Round 12: Association Cortices, Higher-function Localization, & Hemispheric Asymmetries

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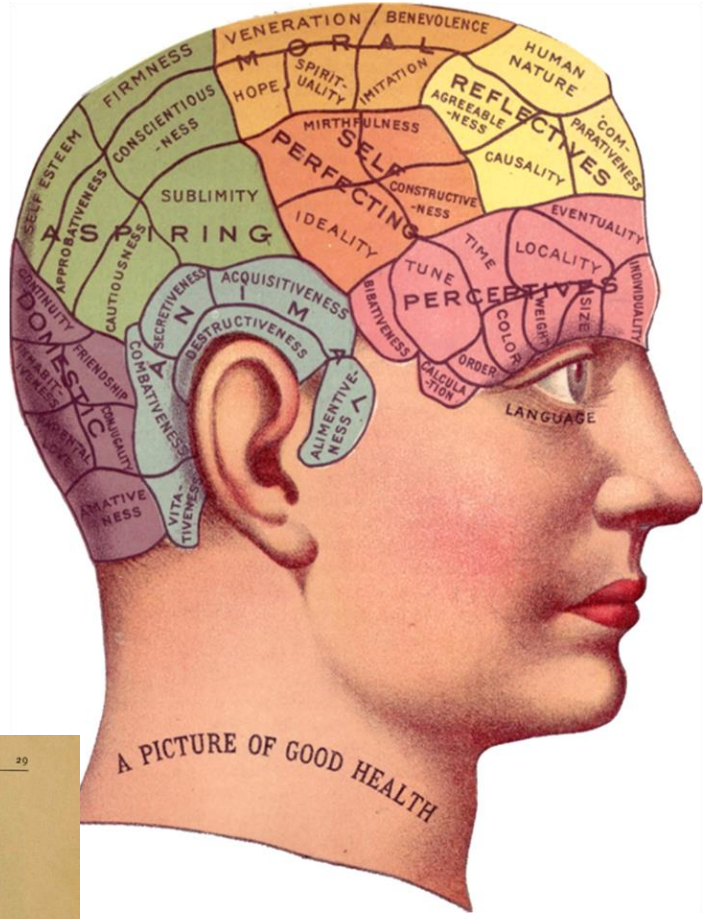
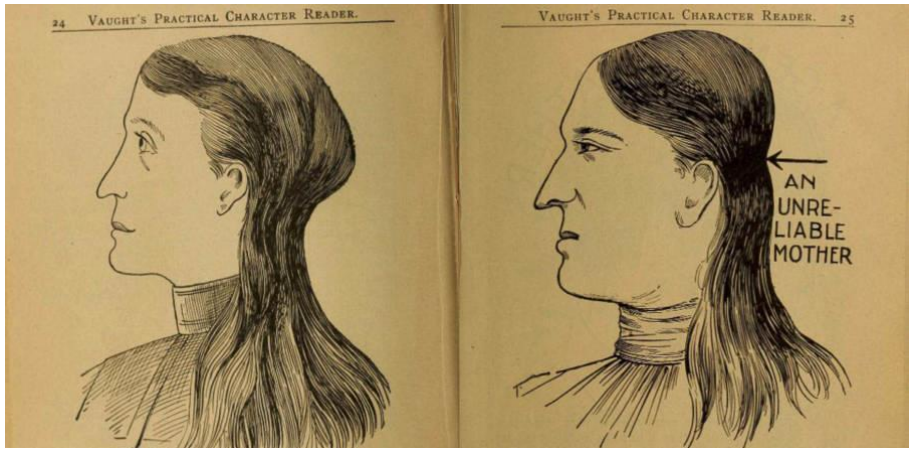
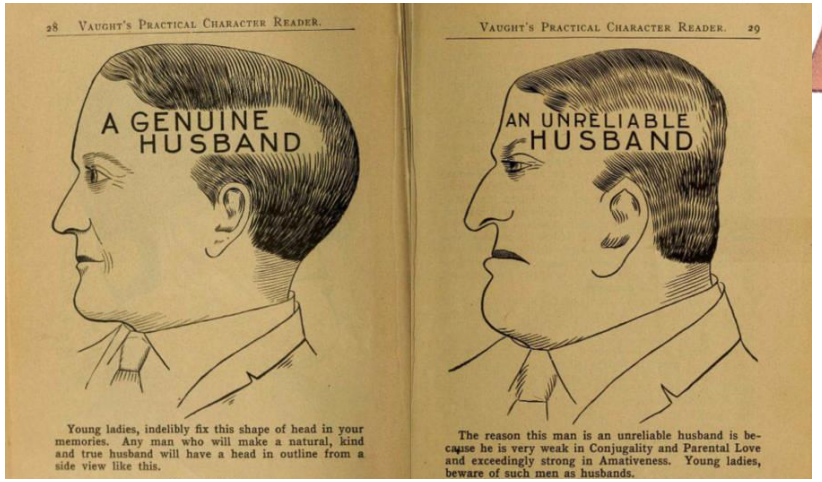
Phrenology

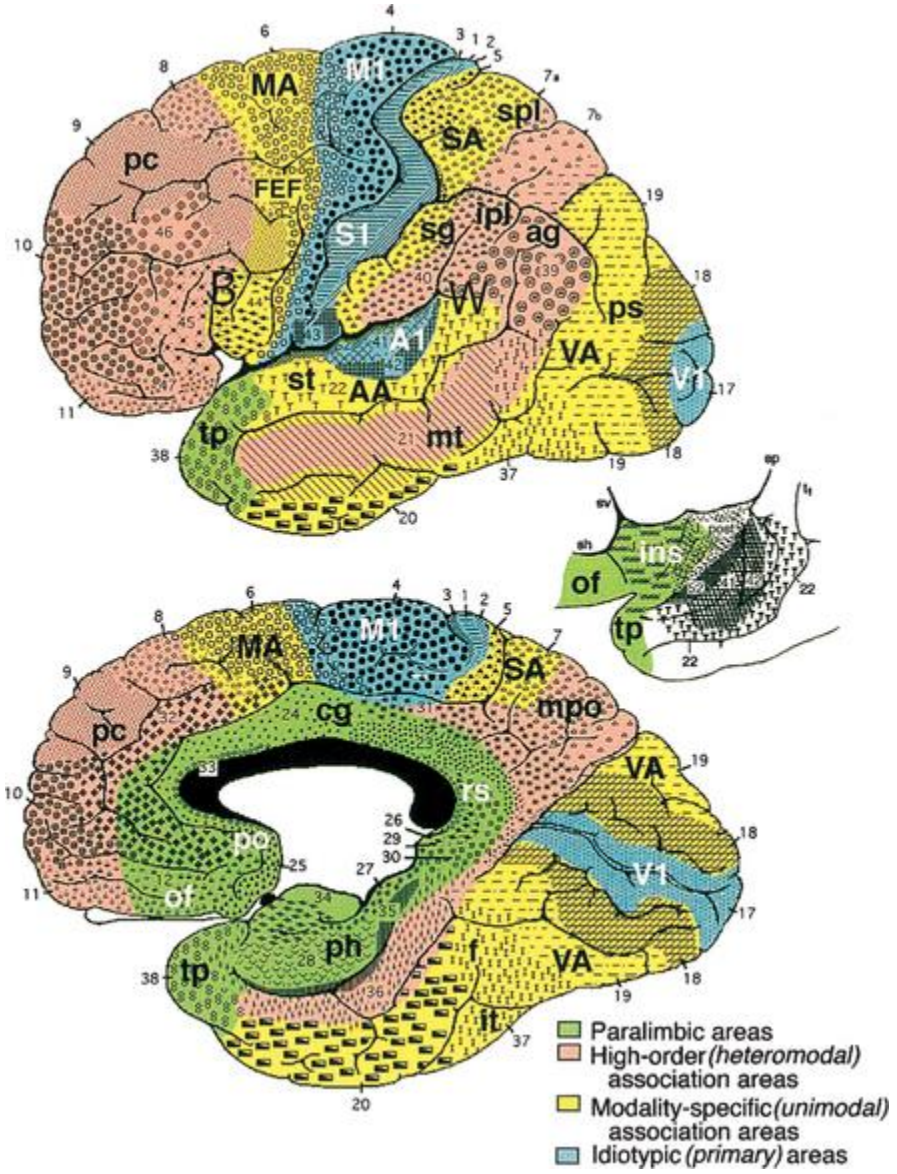
- Popular from 1810-1840

- Franz Gall 1819:
  - Brain is the organ of the mind
  - Bain is not a homogenous unity, but an aggregate of mental organs with specific functions
  - Relative size of organ indicative of power/strength
  - Skull ossifies over brain during infant development, so external craniological means could be used to diagnose the internal states of mental characteristics



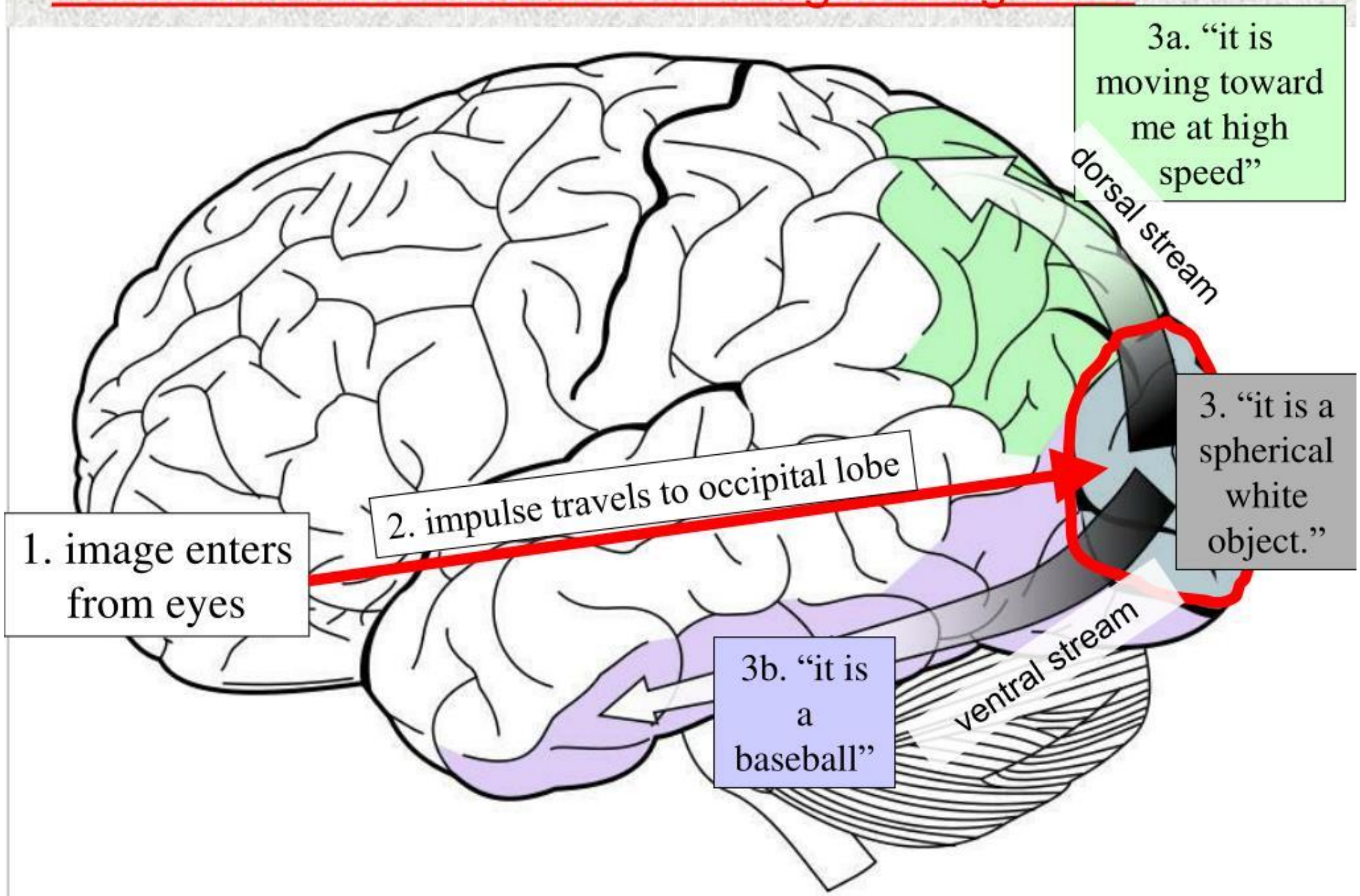






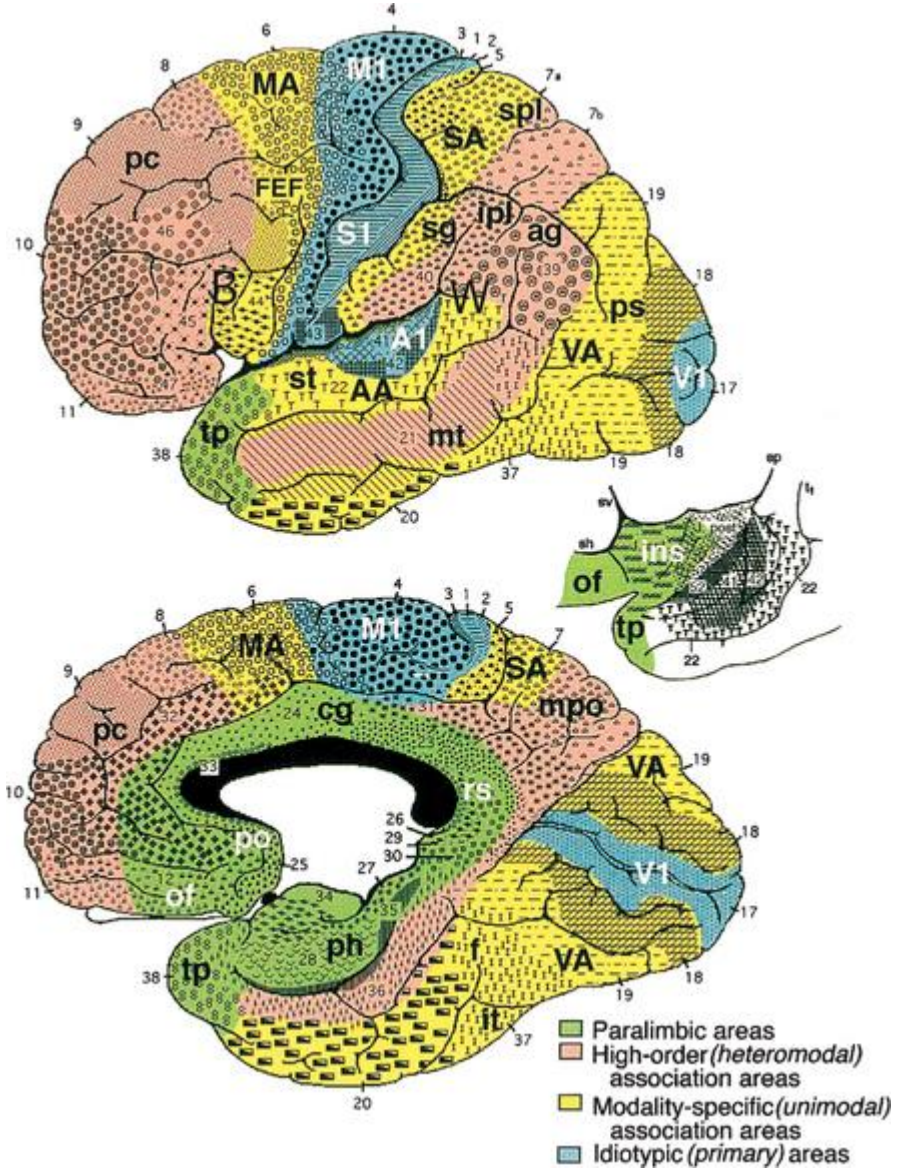
- Primary/Idiotypic – basic processing of most elemental input (e.g., lines)
- Secondary/ Modality-Specific Unimodal Association – elaborative processing (e.g., shapes, objects)
- Association/High-Order Heteromodal – Integrative processing (i.e., how you feel about an object, memories of the object)

dorsal and ventral stream of image recognition



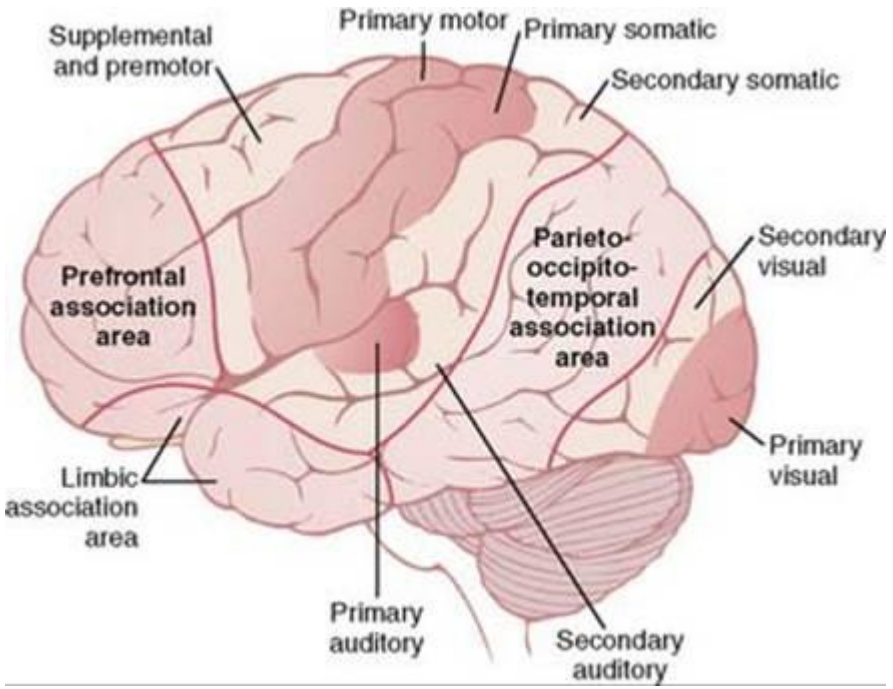
Heteromodal Areas

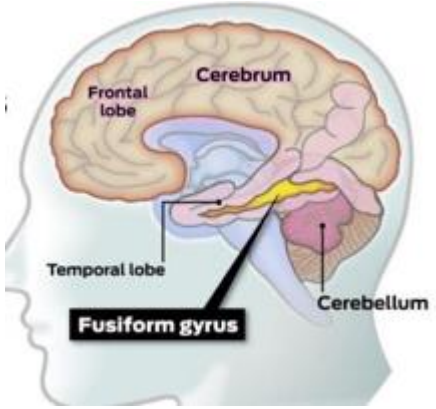
- Heteromodal Area Characteristics
  - Neural responses are not confined to any single sensory modality
  - Predominate sensory inputs come from unimodal areas in multiple modalities and other heteromodal areas
  - Deficits from lesions in these area are always multimodal and never confirmed to tasks under guidance of a single modality
  - Many neurons respond to both sensory & motor input
  - Firing changes depending on motivational relevance
- Transmodal Regions
  - Integration of sensory input into cognition

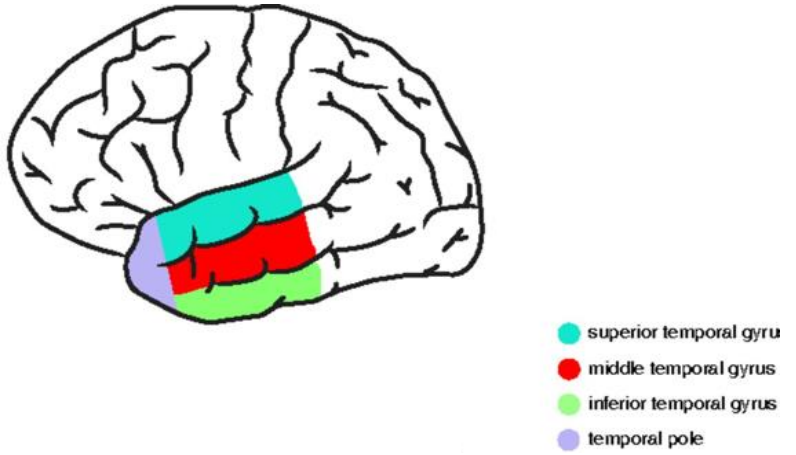


Temporal Heteromodal Cortex

- Exposure to unfamiliar faces activates the fusiform face area
- Exposure to familiar faces also activates lateral midtemporal cortex (transmodal region)
    - Links visual representation of faces -> associations (e.g., name, voice, personal recollections)
    - Holistically leads to recognition





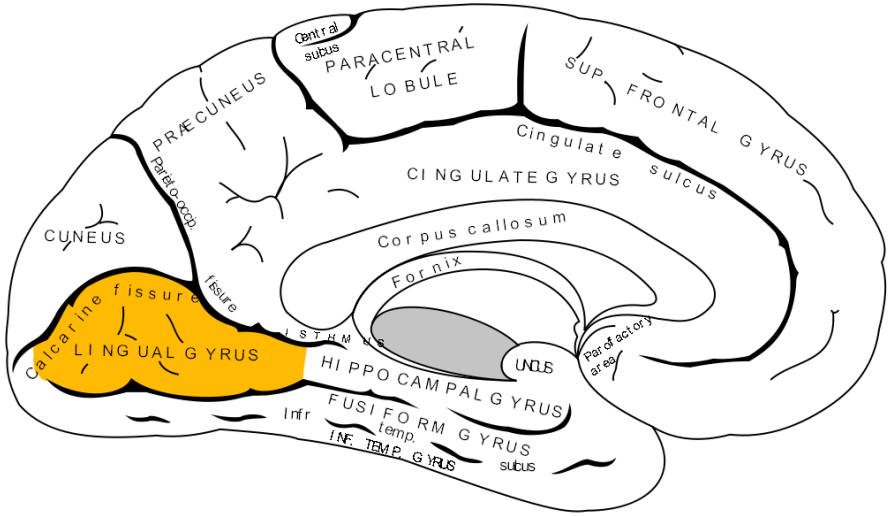


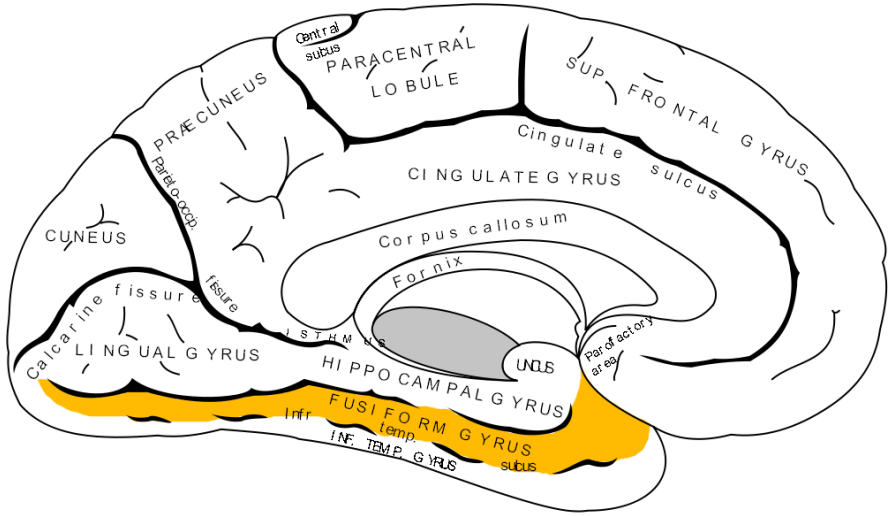
Temporal Heteromodal Cortex

- **Associative Prosopagnosia**
  - Damage to bilateral, mid-anterior lingual & fusiform gyrus
  - Can determine if two faces are the same or not
  - Cannot recognize a specific face – relate stimulus to personal experience
    - Face can elicit an emotional response
    - Can recognize when given different stimulus (e.g., voice)

  - May also have trouble recognizing specific members of a group (e.g., a favorite pet, a particular car)

- **Associative Visual Object Agnosia**
  - Cannot recognize object categories, describe its nature, or use
  - Can determine if two objects are perceptually identical





Temporal Heteromodal Cortex

- **Hemispheric Differences**
  - Prosopagnosia can also occur when there is a unilateral right hemisphere lesion
  - Object agnosia is more likely when there is a unilateral left hemisphere lesion

  - Right hemisphere -> role in activation of autobiographical memories

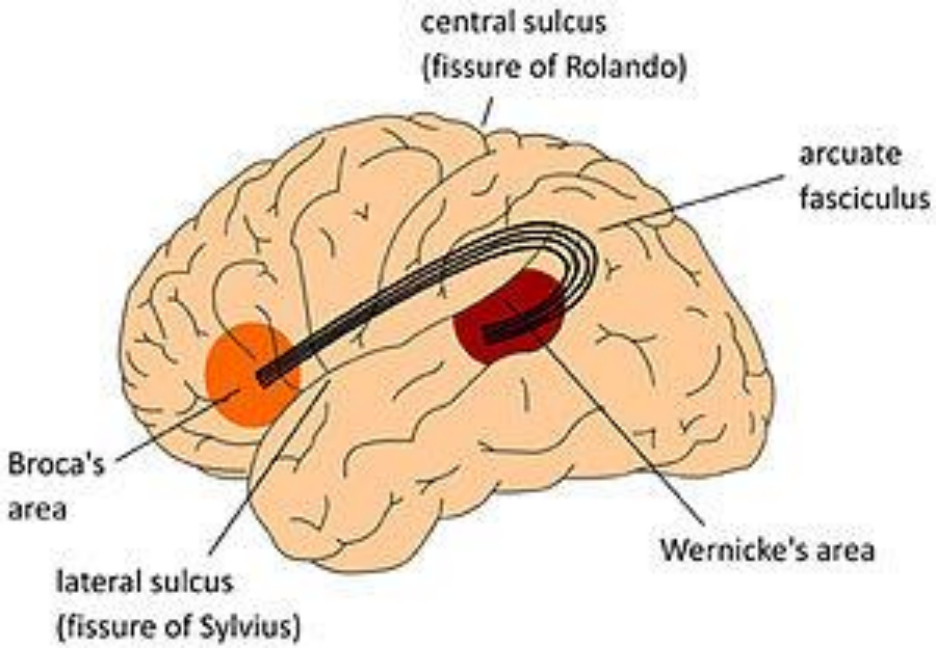
- **Other associative agnosias**
  - Auditory object agnosia – cannot match sound (e.g., ring, siren) with object (e.g., telephone, ambulance)
  - Phonagnosia – cannot identify familiar voices

- **Locus & Implications**
  - The primary processing areas are intact -> elementary processing is unaffected
  - Transmodal areas, such as the heteromodal middle temporal gyrus is damaged
    - Not a repository for knowledge related to faces, objects
    - Pathway for accessing relevant distributed associations that collectively lead to recognition

Temporoparietal Transmodal Region

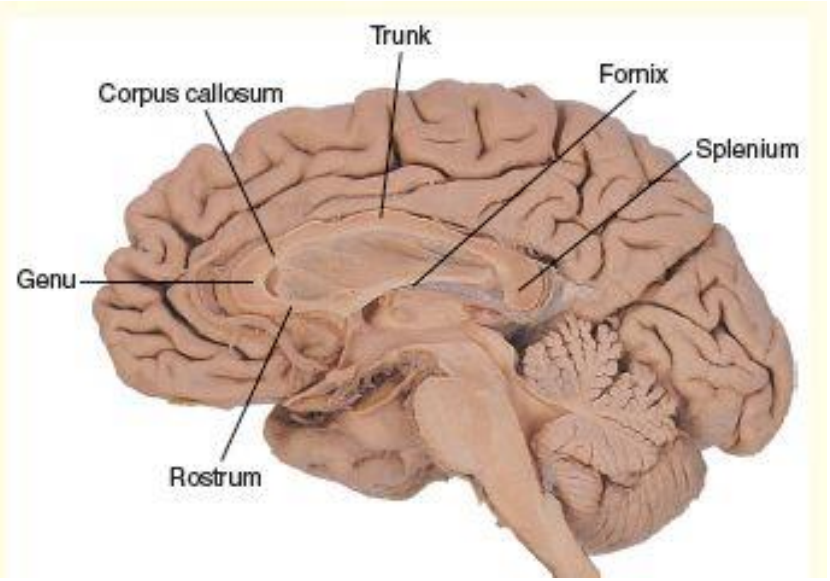
- Language -> elaboration & communication of experiences and thoughts through arbitrary symbols (e.g., sounds/speech, figures/text)
- Wernicke's and Broca's areas are anchors of a language network

- **Wernicke's area**
  - Transmodal gateway that coordinates reciprocal interactions between sensory representations of word forms & arbitrary (symbolic) associations that give meaning
  - Damage does not affect word representations themselves but affects ability to understand/decode words in any modality (spoken, written)
  - Deficit in comprehension & production



Temporoparietal Transmodal Region

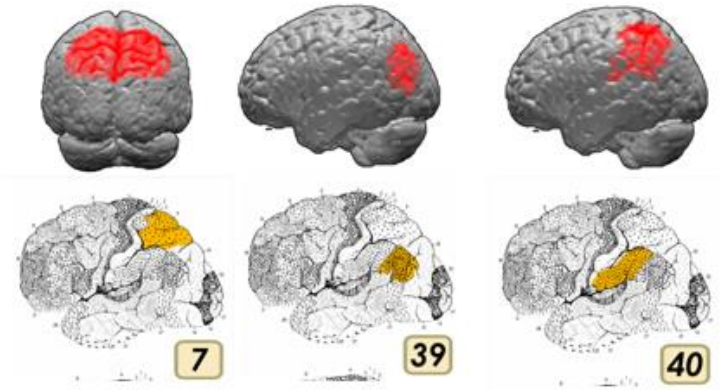
- **Pure Alexia (Word Blindness)**
    - Areas that encode visual word forms are disconnected from visual input or cannot communicate with Wernicke's area
    - Typically lesion in Splenium of corpus callosum
    - Interferes with transfer of visual information from intact visual processing areas of the right hemisphere to the word-form areas in the left hemisphere



- As with associative agnosias, the problem is in linking raw sensory input with relevant, integrated knowledge that gives meaning to stimuli

Posterior Parietal Heteromodal Area

- **Role in Spatial Attention**
  - Intraparietal cortex – integrates distributed spatial information
  - Damage:
    - Modality specific information channels related to extrapersonal space are intact
    - Cannot be bound into a coherent & interactive representation necessary to adaptive deployment od spatial attention
  - Not a spatial map but critical gateway for access & integrating information re: attention & exploration of extrapersonal space
  - Right hemisphere damage related to difficulties in mental rotation & identification of objects viewed from uncommon perspectives

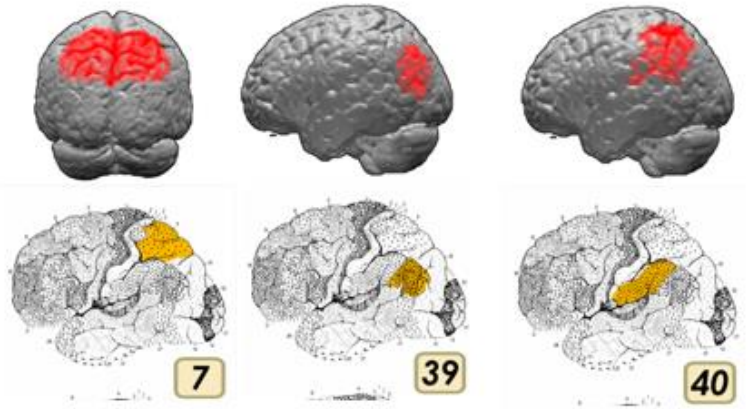


- **Balint's Syndrome**
  - Breakdown of visuospatial integration
  - Inability to make voluntary eye movements to a point in space even though spontaneous eye movements are unaffected
  - Deficit in using visual guidance to grasp and object
  - Difficulty attending to visual stimuli

Posterior Parietal Heteromodal Area

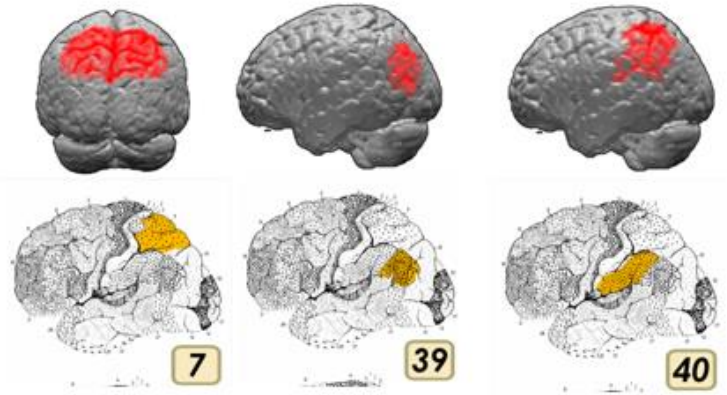
- **Ideomotor Apraxia**
  - Inferior Parietal lobe -> spatiotemporal representations of skilled movements
  - Damage: Unable to pantomime the use of an object or infer the nature of the object

- **Gerstmann's Syndrome**
  - Left/right confusion
  - Finger Agnosia – inability to name a specific finger when it is touched
  - Dysgraphia
  - Dyscalculia



Posterior Parietal Heteromodal Area

- **Role in Mood & Motivation**
  - Motivation indifference for contralateral hemisphere
  - Right hemisphere lesion can lead to psychotic and affective disturbances
  - Wernicke's aphasia pts can show severe mood alterations:
    - Anger
    - Paranoia
    - Indifference
  - May be related to damages sensory-limbic interactions

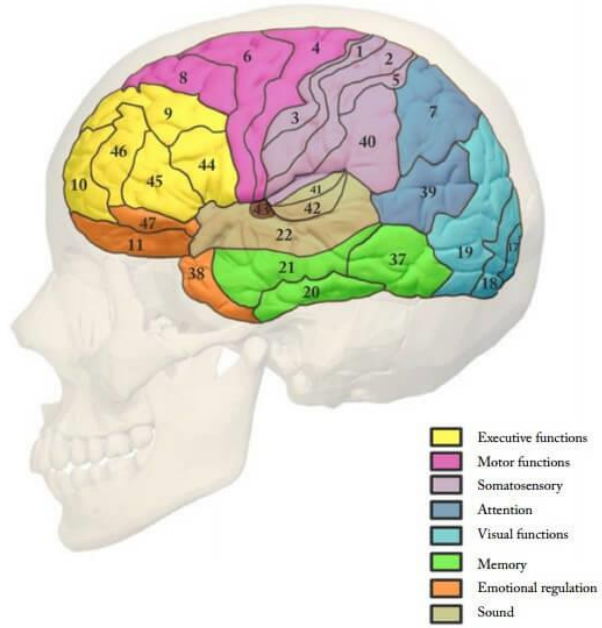


Prefrontal Heteromodal Area

- Comprised of Brodmann's areas 9, 10, 11, 12, 45, 46, 47

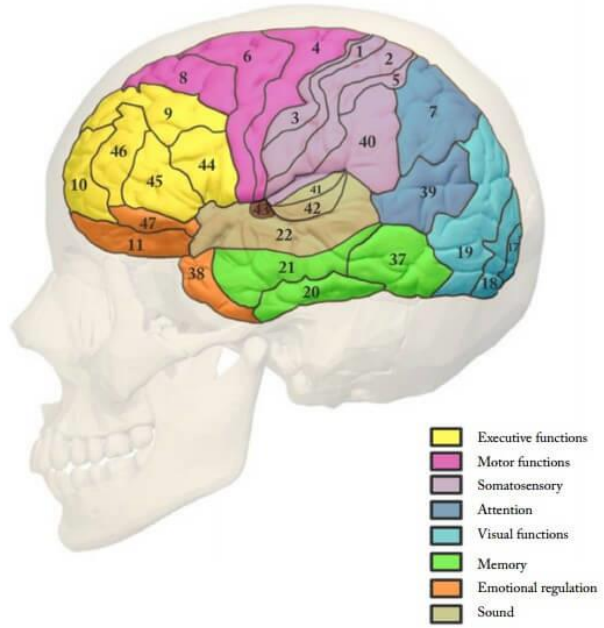
- Orient attentional focus toward internal mental processes
- Weigh consequences of future actions and to plan accordingly
  - Select appropriate motor response from many available options

- Two functional centers
  - Working memory/Executive function/Attention
  - Comportment (behavior)



Prefrontal Heteromodal Area

- **Frontal Lobe Syndrome**
  - Childish, profane, careless, facetious, grandiose, and easily angered
  - Lose spontaneity, curiosity, and initiative and develop an apathetic blunting of feeling, drive, mentation, and behavior
  - Lack of foresight, judgment, and insight, and lose the ability to delay gratification
  - Loss of capacity for remorse
  - Impaired abstract reasoning, creativity, problem solving, and mental flexibility
  - Lose ability to plan/sequence complex behaviors, strategic decision making based on the assessment of differential risks, flexibly shift focus, follow multistep instructions

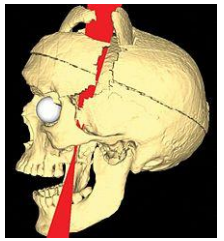


Phineas P. Gage

- September 13, 1848
  - Railroad accident sent tamping iron through his head
  - At time of accident, some convulsions but was sitting up and talking 30 mins after, “Doctor, here is business enough for you.”
    - Vomited, pushing teacup full of brain up the top of skull
  - In and out of comma 1st month
  - April 1849, mostly recovered physically
  - August 1852 long-distance stagecoach driver in Chili
  - 1860 epileptic seizures, died in May

  - Prior to accident: Smart, likeable, efficient, capable, reliable.
  - Immediately after the accident: Fitful, irreverent, profane, impatient, obstinate, impulsive

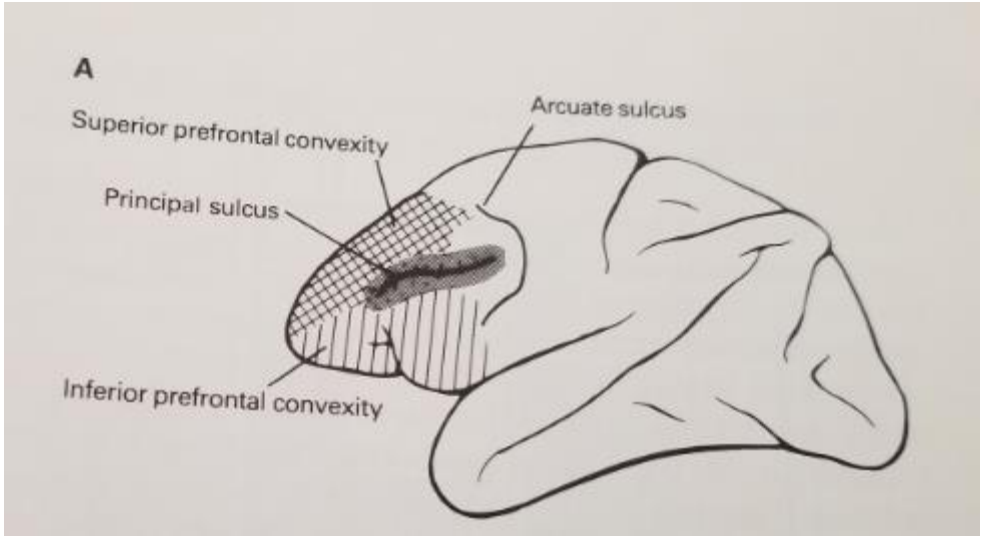
  - Stagecoach work
    - Highly structure, required clear sequences of tasks, foresight, planning, adaptation
    - Harness & care of horses, load & unload luggage, charge fares, route rough frequently dangerous



Monkey Studies

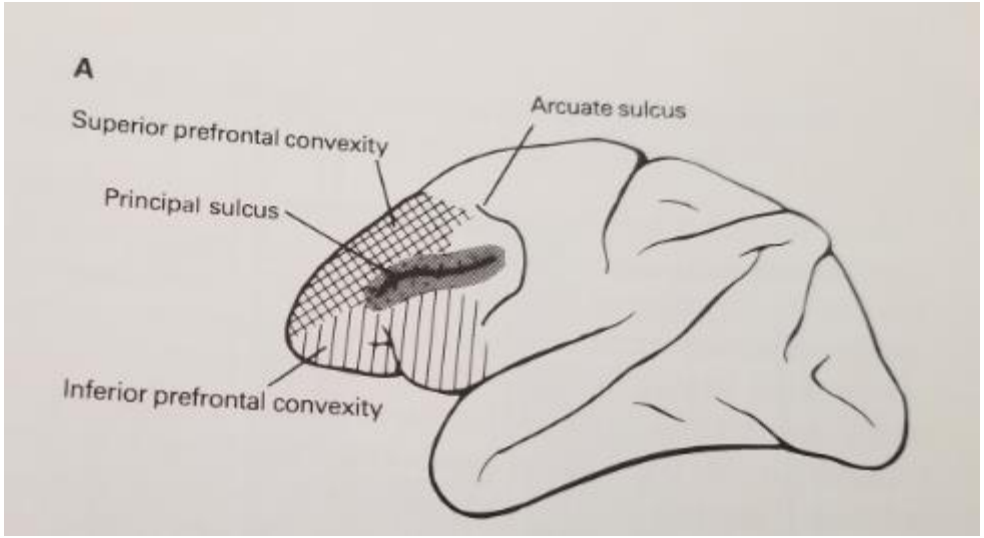
- **Principle Sulcus**
  - **Function:** Strategic planning for higher motor actions & cognitive tasks requiring spatial information
  - **Lesion:** Impairs ability to perform task involving delayed spatial response
    - Task
      - Two containers, one of left & one on right. Monkey watches food being placed in one. Delay of <5 secs, lesioned monkeys cannot perform task
      - Deficit in working memory requiring spatial information

- Cellular studies
  - Some neurons fire when a cue is presented and continue to fire throughout delay
  - Specific neurons fire only when stimuli at particular position in visual field
    - Map of contralateral visual field for use in working memory to direct eye & hand movements



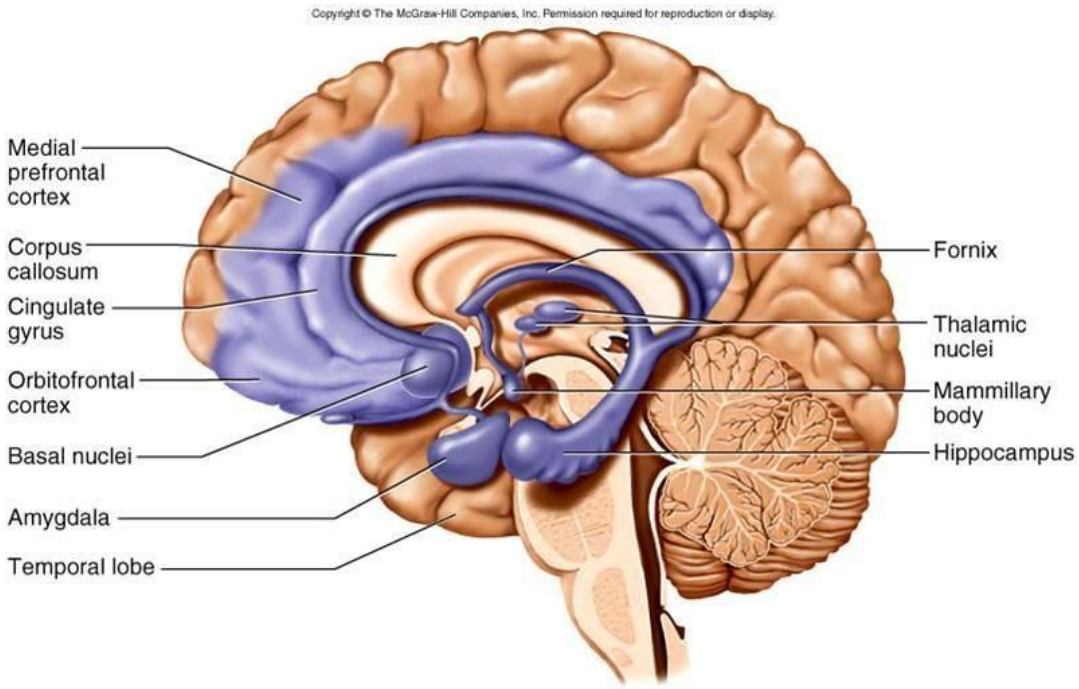
Monkey Studies

- **Inferior Prefrontal Convexity**
  - **Function:** Choose among response options via different sensory cues
  - **Lesion:** Interfere with tasks that require inhibition of certain motor responses at appropriate times
    - Task
      - Move to left when auditory stimulus comes from above vs move to right when it comes from below



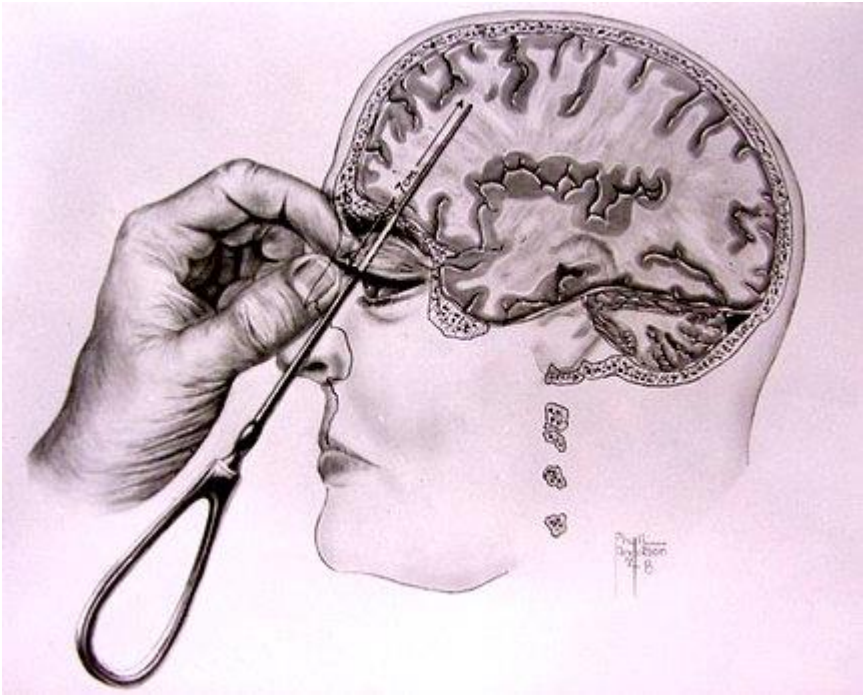
Orbitofrontal Cortex & Cingulate Gyrus

- Lesions affect affective responses
  - Lesioned monkeys fail to exhibit typical rage when they do no receive expected reward
  - Electrical stimulation affects autonomic responses
    - Blood pressure, pupil dilation, salivation, gastrointestinal contractions



Lobotomy

- 1935 John Fulton noted calming effect of frontal cortical lesions in chimpanzees
- Egas Moniz, a Portuguese neuropsychologist attended meetings and suggested severance of frontal-limbic association cortex in humans for treatment of severe mental illness, specifically Schizophrenia
- Early results showed favorable results …
- However, soon adverse complications
  - Epilepsy, personality changes – lack of inhibition & initiative/drive



Lobotomy

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.

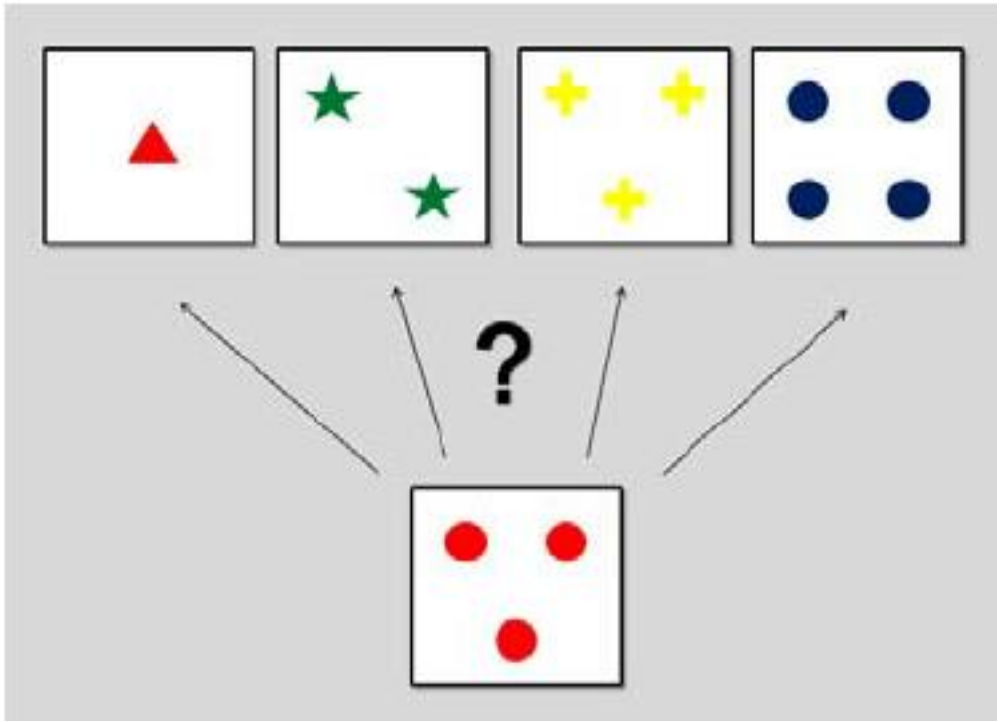
Fig. 22. Case 624. Simple schizophrenia patients make nice household pets after operation. (a) Before lobotomy. (b) One year later.

Lobotomy & IQ

- Conventional tests of intelligence appeared to show little effect
  - ? -> Frontal lobe assumed to be responsible for abstract thought & reasoning

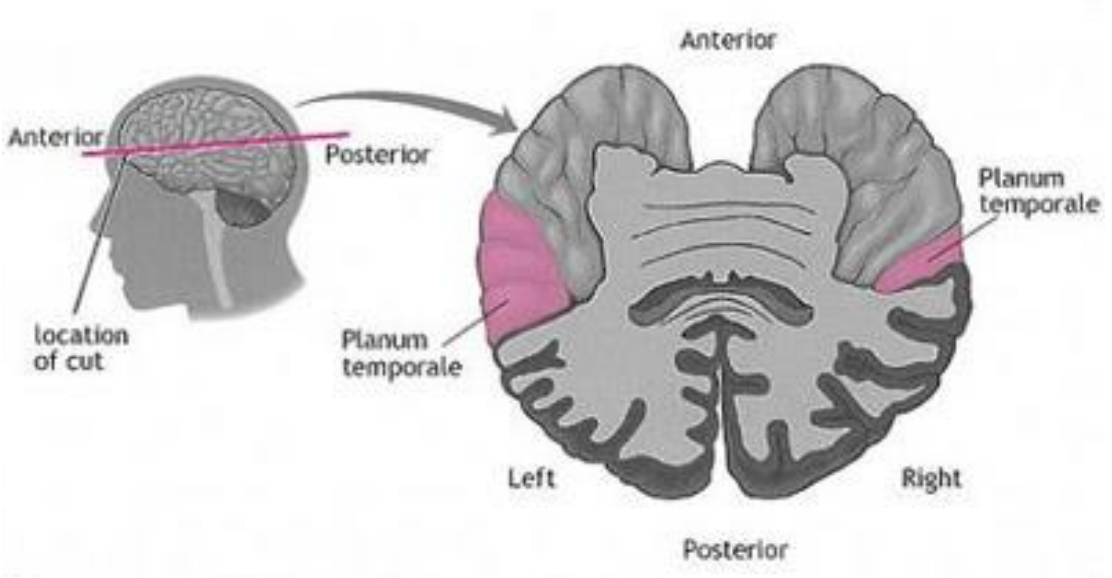
- Show deficits in specific tasks
  - Wisconsin card sorting task
    - Perseverate & cannot adjust strategy

  - Verbal naming from memory
  - Reduced spontaneity of behavior



Hemispheric Asymmetries

- Size differences (present even in human fetuses)
  - Planum Temporale – region that includes Wernicke's area
    - Of 100 brains
      - 65% larger left
      - 11% larger right
      - 24% approximately equal



Hemispheric Asymmetries

- **Sodium Amytal Tests**
  - Neurosurgical procedure to determine which hemisphere responsible for language
  - Sodium Amytal (Barbiturate) is injected to left/right carotid artery. Patient counts or speaks aloud, once drug starts working pt no longer speaks or responds to commands

  - All right-handed -> left hemisphere speech
  - Most left-landed -> left hemisphere speech. 15% have right-hemisphere speech, some have speech in both hemispheres

  - Affects on mood
    - Left injections tend to produce depression
    - Right injections tend to produce euphoria

Hemispheric Asymmetries

- Tachistoscope Experiments
  - Tasks
    - Visuospatial – recognize face
    - Verbal – recognize word
  - Results
    - Right-handed subjects perform
      - Verbal task better when stimuli presented on right side (processed by left hemisphere)
      - Spatial tasks better when stimuli presented on left side (processed by right hemisphere)

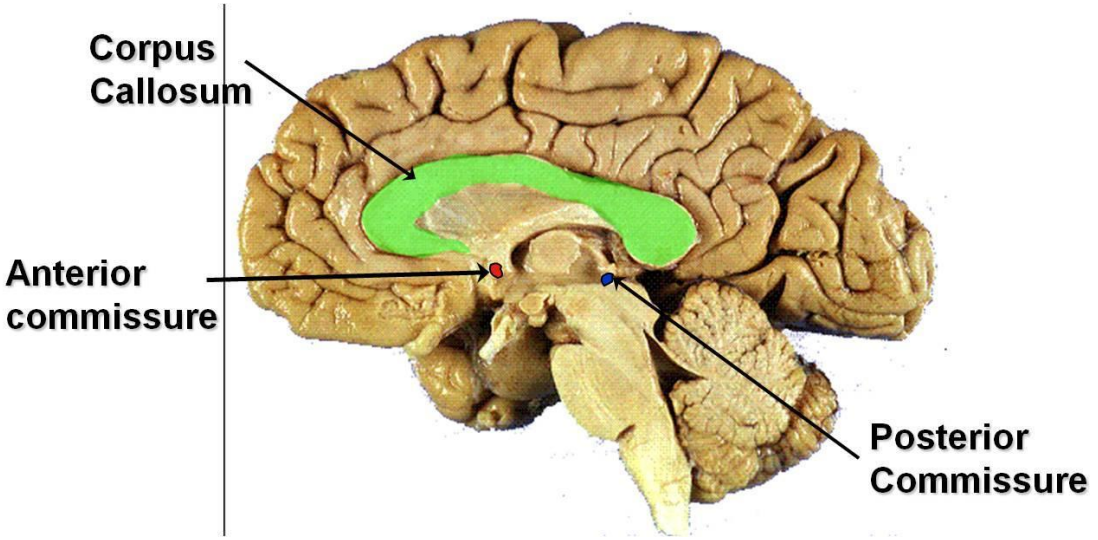
- Dichotic Auditory Experiments
  - Task
    - Auditory stimuli played simultaneously to both ears
  - Results
    - Right-handed subjects perform
      - Right ear better for verbal material
      - Left ear better for nonverbal (e.g., music recognition)

Split Brain

- Sever the corpus collosum & anterior commissure to prevent spread of epileptic seizures

- Each hemisphere is capable of functioning independently
- Right hemisphere is generally mute, cannot communicate experience verbally
    - Limited ability to perform tasks that require complex reasoning or analysis

- Patients usually perform well in everyday life because all information is being presented to both hemisphere
- In experiments, when presenting to one visual field vs the other
    - Right visual field -> patient can name stimulus
    - Left visual field -> pick out picture



Right Hemisphere Specialization

- Complex and nonlinguistic perceptual tasks (e.g., face identification)
- Spatial distribution of attention
- emotion and affect
- paralinguistic aspects of communication
    - Right hemisphere: Emotional prosody
    - Left hemisphere: Phoneme production, word choice, syntax, grammar

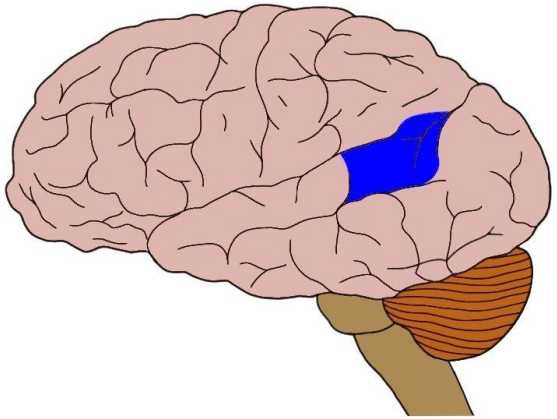
- Dichotic listening - left ear (right hemisphere) advantage for pitch and melody identification
- Tachistoscopic experiments - left visual-field (right hemisphere) superiority for depth perception, spatial localization, and identification of complex geometric shapes

- Mood
    - Coordinate nearly all aspects of emotional expression (affect) & experience (mood)
    - Express & Interpret emotion in speech prosody, facial expressions, gesture
    - Sexual pleasure
    - Right temporolimbic seizure foci -> mood disturbances
    - Left temporolimbic seizure foci -> ideational disorders

Right Hemisphere Specialization
Parietal Association Area

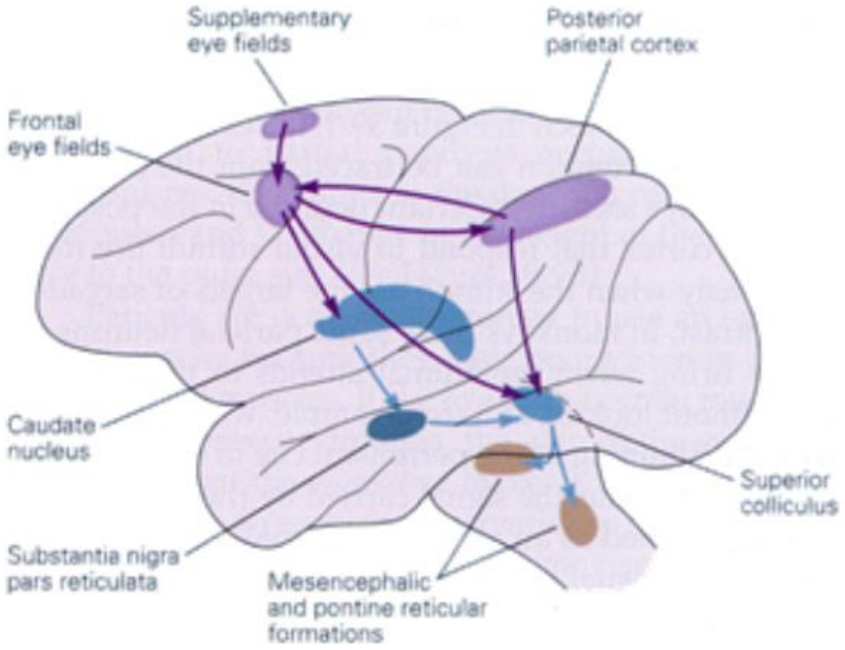
- Lesions to non-dominant hemisphere (usually right)
  - Neglect Syndrome - Lack of appreciation of the spatial aspects of all sensory inputs from left side of body and external space
    - Completely ignore left side of body (e.g., won't wash or dress that side)
    - If arm or leg is passively moved into field of vision, deny ownership
    - Only draw half of objects

  - Right homolog of Wernicke's area
    - Failure to appreciate aspect of verbal message conveyed by the tone, loudness, and timing



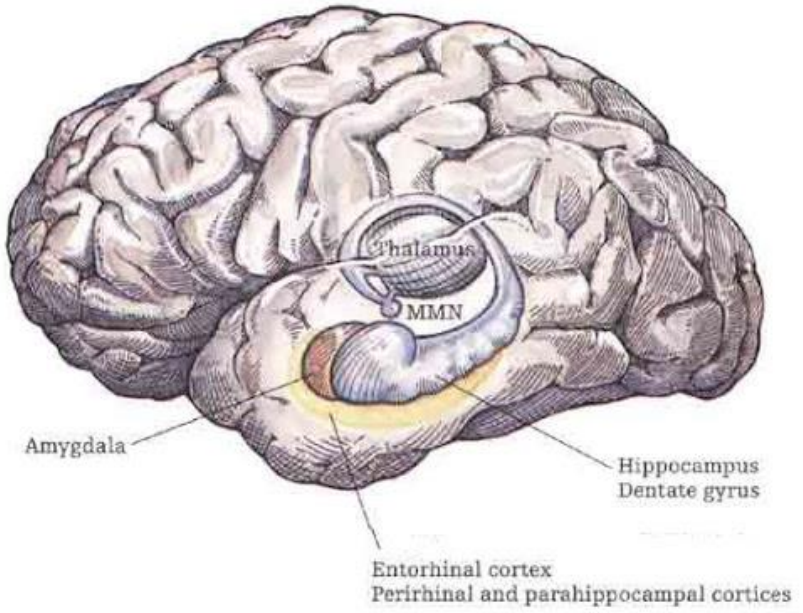
Dorsal Parietofrontal Network: Spatial Orientation

- **Epicenters:** Intraparietal sulcus, frontal eye fields, cingulate gyrus
- **Parietal component** -> perceptual representation of behaviorally relevant locations & their transformations into targets for attentional actions
- **Frontal Component** -> Choosing & sequencing exploratory & orienting movements
- **Cingulate Gyrus** -> Distribution of effort & motivation
- **Damage:** Deficits of spatial attention & exploration



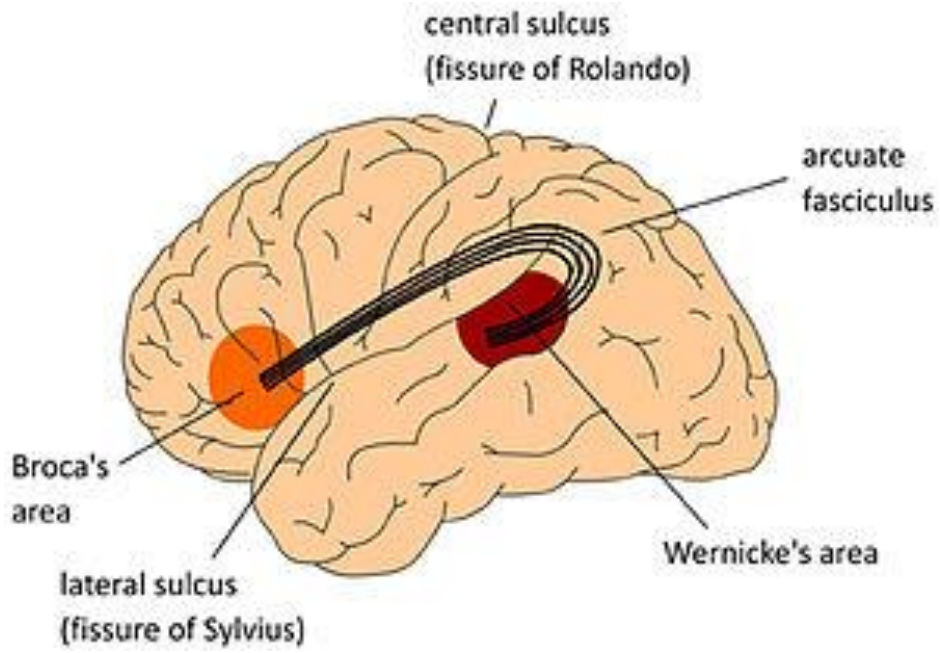
Limbic Network: Memory & Emotion

- **Epicenters:** Hippocampal-entorhinal complex & amygdala
- **Hippocampal-Entorhinal Complex** -> Memory & learning
- **Amygdala** -> Drive, emotion, visceral tone
- **Damage:**
  - Deficits of memory
  - Emotion
  - Affiliative behaviors (i.e., social interactions that function to reinforce social bonds)
  - Autonomic responses



Perisylvian Network: Language

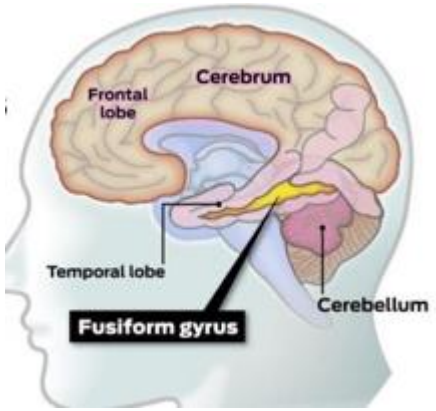
- **Epicenters:** Broca's & Wernicke's
  - Also, striatum, association areas of frontal, temporal, & parietal lobes
- **Broca's** -> Word choice, syntax, grammar
- **Wernicke's** -> Lexical, semantic
- **Damage:** aphasia, alexia, agraphia

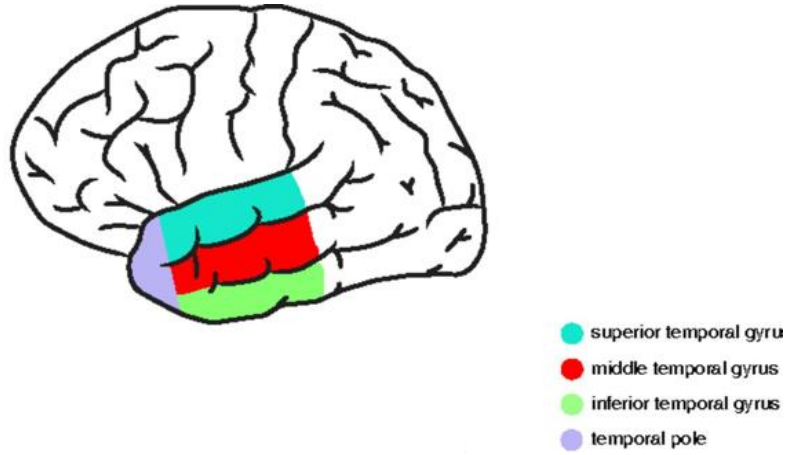


Ventral Occipitotemporal Network: Face & Object Recognition

- **Epicenters:** Middle Temporal gyrus, temporal pole, fusiform gyrus, inferior temporal gyrus

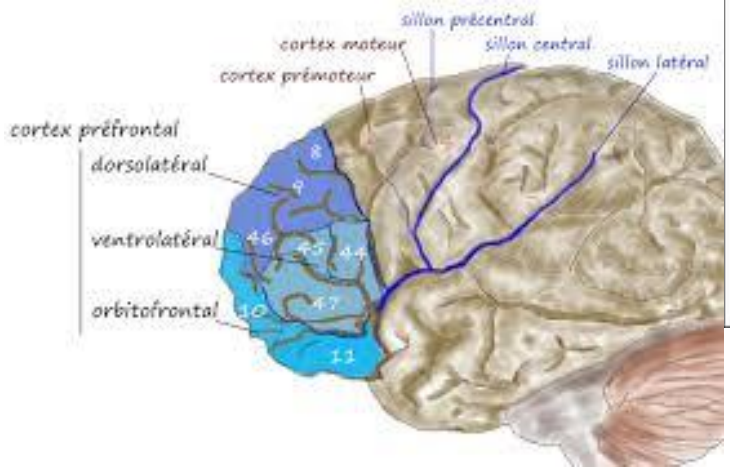
- **Damage:** object agnosia, prosopagnosia
  - Usually to fusiform gyrus bc of its vascular supply

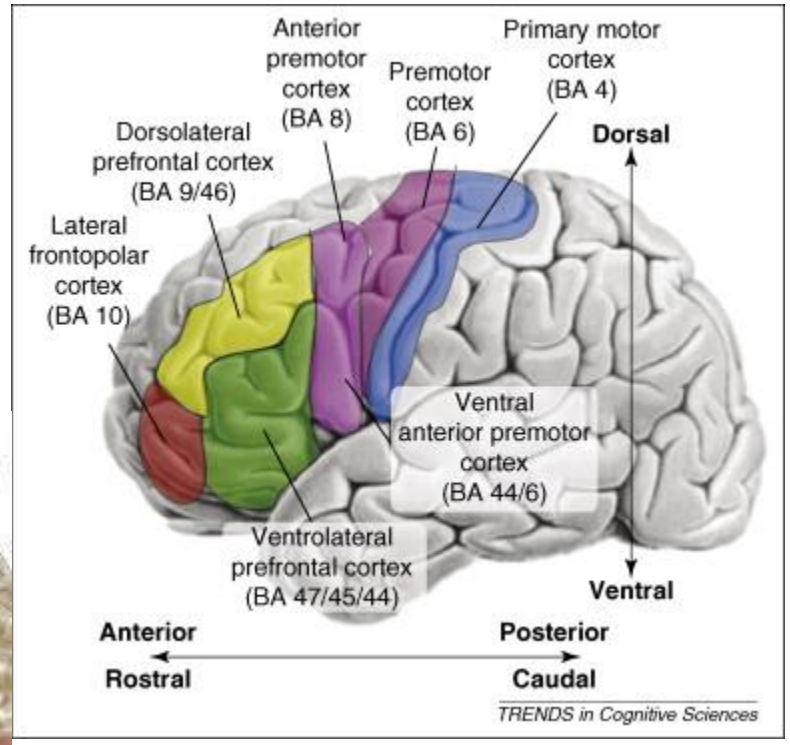




Prefrontal:
Executive Function & Comportment

- **Epicenters:**
  - Prefrontal heteromodal cortex & orbitofrontal -> Comportment
  - Prefrontal heteromodal cortex (Dorsolateral prefrontal) & Posterior Parietal cortex, Caudate nucleus, mediodorsal thalamus-> working memory & Related executive function





Thank You