COGS 17 section A02

learning & memory, language and lateralization

section resources repo

part 1: learning & memory

reminders

- midterm III + final is **next monday** (6/9)
  - midterm III: **3:00 - 4:20 PM**
    - 125 pts
    - range: weeks 8-10
  - final: **4:30 - 5:50 PM**
    - 100 pts
    - range: cumulative
  - keep track of your pace!!
- yay last section!!

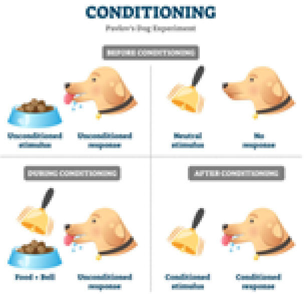
learning: a permanent change in behavior due to experience

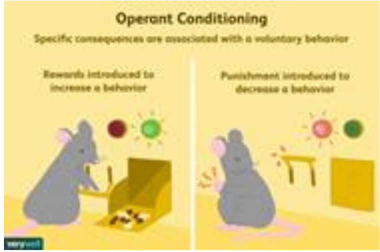
law of effect (thorndike 1905)

- behaviors followed by reinforcement are more likely to be repeated

conditioning: process in which associations are formed between stimulus, context, action

1. classical conditioning (pavlov): association between 2 stimuli
    a. requires temporal contiguity (stimuli most *co-occur* closely in time)
2. operant conditioning: learning through consequences of behavior

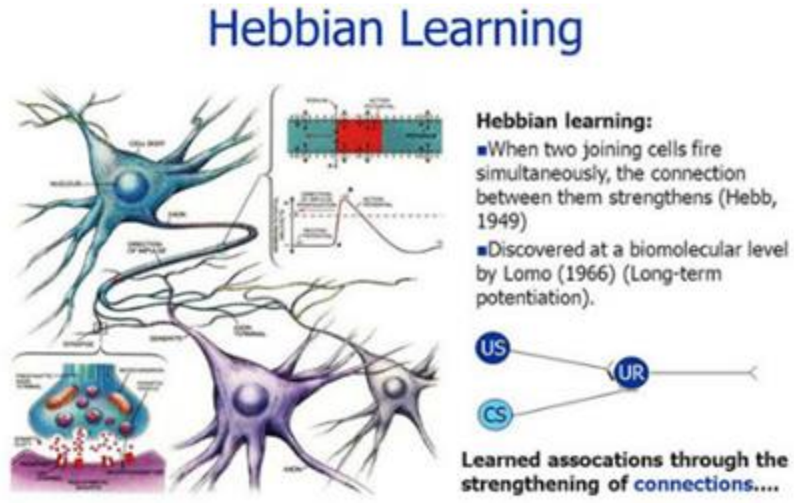




neural basis of learning

hebbian learning rule: neurons that *fire* together, *wire* together

- temporal co-occurrence of stimuli → repeated co-activation of neural circuits → strengthen synaptic connections
  - functionally linked neural networks to participate in learning and retrieval of associations
- learning induced changes involve:
  - structural change at synapses and receptors
  - metabolic changes affecting neurotransmitter activity and availability

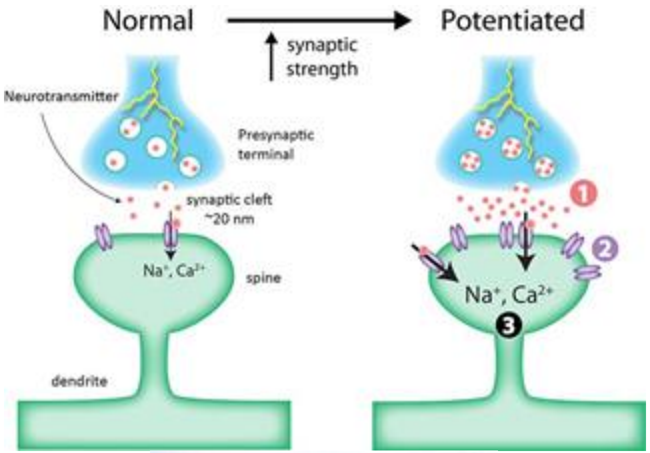


long term potentiation

semi-permanent changes in synapse strength supporting learning and memory

postsynaptic mechanisms

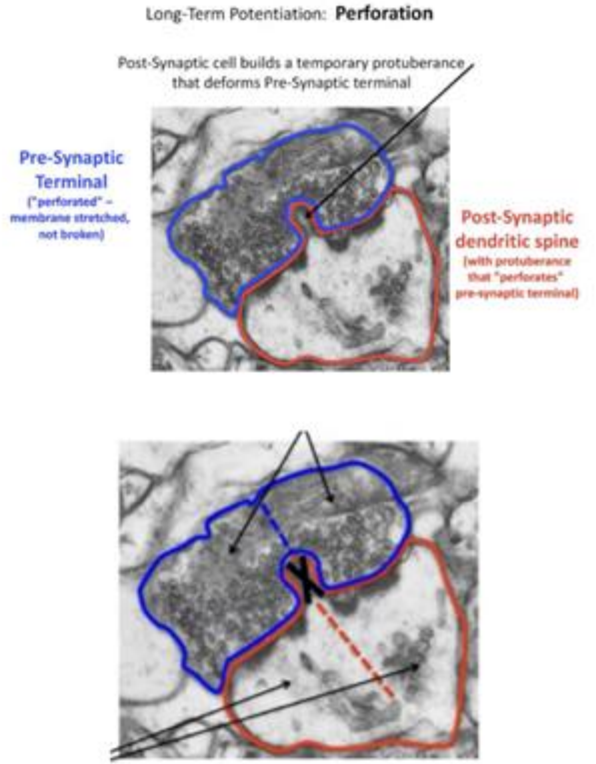
- structural changes:
  - more receptor sites
  - **dendridization**: more dendritic branching (increase surface area)
- example: 2 classic glutamate receptors
  - AMPA receptors: ionotropic, opens with glutamate allowing Na+ influx
  - NMDA receptors: blocked by Mg++, only opens if cell already depolarized
  - high glutamate input activates AMPA → depolarization ejects Mg++ → NMDA opens → Ca++ influx
    - outcome: new AMPA form/increase sensitivity; NMDA → AMPA; more dendritic branching



long term potentiation

presynaptic and genetic changes

- retrograde messengers (eg. NO)
  - released from postsynaptic cell → positive feedback loop to enhance NT release in presynaptic cell
- perforation
  - occurs where terminal button meets axon of next cell
  - postsynaptic dendritic growth pokes into presynaptic active zone causes splitting/dividing
    - increased number and size of NT release sites by creating new terminal buttons
- gene expression
  - DNA –(transcription)→ RNA –(translation)→ protein
    - protein synthesis modifies vesicles and cell metabolism



neurogenesis

- very rare
- mostly in hippocampus

memory

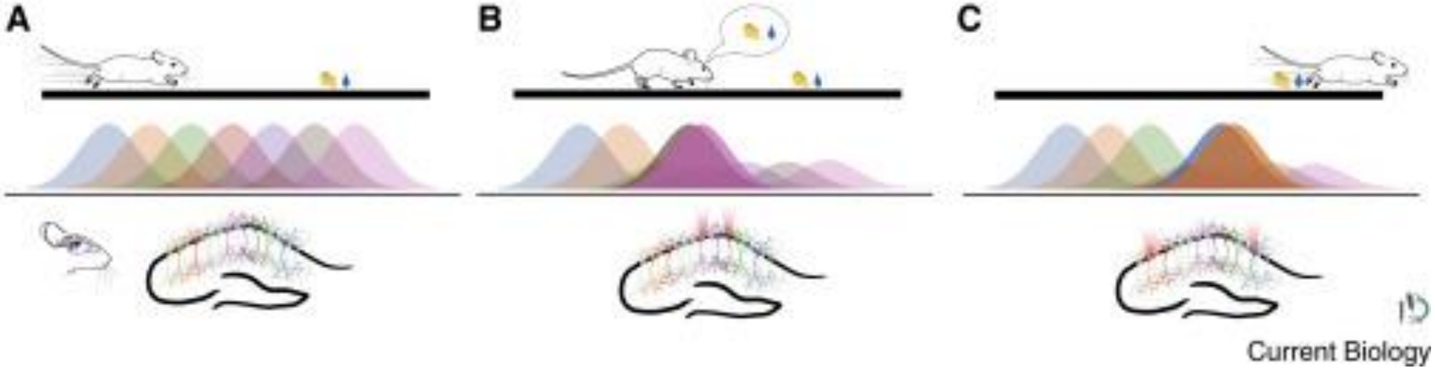
active retrieval of previously learned information

Type	Function	Key Brain Areas
Spatial	Location recall, spatial familiarity	Hippocampus
Procedural	Motor skills, "how-to" tasks	Cerebellum, Striatum (Basal Ganglia)
Declarative - **Episodic**: Personal experiences - **Semantic**/Associative: Factual knowledge	Facts, events	Hippocampus, Mediodorsal Thalamus

spatial memory

hippocampus: key in building cognitive maps

- **place cells**: activate in specific familiar locations during maze learning
- greater hippocampal volume in individuals with intensive spatial experience
    - eg. taxi drivers
- PET scan results: increased hippocampal activity when answering spatial questions
- damage impairs spatial learning, navigation



procedural memory

memory for motor skills and conditioned responses – sequences of behavior you learned how to do, knowing *how*

key players

- cerebellum
  - motor learning and classical conditioning
  - ***storage*** of conditioned responses
- basal ganglia
  - habit learning, motor sequence integration, action selection
- midbrain red nucleus
  - motor output; ***expression*** of learned motor responses

double dissociation

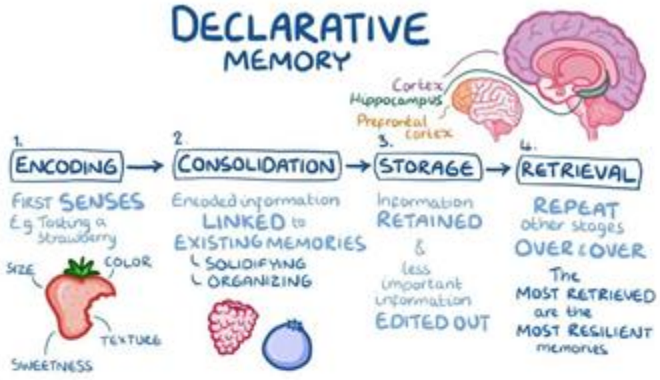
Lesion Site	**Impaired Task**	**Spared Task**
Cerebellum	Procedural (Condition A)	Declarative/Spatial (Condition B)
Hippocampus	Declarative/Spatial (Condition B)	Procedural (Condition A)

declarative memory

facts, events, rules, personal experiences; knowing *what*

neural pathway

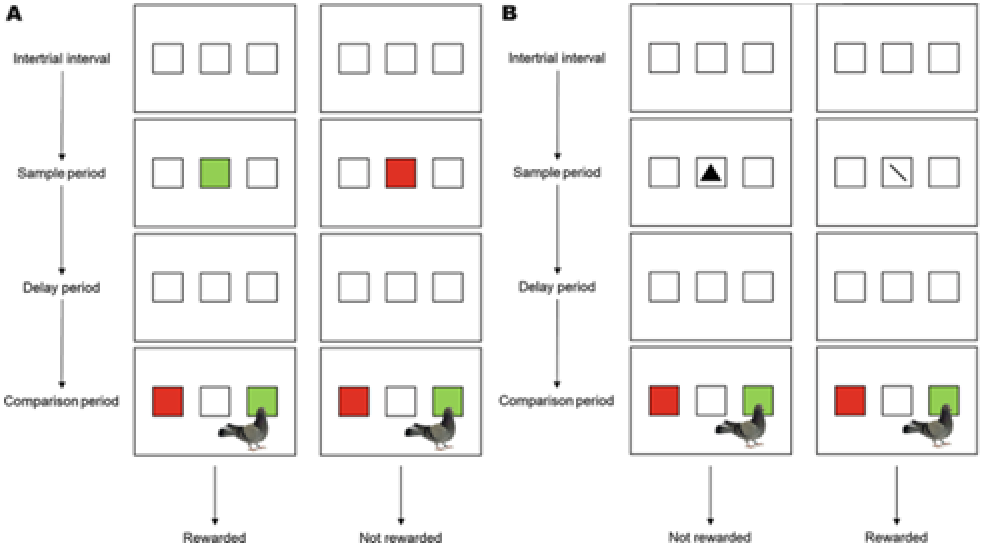
- cortical sensory → medial temporal lobe → mediodorsal thalamus → prefrontal cortex (working memory) → higher cortical
- hippocampus also crucial in declarative memory consolidation and retrieval
- amygdala also important in consolidating temporary associations to long term memory
  - emotion facilitates memory formation



declarative memory lesions and case studies

match to sample task

- present sample stimulus, must select a stimulus from a set of comparison stimuli that matches the sample
- hippocampus lesion: performance impaired w/ novel stimuli since requires application of learned rule
  - conclusion: hippocampus plays vital role in memory formation and retrieval



declarative memory lesions and case studies

H.M.

- surgically removed hippocampus, amygdala, temporal cortex
- results
  - anterograde amnesia (can’t form new episodic memories)
  - can learn new skills (procedural √) but no memory of having done them (declarative X)
  - preserved IQ, personality

korsakoff’s syndrome

- B1 deficiency from chronic alcoholism → damage thalamus to prefrontal cortex connection
- leads to anterograde amnesia and confabulation (fabricating memories)

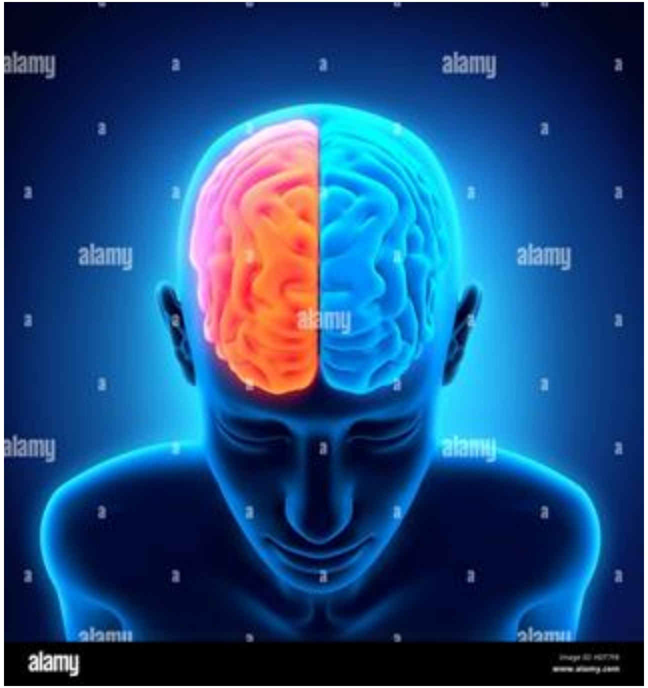
cortical long term memory storage

hippocampus and thalamus are NOT storage sites – only memory consolidation and retrieval (learning and recall)

long term storage in distributed cortical regions depending on memory type

- memory types are stored in modality-specific cortical regions

Memory Type	Cortical Storage Region	Effect of Damage
Familiar Faces	Fusiform Gyrus (Inferior Temporal Cortex)	Prosopagnosia – face blindness
Voices, Words (Auditory-Verbal)	Dorsal Temporal Cortex	Impaired recognition of voices, words
Praxic/Spatial within Reach	Posterior Parietal Cortex	Disruption of action-space memory

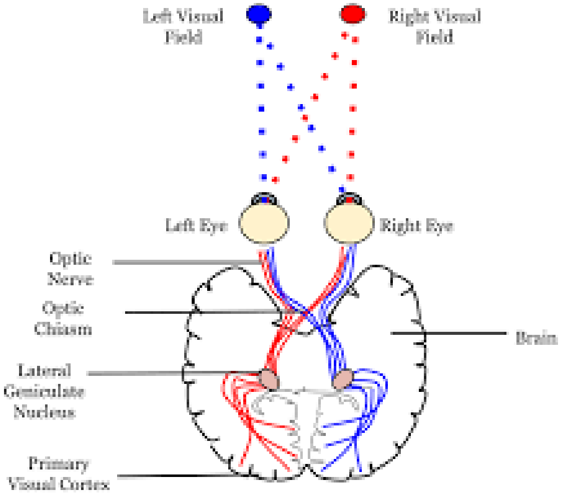


part 2: language & lateralization

bilateral crossover review

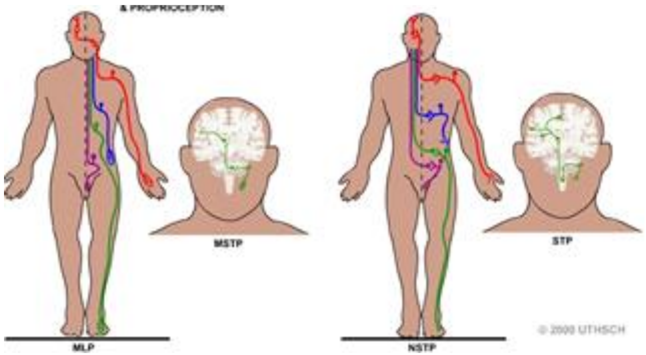
vision

- right visual cortex receives input from left visual field
- left visual cortex receives input from right visual field
- nasal hemiretina information crosses at the optic chiasm



somatosensory

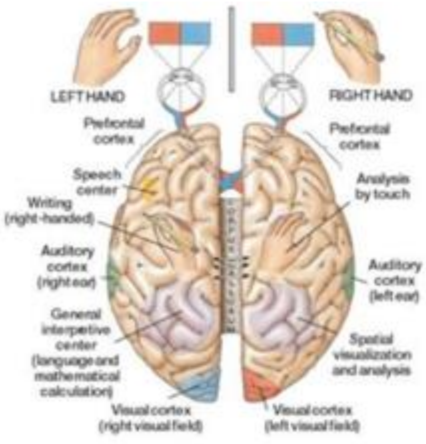
- right somatosensory cortex processes sensation from left side of body
- left somatosensory cortex processes sensation from right side of body
- more bilateral facial input



motor

- right hemisphere controls left side of body
- left hemisphere controls right side of body
- facial muscles receive input from both hemispheres (contralateral side dominant)

lateralization



specialization of one hemisphere for certain cognitive/motor functions

wada test

- temporarily anesthetizes one hemisphere to test functional dominance
- test which hemisphere affects performance
    - left: language (speech, writing, comprehension), sequential and analytical processing
    - right: visuospatial processing, socio-emotional recognition (faces, tone, affect)

interference

- dual task performance shows hemispheric constraints
    - talking (left dominant) slows right-hand tapping more
    - listening to lyrics (left dominant) interferes with reading (left dominant) more than listening to music (right dominant)
- stuttering often found in left handers (less clear lateralization; inter-hemispheric competition for speech control?)

physical differences in lateralization

corpus callosum

- large bundle of axons connect L and R cerebral hemispheres
- coordinates sensory, motor, cognitive info between both sides of body
    - left-handers: thicker corpus callosum → greater interhemispheric communication, more ambidextrous
    - women: thicker corpus callosum → less lateralized, better compensation post-damage

planum temporale (in temporal lobe, incl. wernicke’s)

- larger in L hemisphere

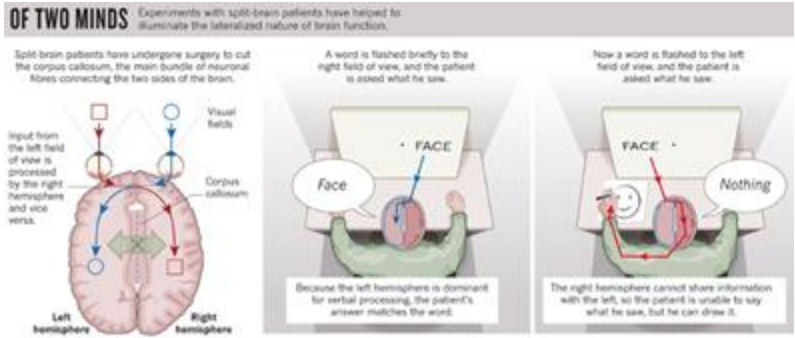
anterior commissure (connecting anterior temporal lobes)

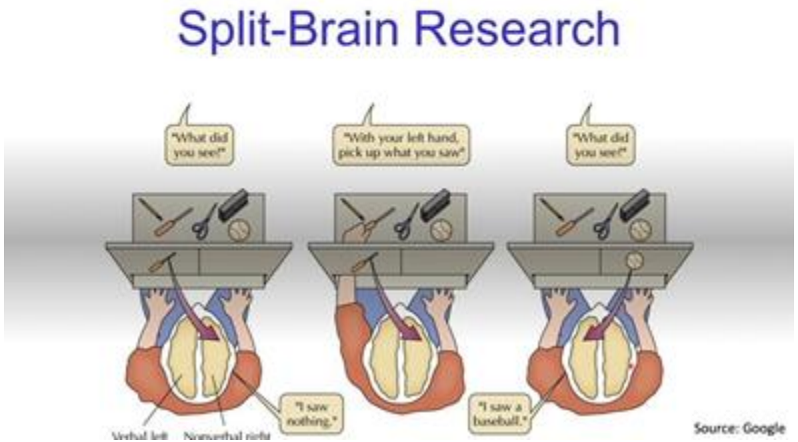
- larger in females and homosexual males

interhemispheric communication

split brain research

- severed corpus callosum → disconnection between hemispheres
- test
  - visual flashed in RVF (left hemisphere control)
    - *can* name visual
    - can identify by touch with right hand
  - visual flashed in LVF (right hemisphere control)
    - *can't* name visual (R hemisphere lacks language)
    - can identify by touch with left hand

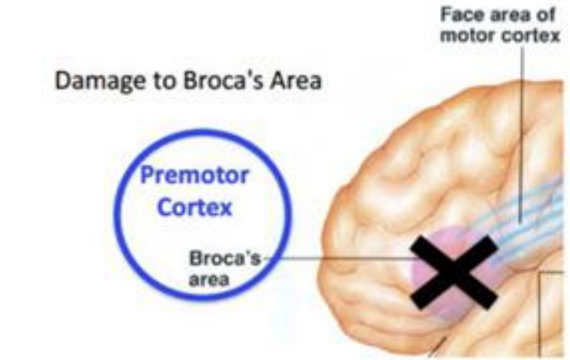


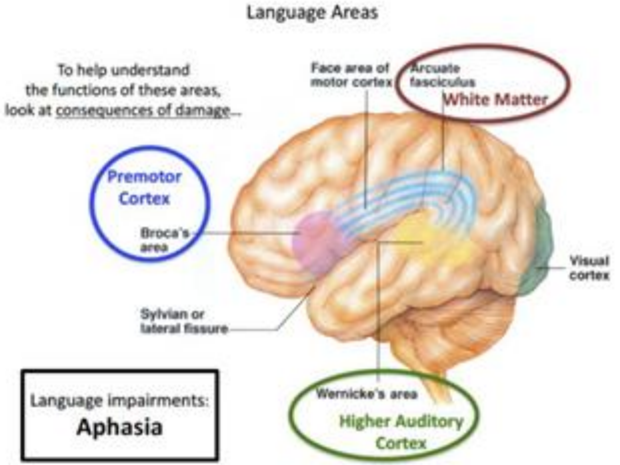


left hemisphere specialization (language)

broca’s area

- left frontal lobe, near primary motor cortex
- language *production*
- damage → broca’s aphasia (nonfluent/productive aphasia)
    - symptoms:
        - articulation difficulties (laborious, mispronounced speech)
        - anomia (can’t find word)
        - agrammatism (deficits in grammar production)
            - can’t retrieve close-class words (prepositions, articles, conjunctions…)
    - can generally understand speech, produce generally meaningful speech
    - patients are generally aware of their deficits and are frustrated

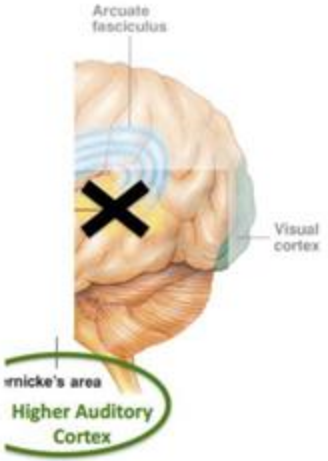


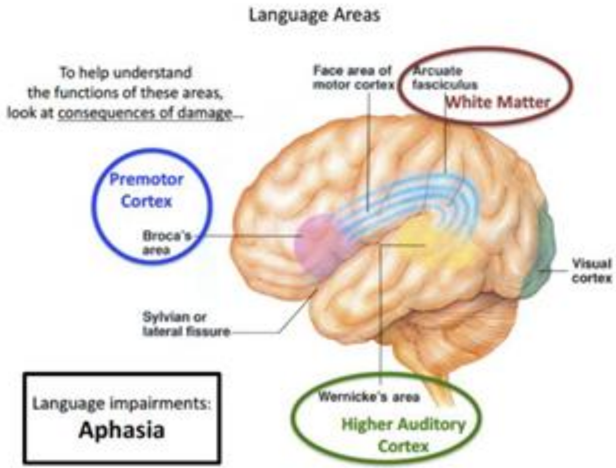


left hemisphere specialization (language)

wernicke’s area

- left superior temporal gyrus, near auditory cortex
- damage → wernicke’s aphasia (fluent/receptive aphasia)
    - symptoms:
        - fluent, grammatical but *meaningless* speech
        - poor comprehension: can’t follow commands/recognize spoken words
        - anomia (can’t find word) esp for content terms (nouns, verbs, adj)
        - unaware of deficits
        - pure word deafness: can read/write/lip-read but not understand speech





arcuate fasciculus

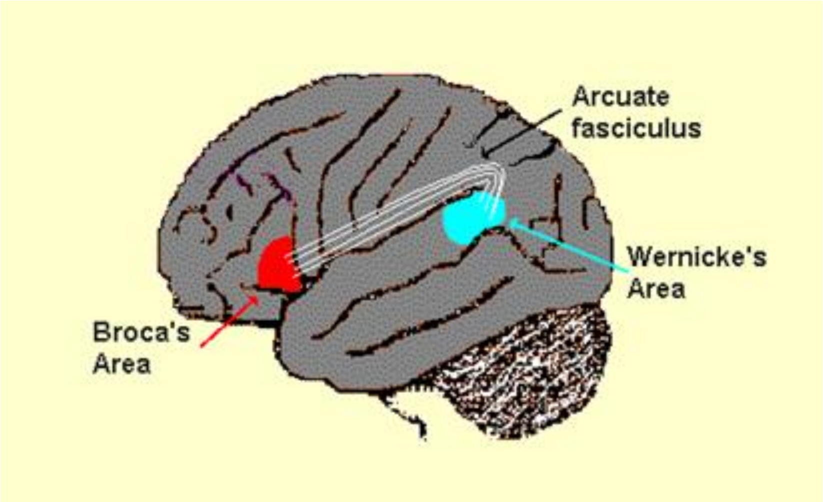
*important: **both** hemispheres and multiple cortical (and non-cortical) areas participate in language!*

white matter tract connecting broca's and wernicke's areas

rehearsal of just-heard or about-to-be-spoken words

damage→ conduction aphasia

- impaired repetition
  - can't establish phonological loop (working memory)
- phonemic paraphasia
  - substitute wrong phoneme to part of word (eg. party → partoo)



right hemisphere specialization

global pattern recognition

- holistic structure, low-detail input
  - eg. magnocellular vision
- organizes narrative
  - assembling story structure
  - getting the gist of situations
  - jokes, sarcasm, figurative meaning
  - musical & melodic perception; organize auditory patterns (emotional tone, rhythm)

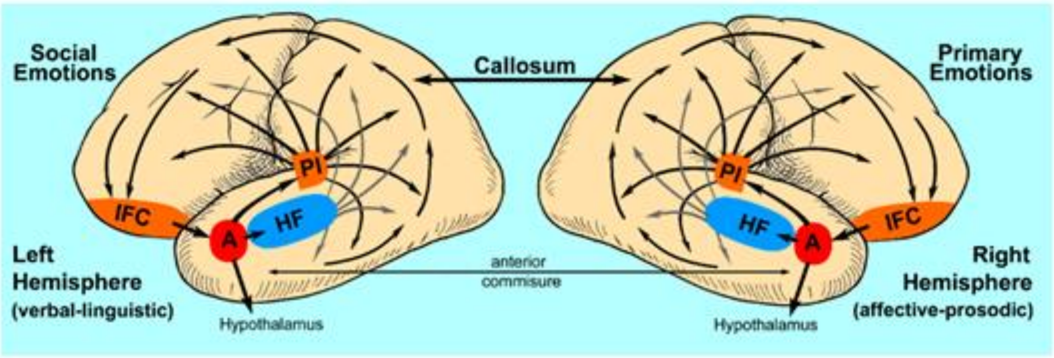
visuospatial processing

- cognitive maps
- spatial relationships (left/right, over/under)
- geometric reasoning

right hemisphere specialization

socio-emotional expression/perception

- recognizing and categorizing emotional communication
    - emotional tone and intent in speech (prosody)
    - nonliteral language (sarcasm and humor)
    - facial expressions



go slay those exams