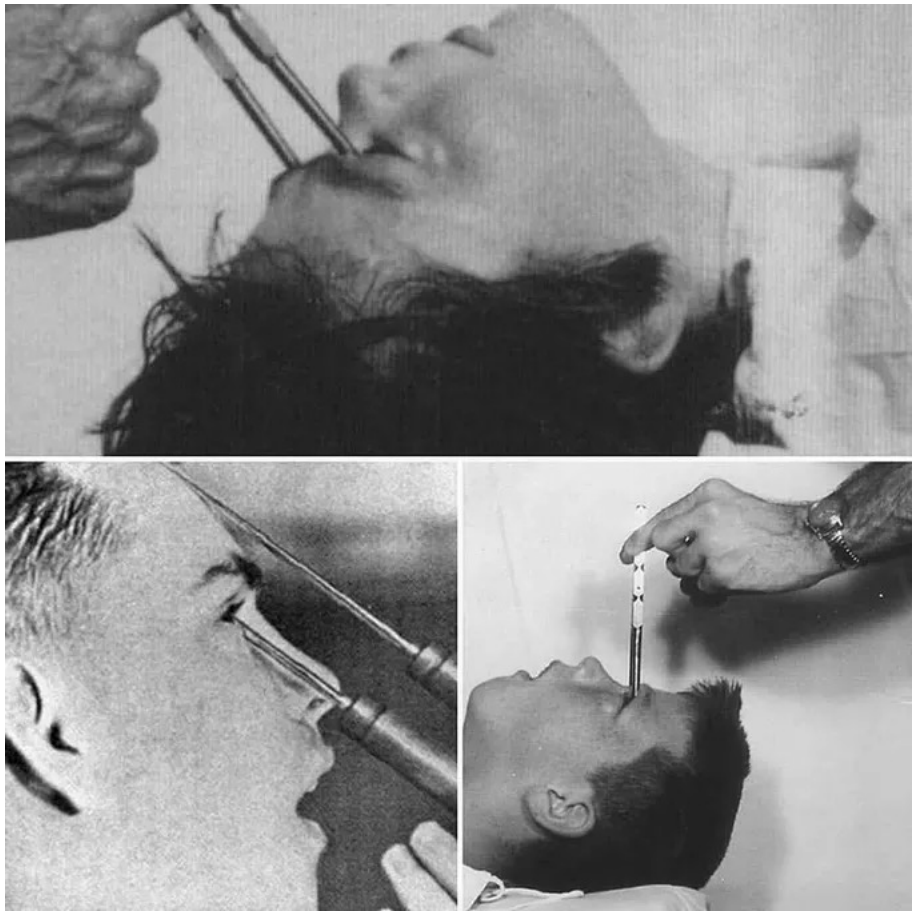
Functional Areas

- Primary Motor Cortex
  - Voluntary Muscle Mvt.
- Premotor/S.M.C (MAC)
  - Planning/Coordination of Movement
- Frontal Eye Field
  - Voluntary Rapid Eye Mvt.
- Prefrontal Cortex
  - Executive Functions, Behavior, Personality
- Broca's Area
  - Muscles of Speech
  - Production of Speech



Lobotomy (前脑叶白质切除术)

- In late 19th and early 20th century, lobotomy was developed as neurosurgical treatment for psychiatric disorder (e.g. schizophrenia, depression) that involves severing connections in the brain's prefrontal cortex.
- The treatment involved drilling holes into patients' skulls & pouring alcohol into the ***prefrontal cortex*** (前额叶); and coring out regions of the brain with needles.



Age has little weight in the choice of a suffering patient. The candidate may be eight years old (Fig. 17) or eighty (Fig. 18). Better social results are obtained in aged patients, probably because

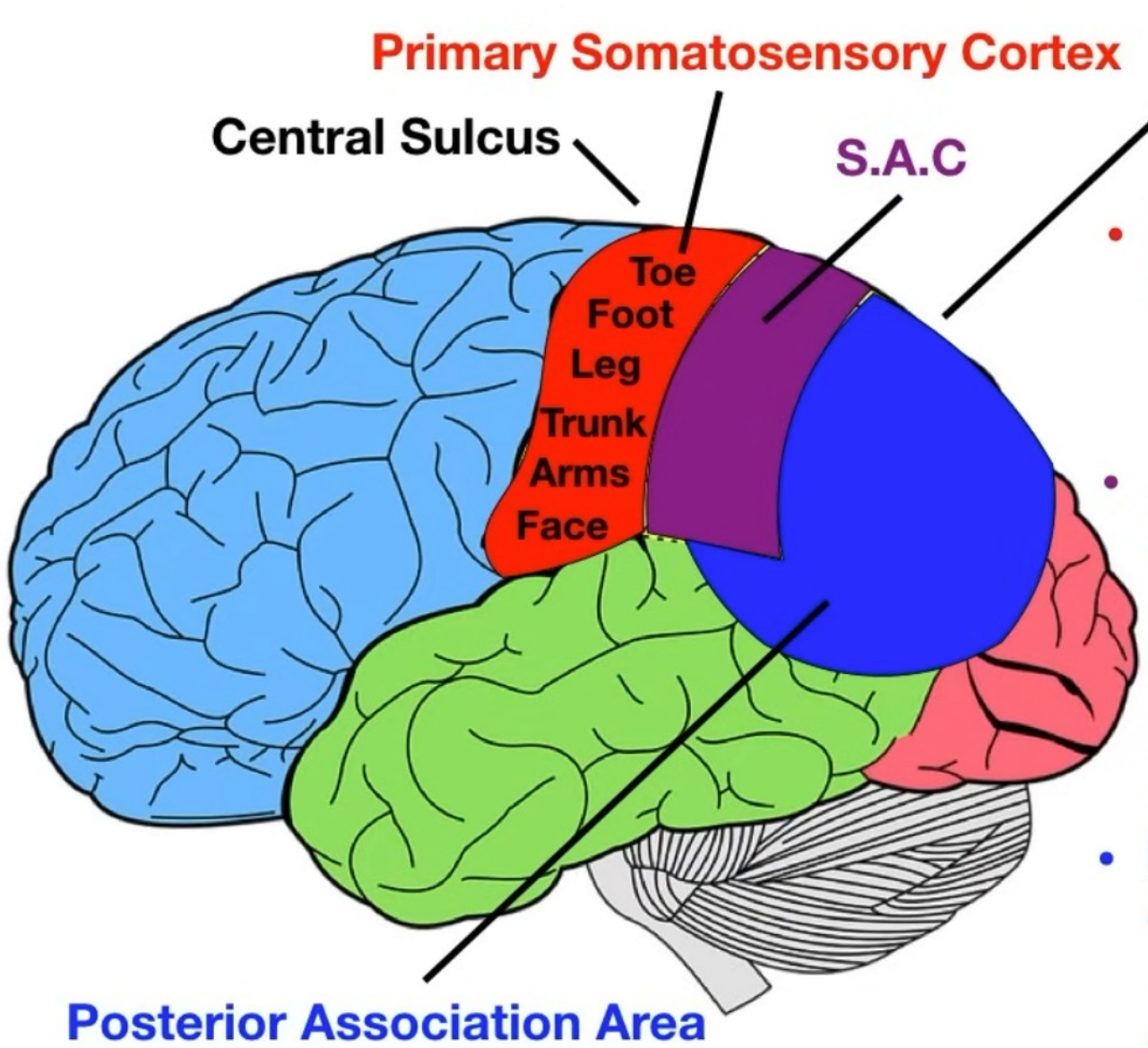
a. b.

Fig. 17. Schizophrenic boy eight years old, who had to be caged in the basement because of his violent behavior. (a) Before lobotomy. (b) A year after lobotomy; no longer dangerous.

In some instances, the best that can be done for the family is to return to the patient to them in an innocuous state, a veritable household pet. (Fig. 22).

a. b.

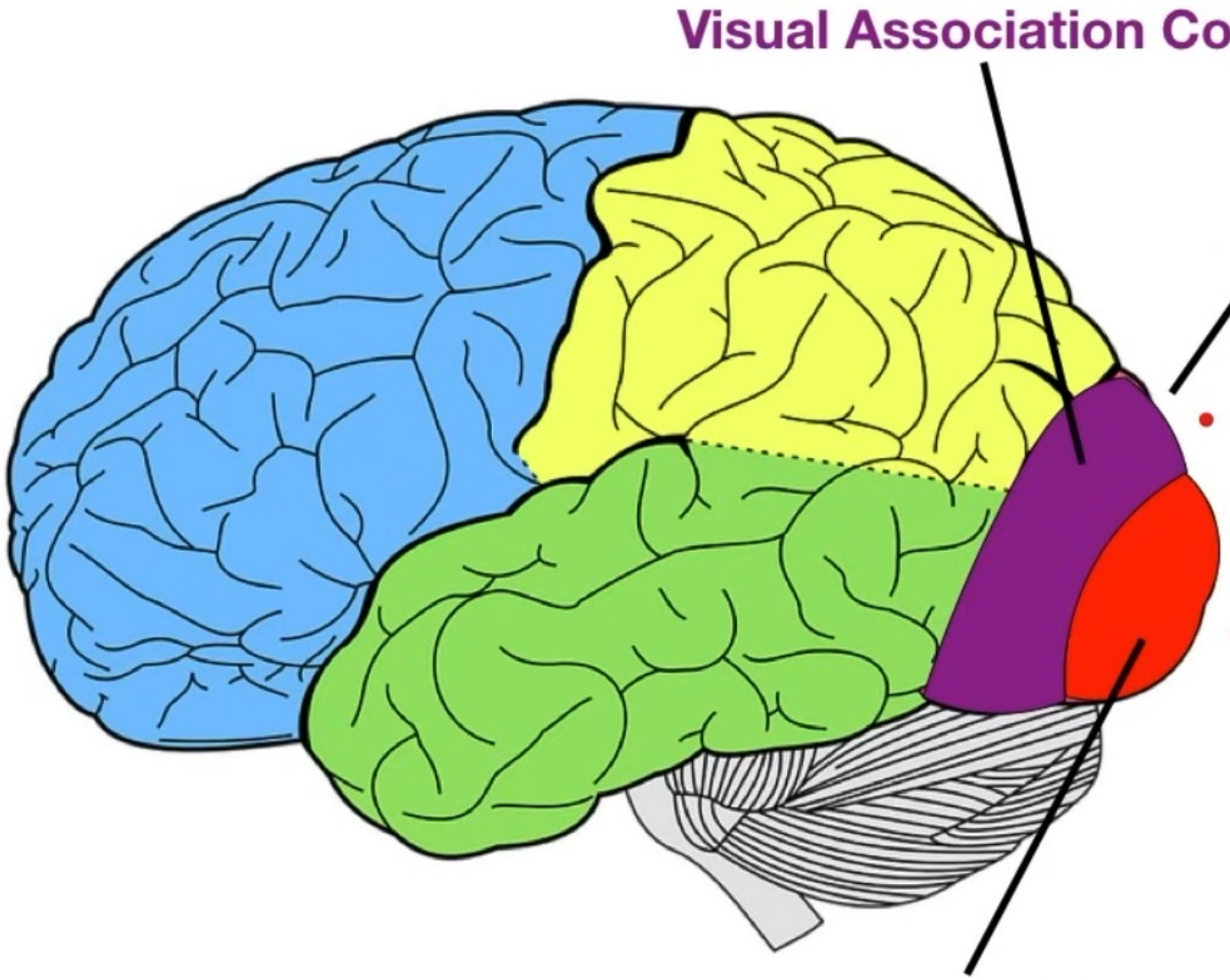
Fig. 22. Case 624. Simple schizophrenia patients make nice household pets after operation. (a) Before lobotomy. (b) One year later.



Parietal

Functional Areas

- Primary Somatosensory Cortex
  - Awareness of Somatic Sensations
  - Touch, Pain, Temperature
- Somatosensory Assoc. Cortex
  - Processiong/Analyzing Somatic Sensations
  - Memory of Sensations
  - Recognition of Sensations
  - Proprioception
- Posterior Association Area
  - Visual, Auditory, Somatosensory Areas Meet
  - Spacial Awareness of Body



Occipital

Functional Areas

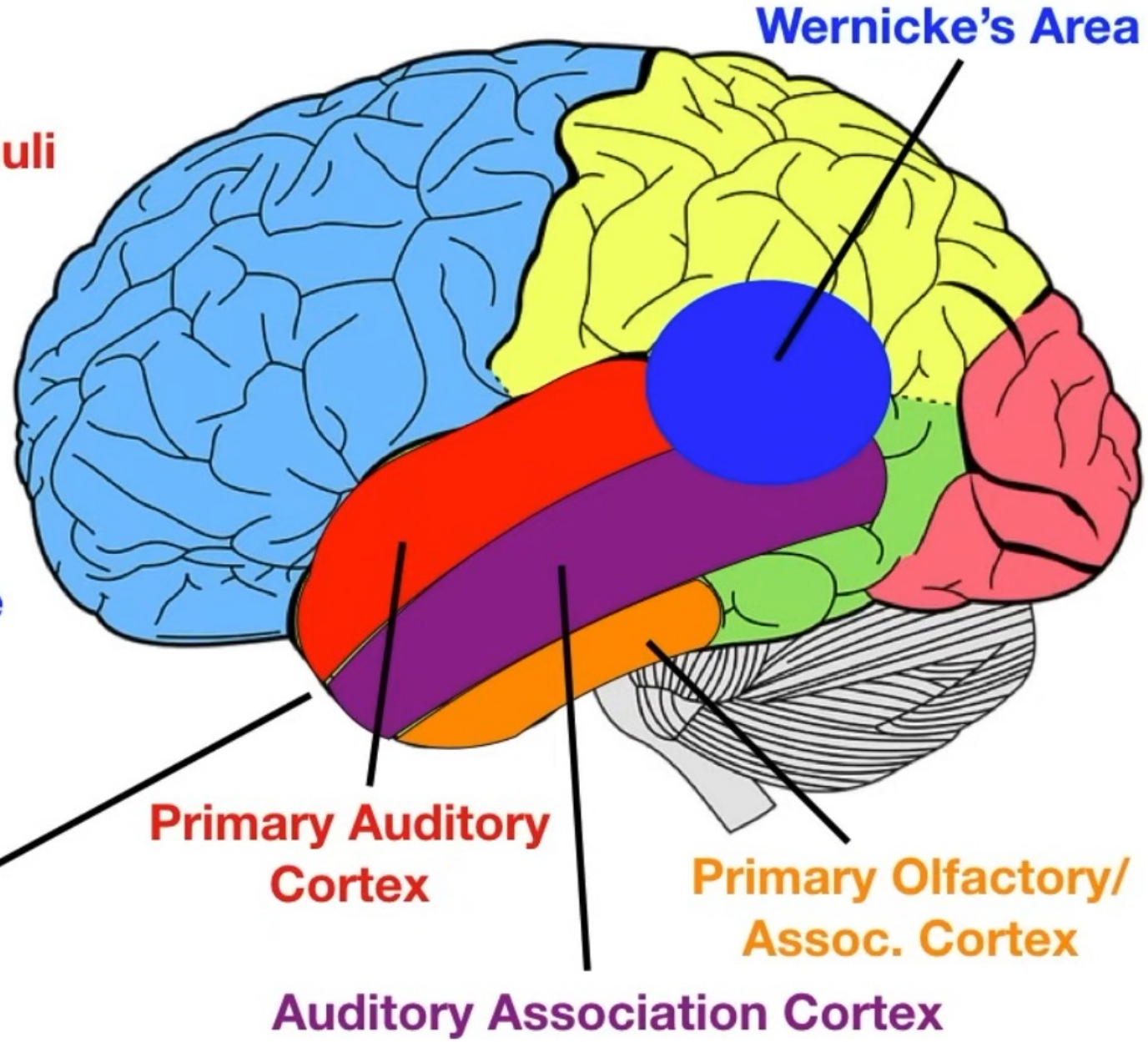
- Primary Visual Cortex
  - Awareness of Visual Stimuli

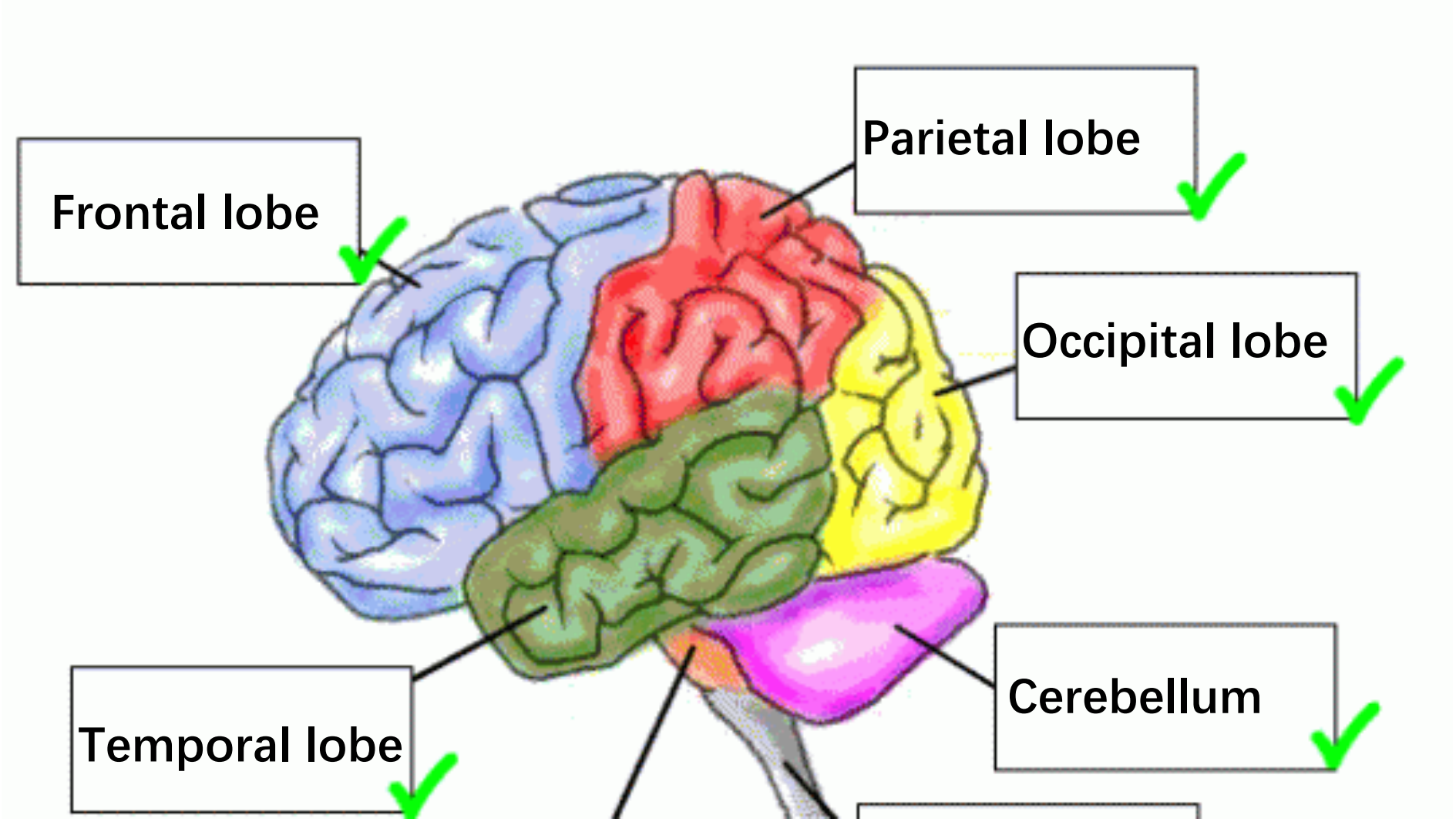
- Visual Assoc. Cortex
  - Process/Analyze Visual Info
  - Understand Visual Stimuli
  - Recognize Visual Stimuli
  - Memory of Visual Stimuli

Functional Areas

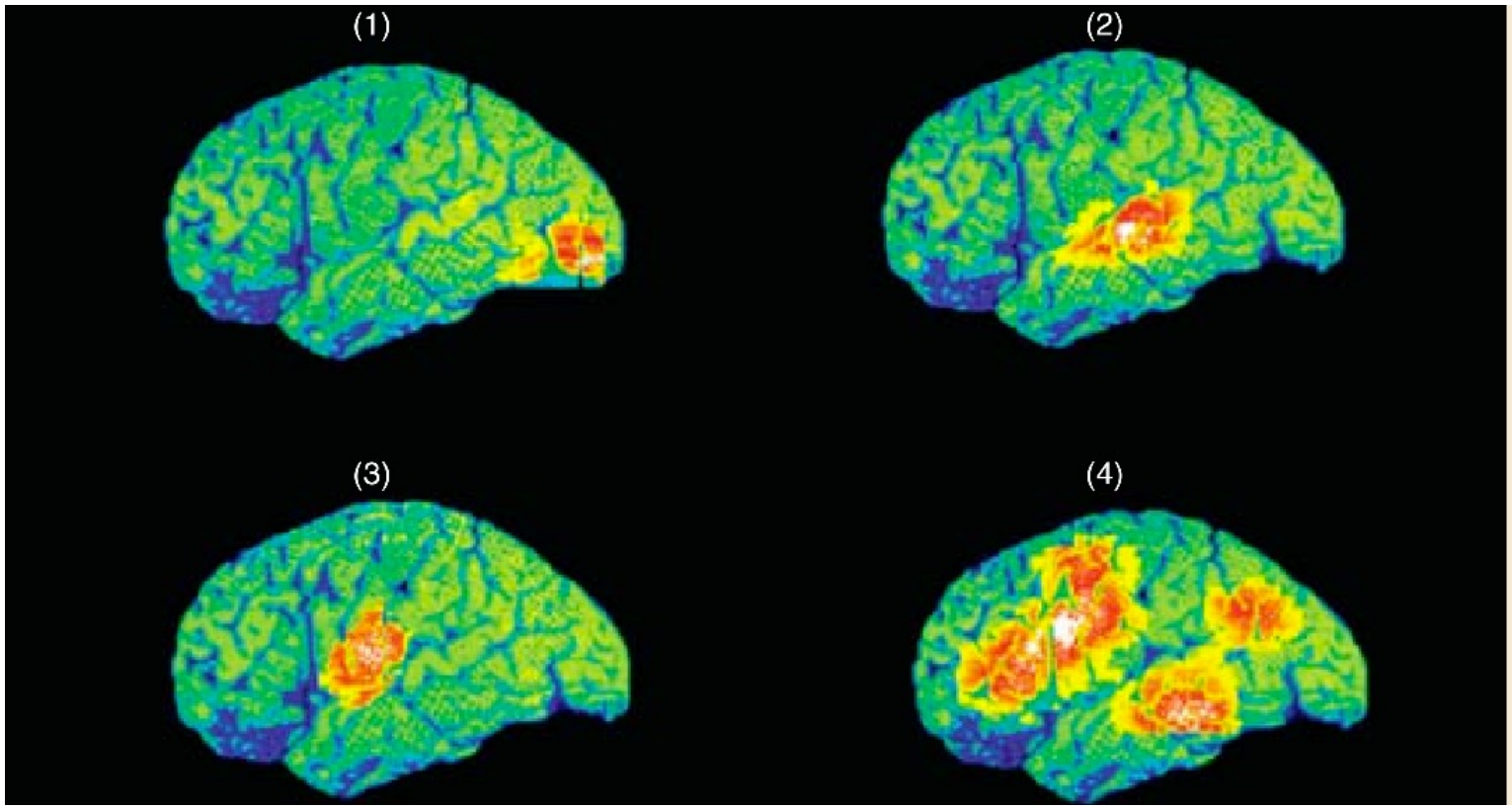
- Primary Auditory Cortex
  - Awareness of Auditory Stimuli
- Auditory Assoc. Cortex
  - Process, Analyze, Understand, Recognize, Memory of Sounds
- Wernicke's Area
  - Comprehend/Understand Written & Spoken Language
- Primary Olfactory Cortex/ Association Cortex
  - Awareness of Smell & Processing of Smell

Temporal




Frontal lobe
Parietal lobe
Occipital lobe
Temporal lobe
Cerebellum

Using what you learned from the discussion of language areas in the brain, try to match each description (A–D) to one of the four diagrams (1)–(4) in Figure 12.3, with a brief explanation of your choices. Each diagram is a representation of information from a PET scan showing how blood flow in the brain is concentrated in different areas during different activities. More intense activity is shown in brighter colors.

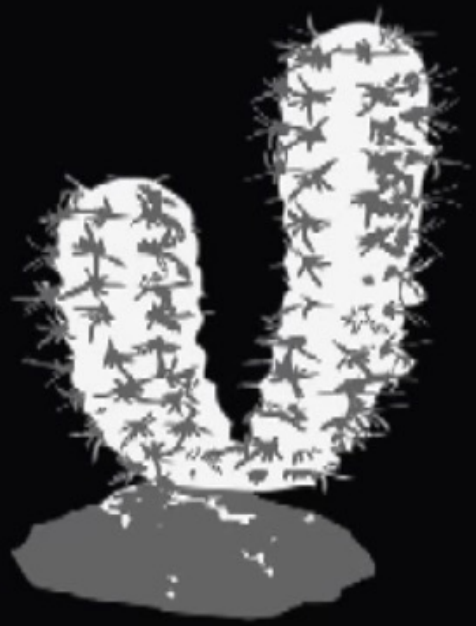


A Hearing/processing words

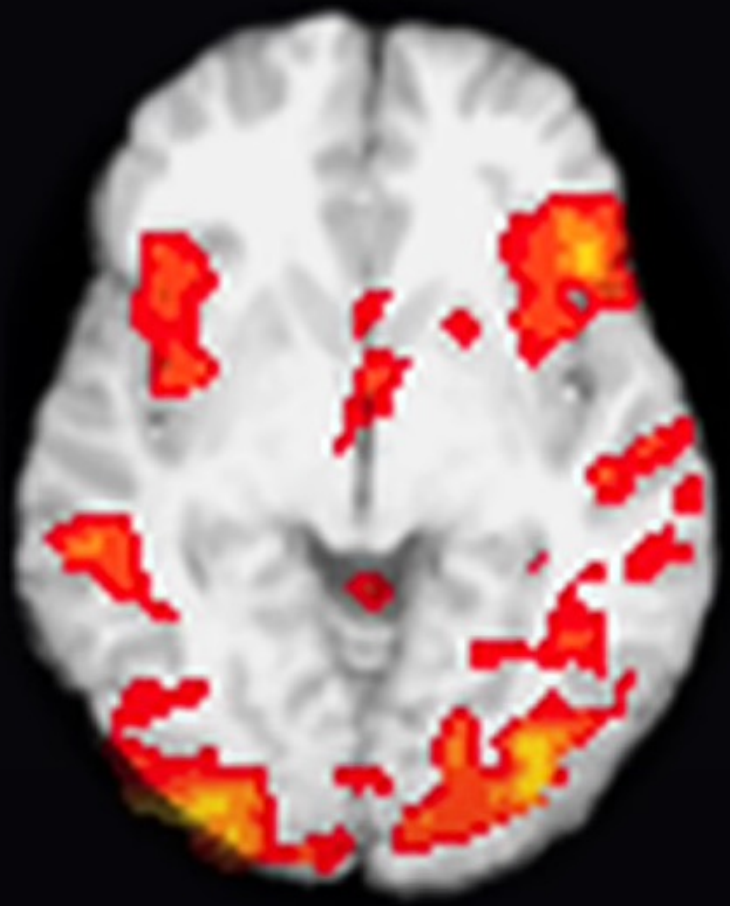
B Speaking/articulating words

C Generating/preparing to speak words

D Seeing/Reading words

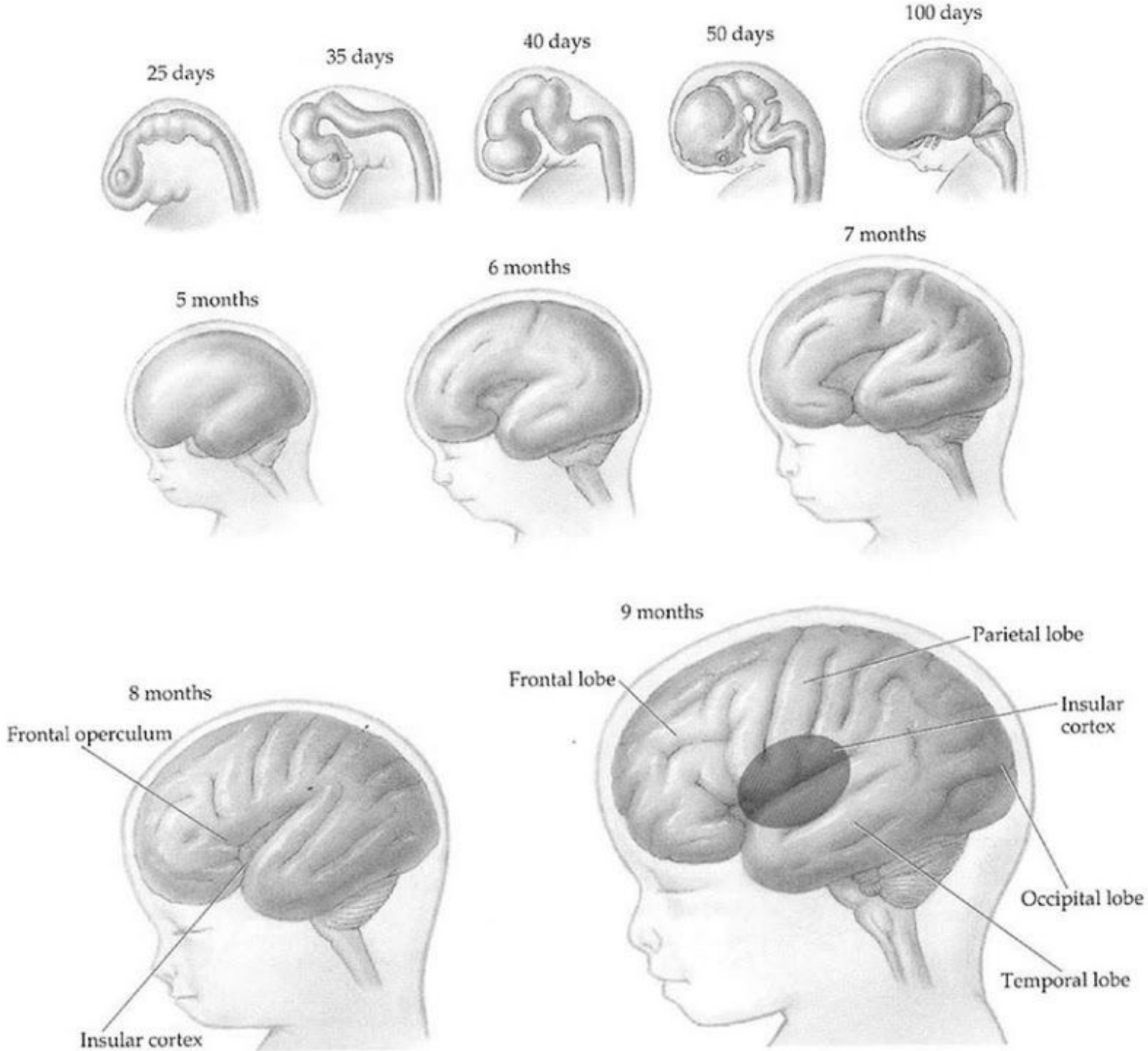


functional MRI Data



Brain development

- Human infants commonly produce their first words at the end of the first year, and they produce utterances with a substantial vocabulary only at about two years of age.
- However, that infants' receptive capacities are substantially better than their production:
    - Long before any effective language production, infants are sensitive to the particular vocal sounds

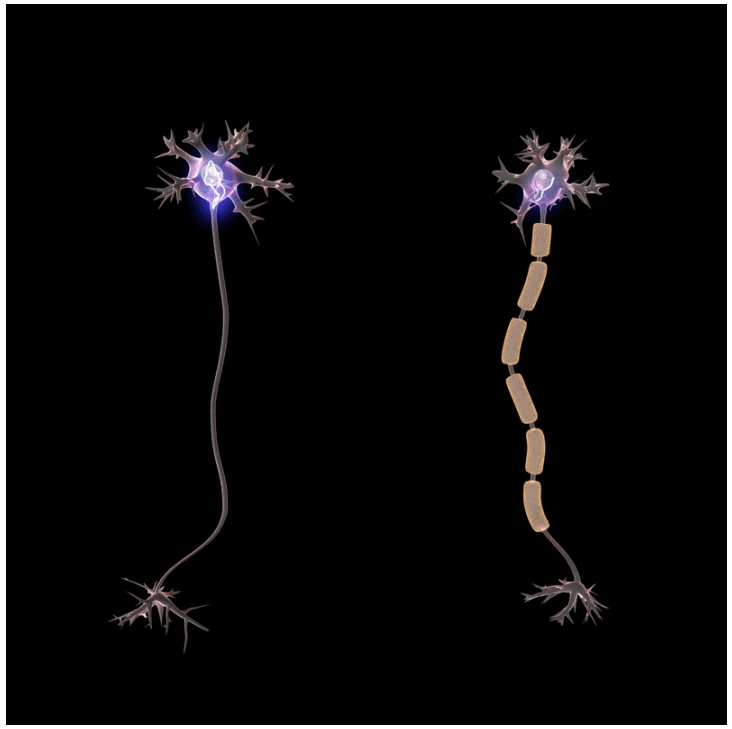

25 days
35 days
40 days
50 days
100 days
5 months
6 months
7 months
8 months
Frontal operculum
Insular cortex
9 months
Parietal lobe
Frontal lobe
Insular cortex
Occipital lobe
Temporal lobe

Development of human brain

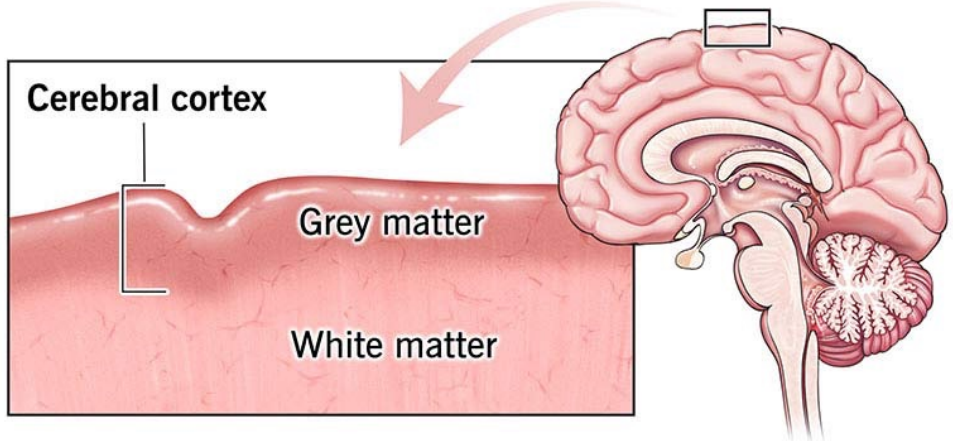
- Brain development is all about ***forming connections.*** Children's' brains respond to their life experiences and the world around them.
- The most-used connections between brain cells are strengthened while others are pruned.
- Typically, brain reaches a mature state of development in early adulthood. However, the creation and dissipation of neural connections, are persist across the lifespan.

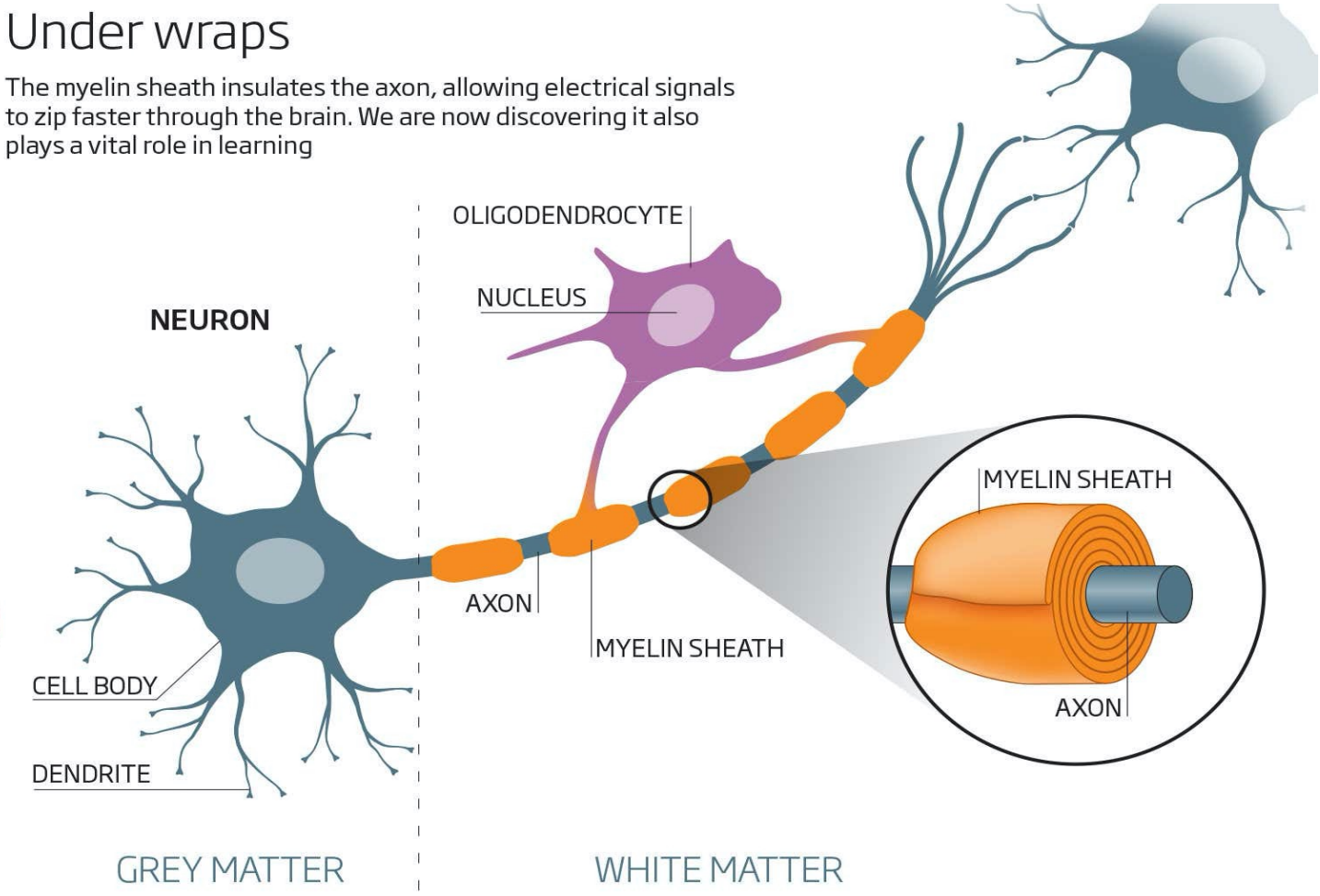
Major brain changes

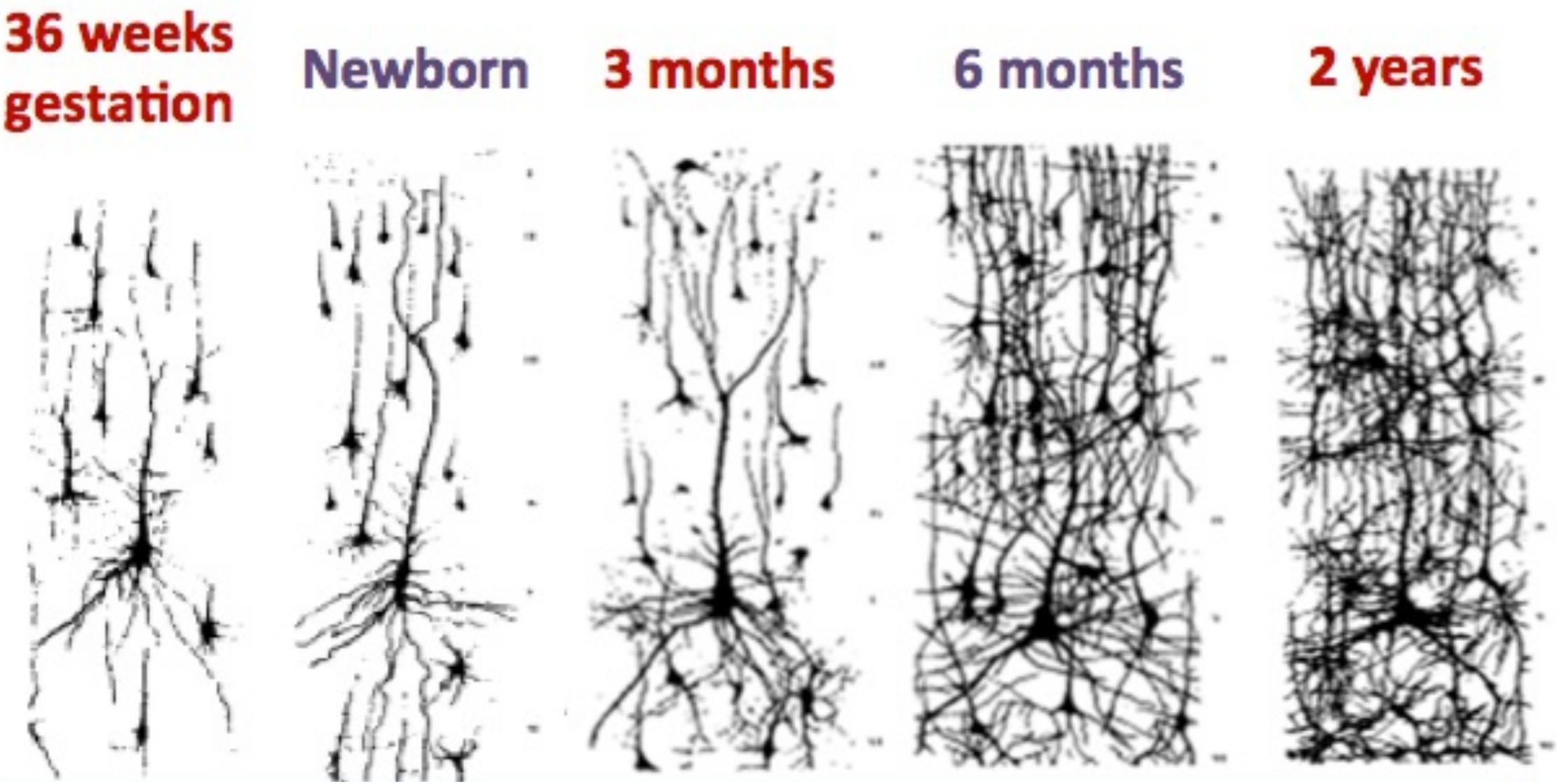
- **Proliferation of dendritic branches (树突分支增生)**: brain cells sprout branches that connect one cell to many others
- **Myelination (髓质化)**: covering the axons with myelin, which allows for rapid movement of brain electrical signals
- **Pruning**: Dying off of brain cells and connections that do not get used



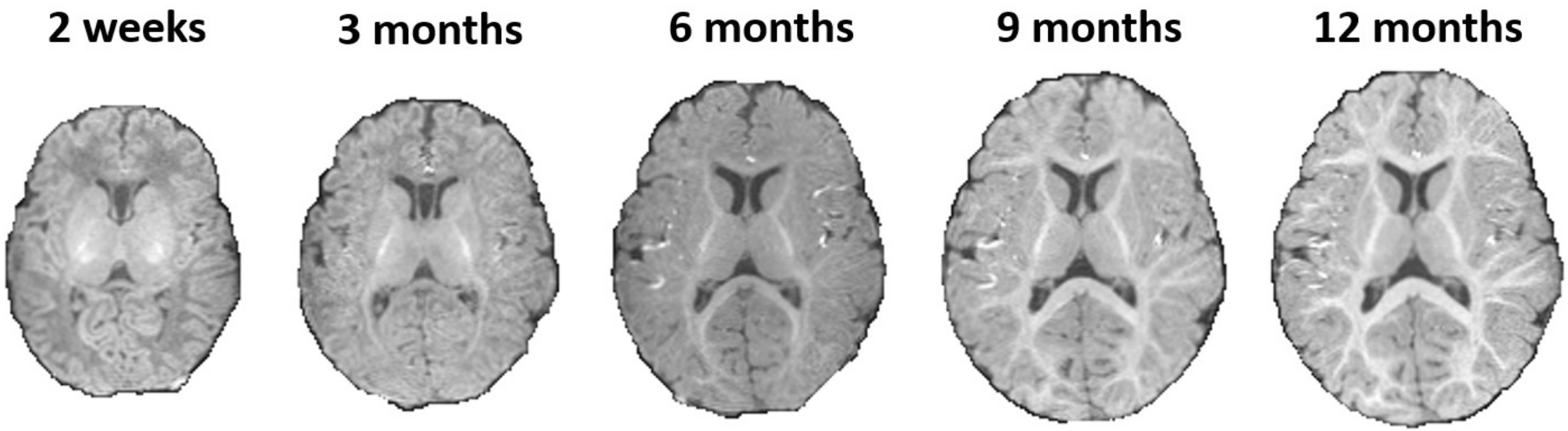
- grey matter = nerve cell bodies, dendrites (树突), bundles of unmyelinated axons
- white matter = myelinated(髓磷脂质的) processes (white in color)





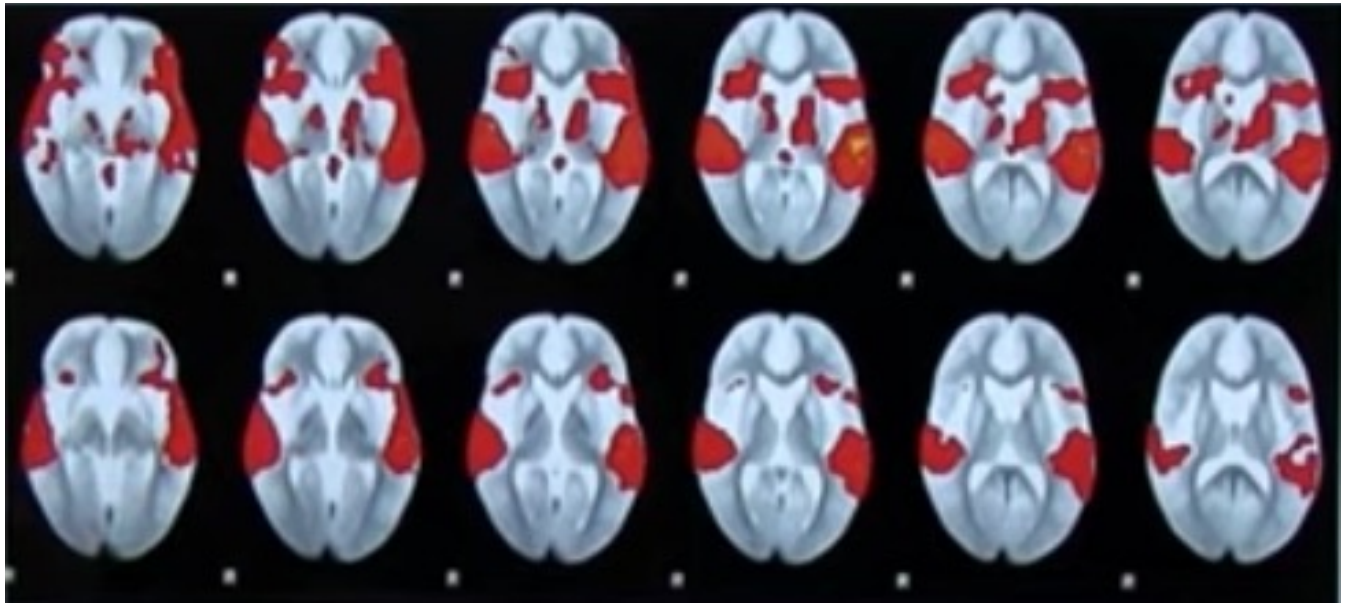

36 weeks gestation
Newborn
3 months
6 months
2 years

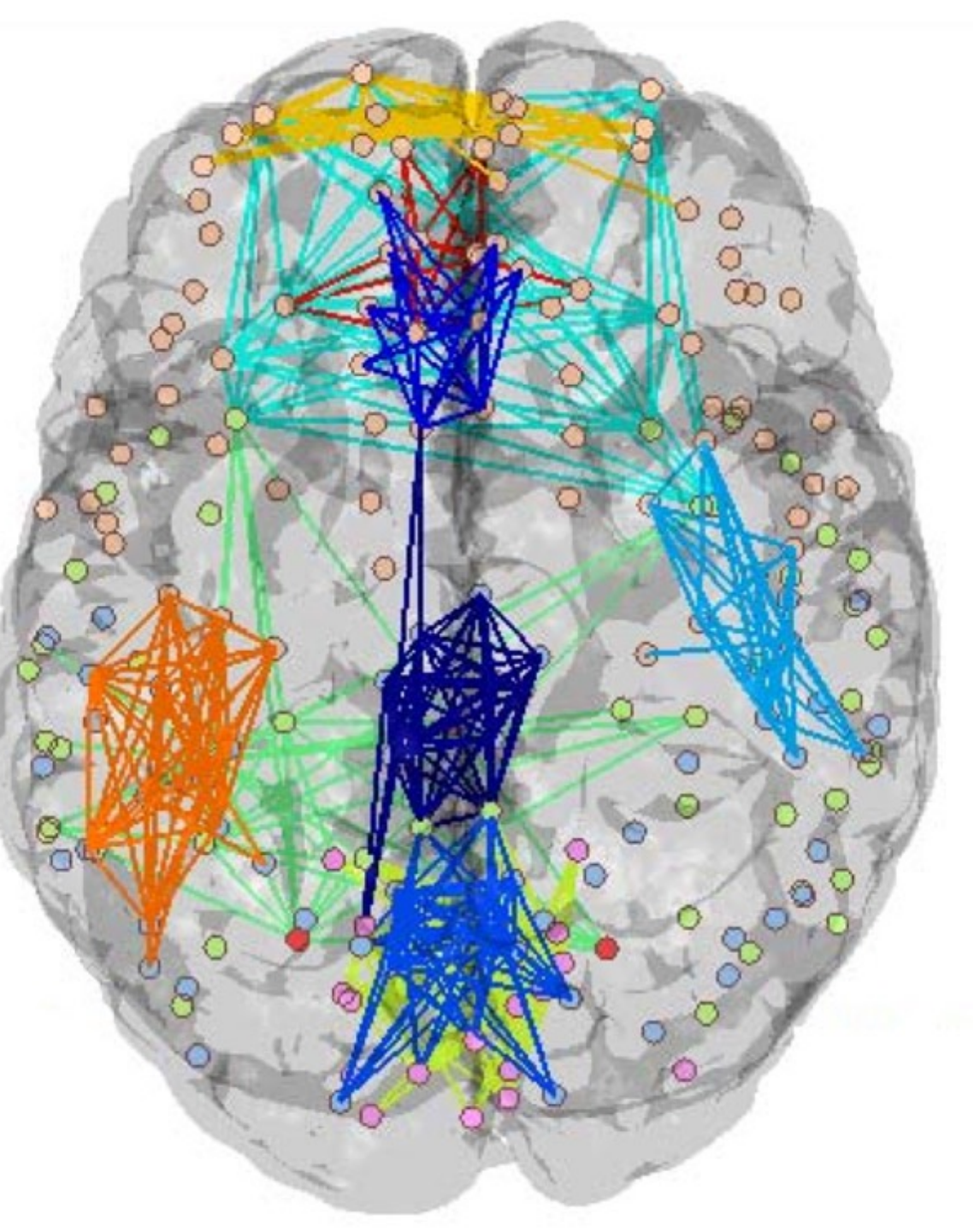
T1-weighted images



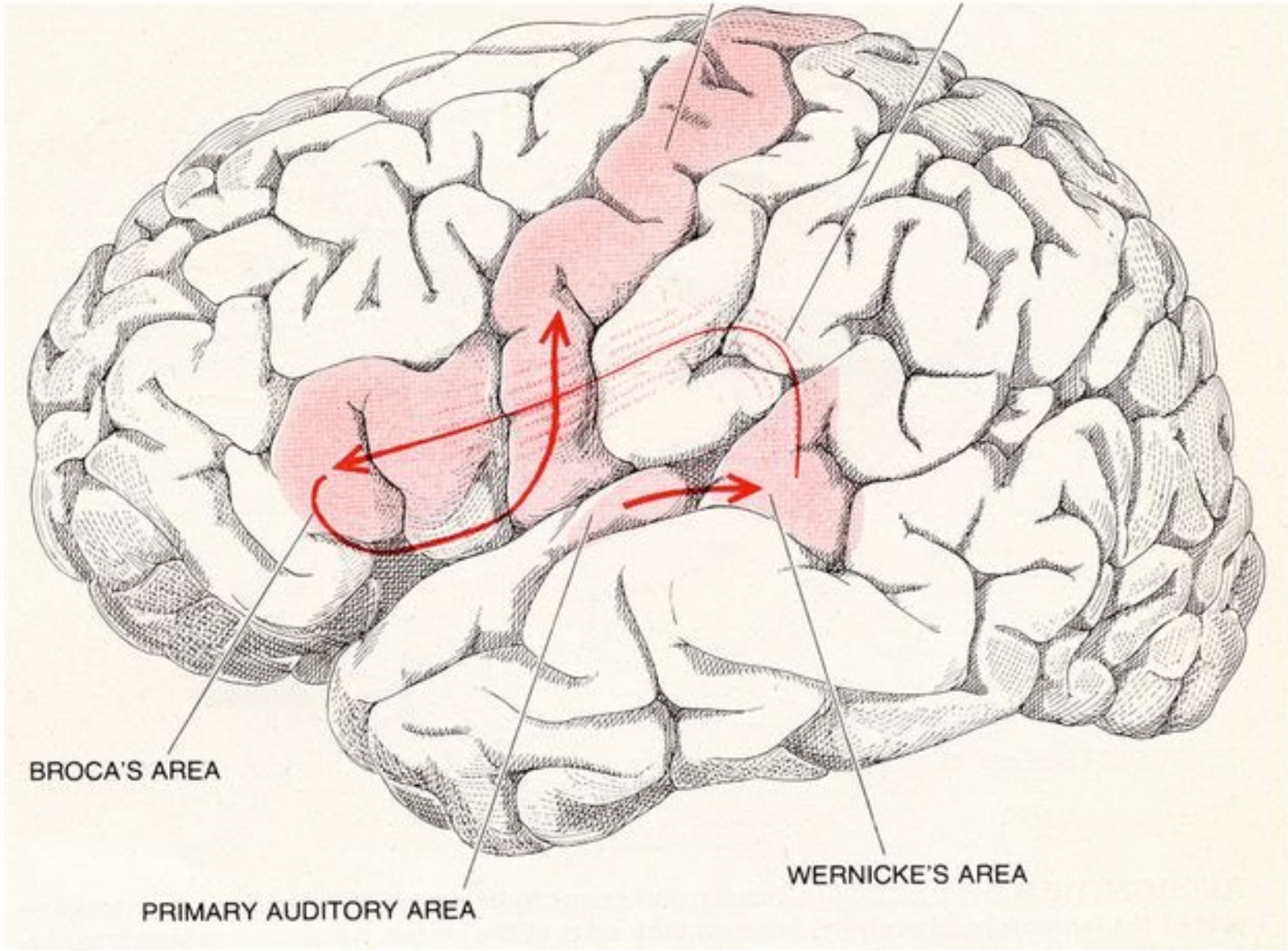
How do networks develop?

- There is a basic structure we are born with
- They are shaped by experience: begin more diffusely, but become distinct modules, highly integrated, and more specialized
- Language activity in ***children vs. adults***





- A view of the brain using dMRI, which tracks the movement of water molecules through the brain.
- Water diffuses in a manner that parallels the white matter tracts that carry neural signals. This imaging technique can provide insights into how information moves between various regions of the brain.


BROCA'S AREA
PRIMARY AUDITORY AREA
WERNICKE'S AREA

Interaction of separate knowledge system

- If a patient do poorly on speech perception, can he/she grasp the meaning of spoken words? --- Yes.

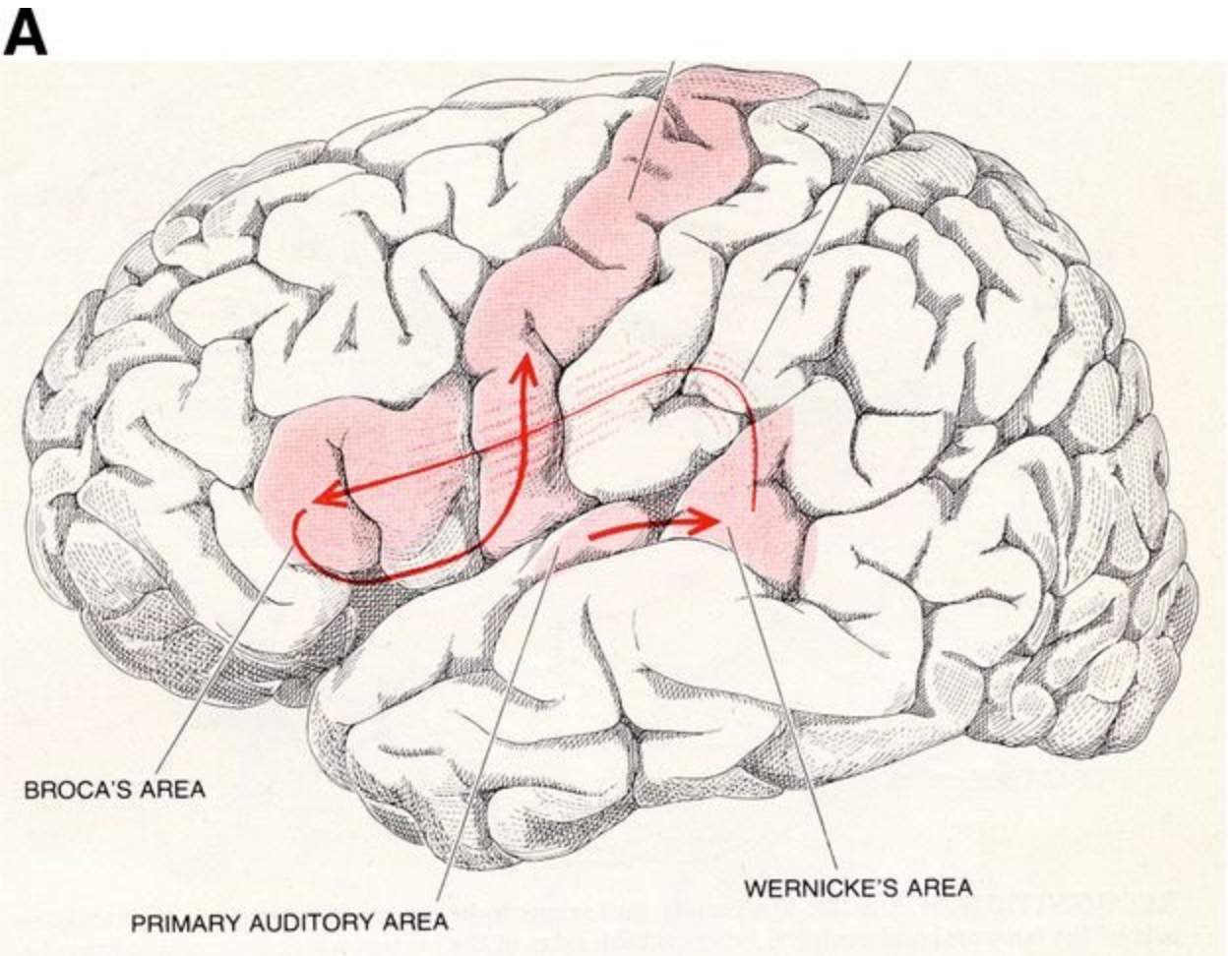
- If a patient has trouble recognizing words, can he/she do well in speech perception? --- Yes.

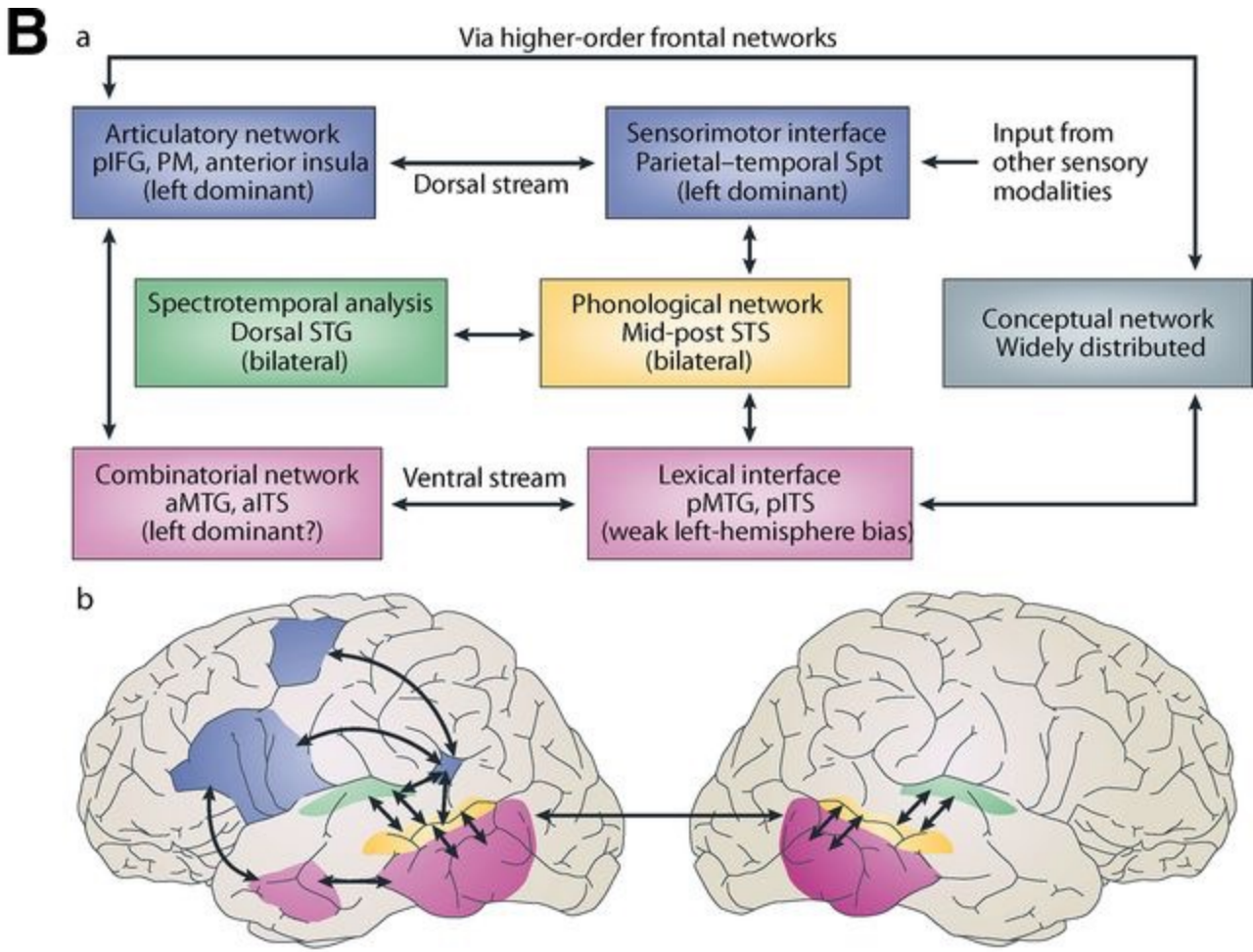
More evidence

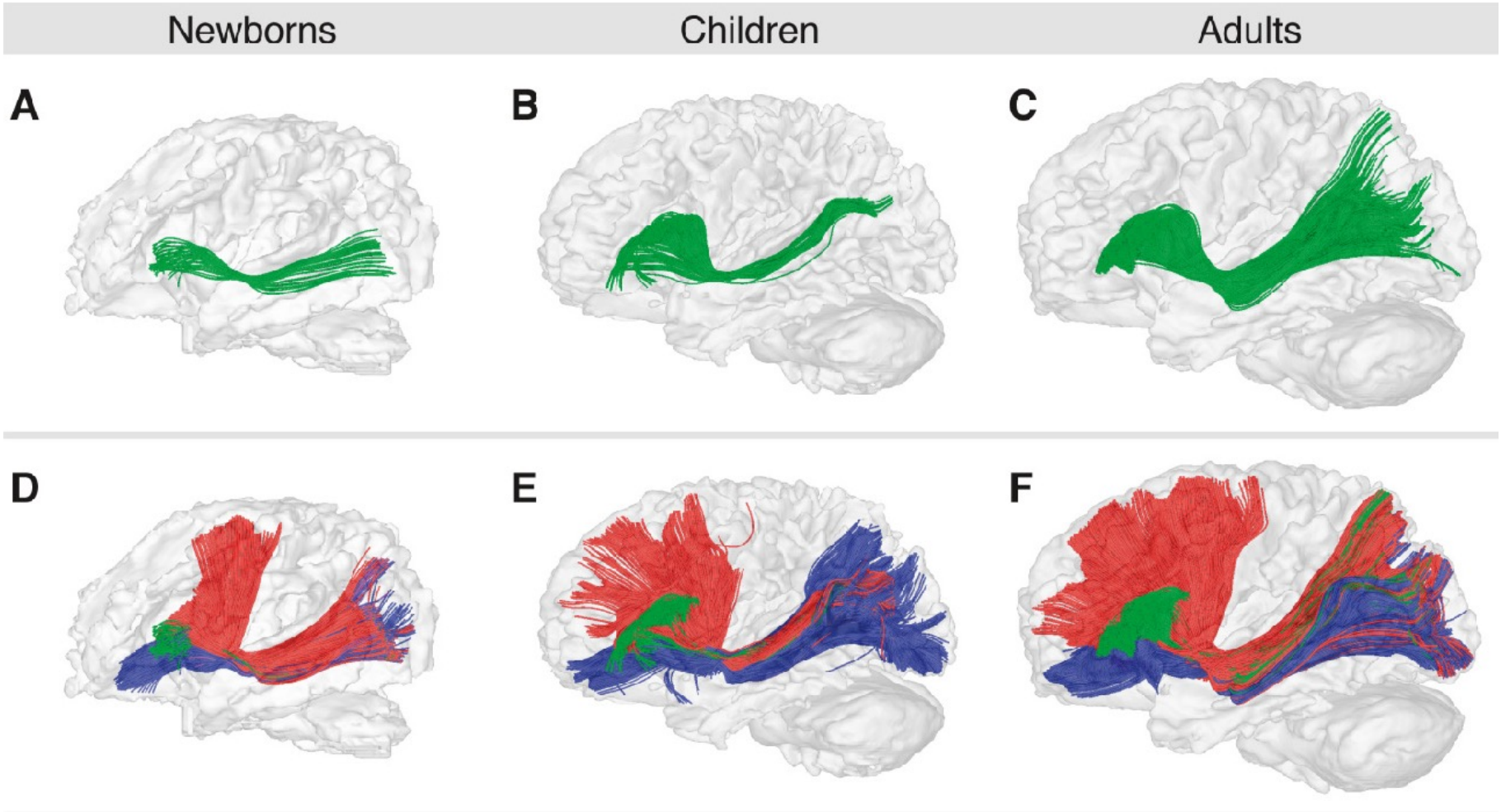
- Bilateral organization of auditory comprehension
  - Word deafness is mostly caused by bilateral STG lesions
  - Unilateral lesions to STG do not cause severe auditory comprehension problems
  - Even when auditory comprehension deficits are caused by unilateral lesions, the deficit tends to be more semantic than phonemic
- Left hemisphere damage does not cause severe auditory comprehension deficits, yet cause deficits on classic speech perception

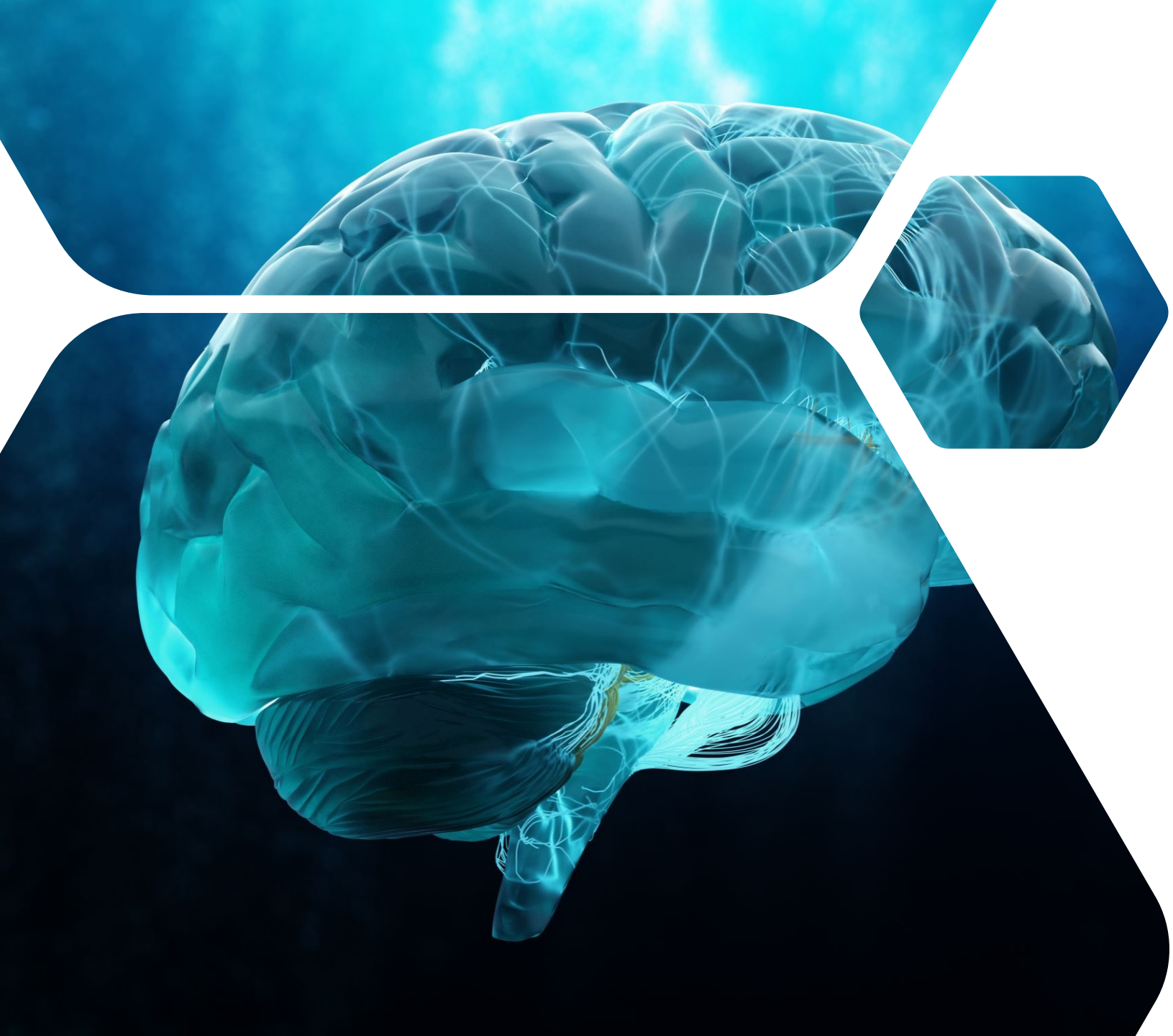
- Maybe word recognition (auditory) and speech perception are two tasks that belong to different language-related networks (Hickok & Poeppel, 2007)
  - Word recognition: maps speech input onto representations of meaning
  - Speech perception: perception of phonetic and phonological information
    - maps the acoustic information about sounds onto the articulatory gestures
    - (this is also why trouble with perception perception tasks can be more directly connected to impairments in language production than understanding)
  - **double dissociation:** neuropsychological evidence for the independence of two mental processes

Ventral stream （腹测流）　　dorsal stream （背测流）






Newborns
Children
Adults
A
B
C
D
E
F



Brain plasticity

- Neuroplasticity is the brain’ s ability to change and adapt as a result of experience. It is also known as brain plasticity.
- Plasticity is defined as being "easily influenced, trained, or controlled."
- Neuroplasticity is when nerve cells change or adjust.

- Researchers have used brain training to rehabilitate patients with brain trauma, Mild Cognitive Impairment, and more.

- But healthy people can also use it to sharpen their brain function in daily life while simultaneously preventing cognitive decline in the future.
  - Second language learning
  - Diet
  - Mood
  - Drugs