Systems Neuroscience

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Language and memory

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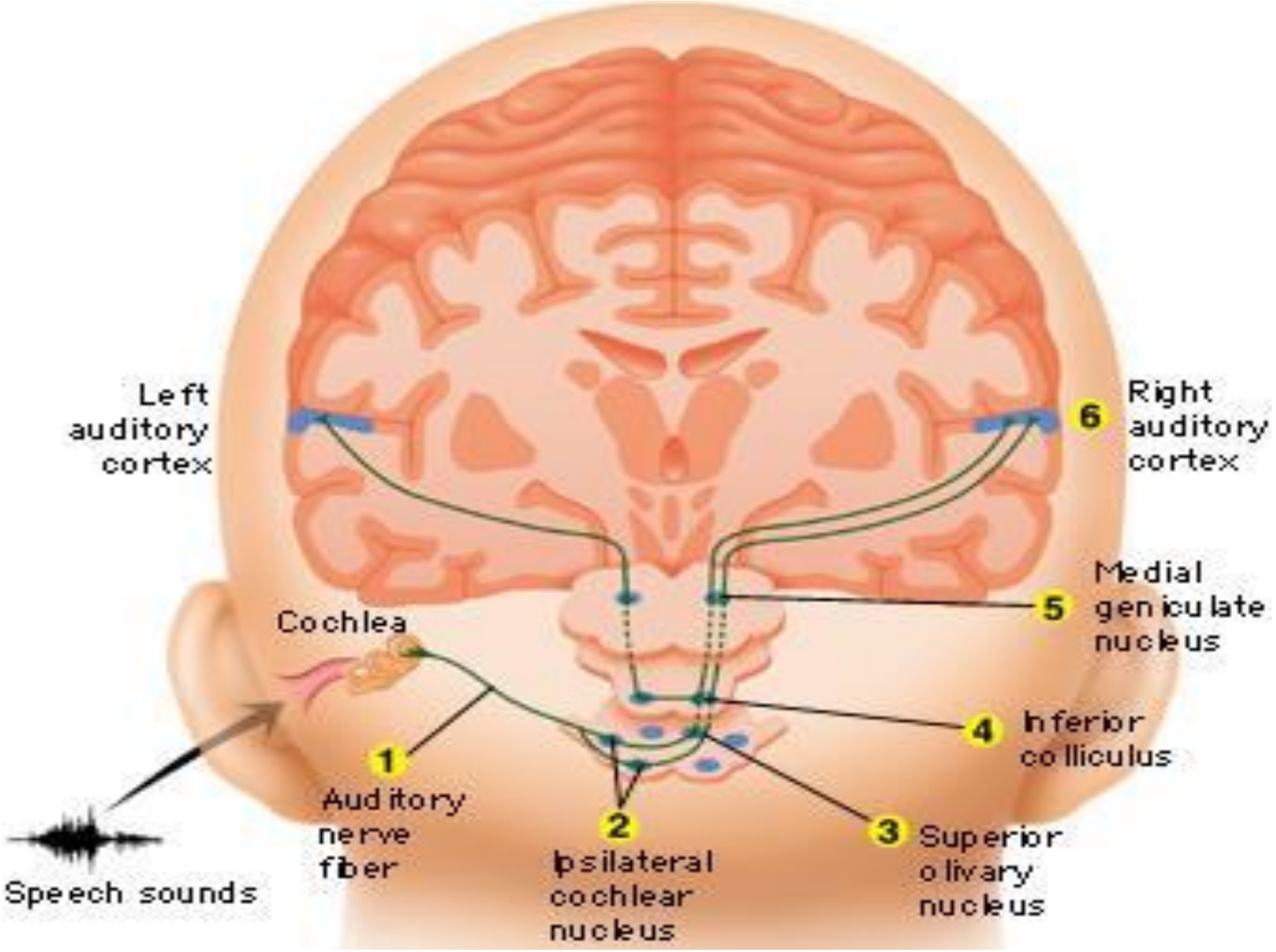
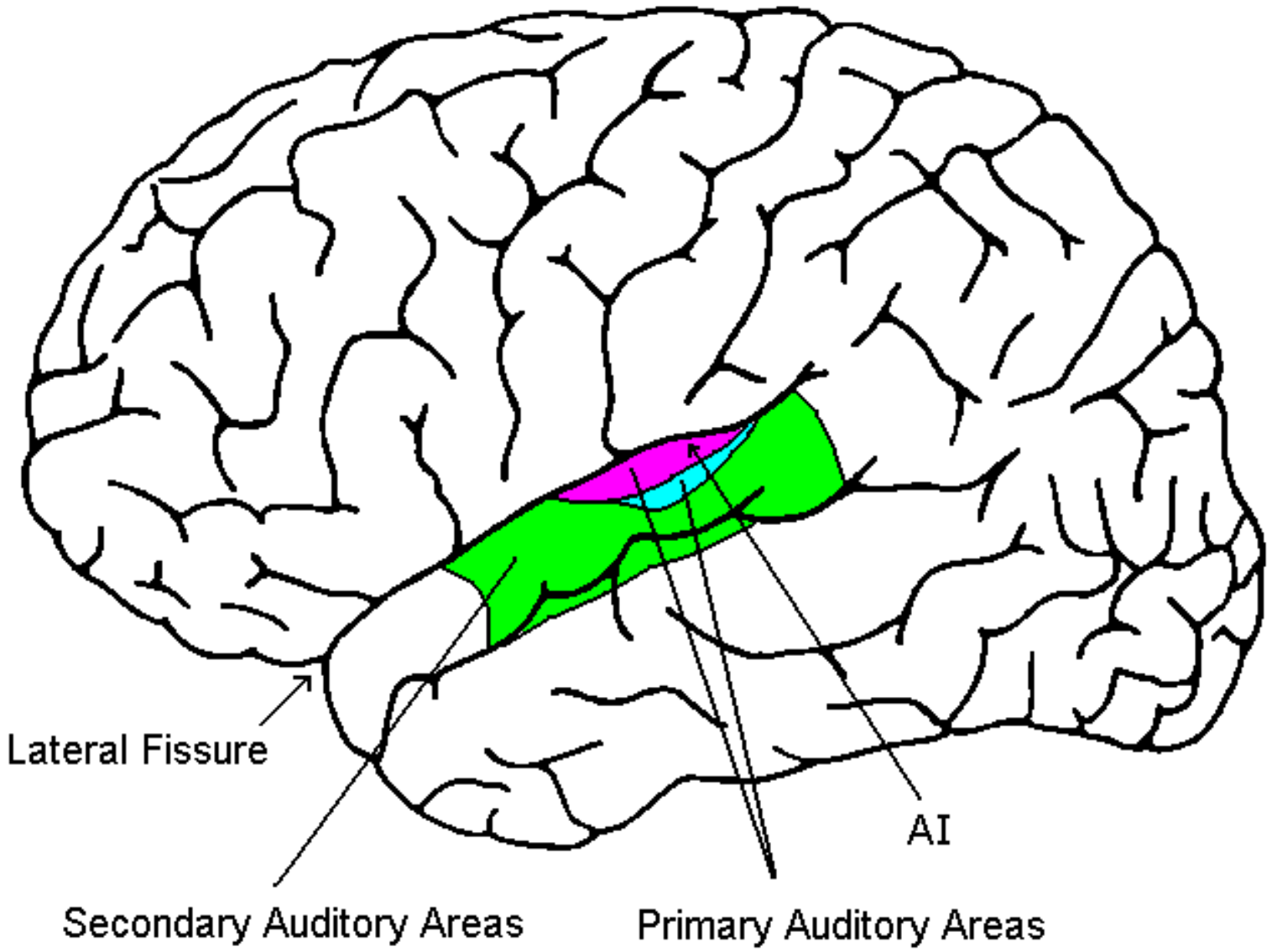
http: www.ini.unizh.ch/~kiper/system_neurosci.html


Left auditory cortex
6
Right auditory cortex
Medial geniculate nucleus
5
Cochlea
4
Inferior colliculus
1
Auditory nerve fiber
2
Ipsilateral cochlear nucleus
3
Superior olivary nucleus
Speech sounds


Lateral Fissure
AI
Secondary Auditory Areas
Primary Auditory Areas

ANIMAL COMMUNICATION MECHANISMS serve the purpose of identifying members of a species

Innate: dance of honeybees: it uses arbitrary conventions to describe objects distant in both space and time

Innate communication systems coupled with learning: birdsongs, primate (alarm) calls

HUMAN LANGUAGE: allows to designate an infinitely large number of items, actions, properties; allow to express relationships between events, such as temporal order and causation.

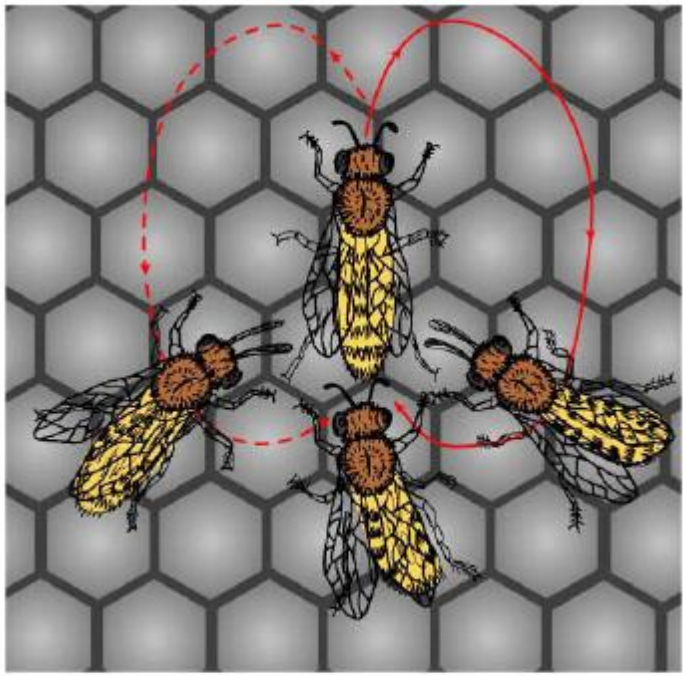
Human language requires synchronization of fine movements with cognitive activity (breathing, articulation, vocal control, manual and facial gesture, hearing, planning, memory). Role of basal ganglia and 'mirror neurons'; sign language.

Lateralization and localization of the language functions are similar as in animal communication. Other features, such as seasonal variation in the size of birdsong nuclei are not relevant to human language.

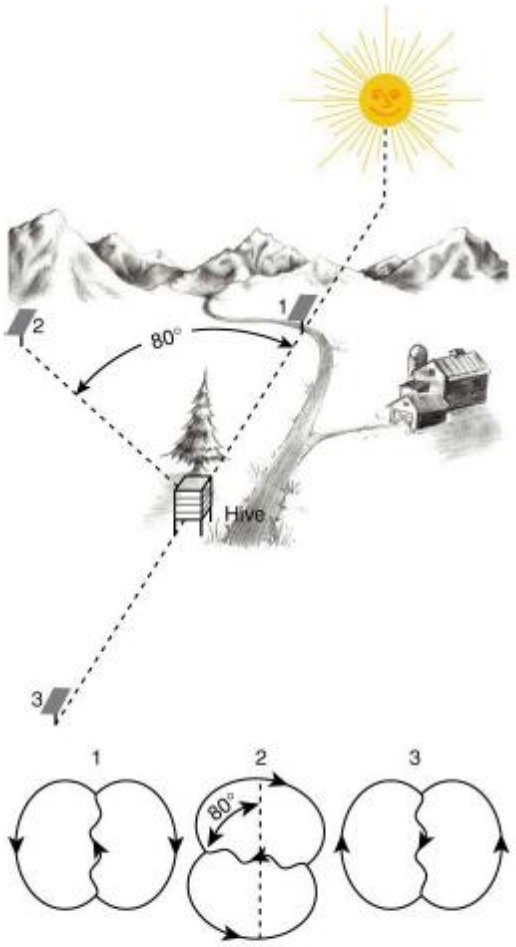
Chomsky: theory of an innate 'universal grammar"

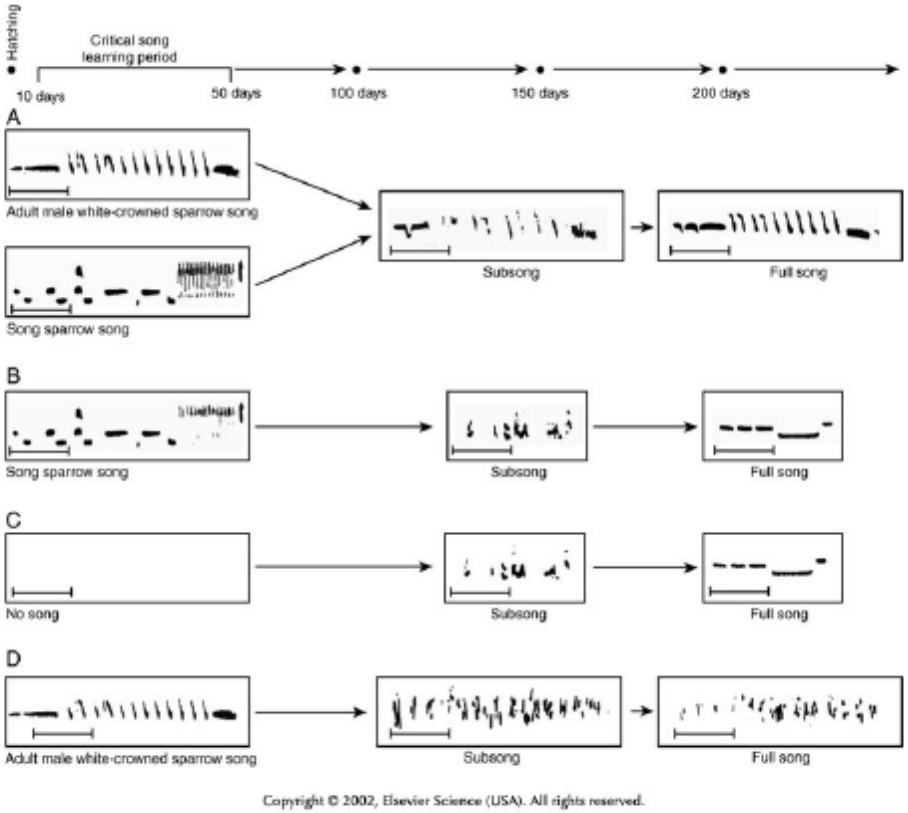
Pinker-Bloom: language evolved by natural selection

Innate knowledge and learning in the development of language abilities

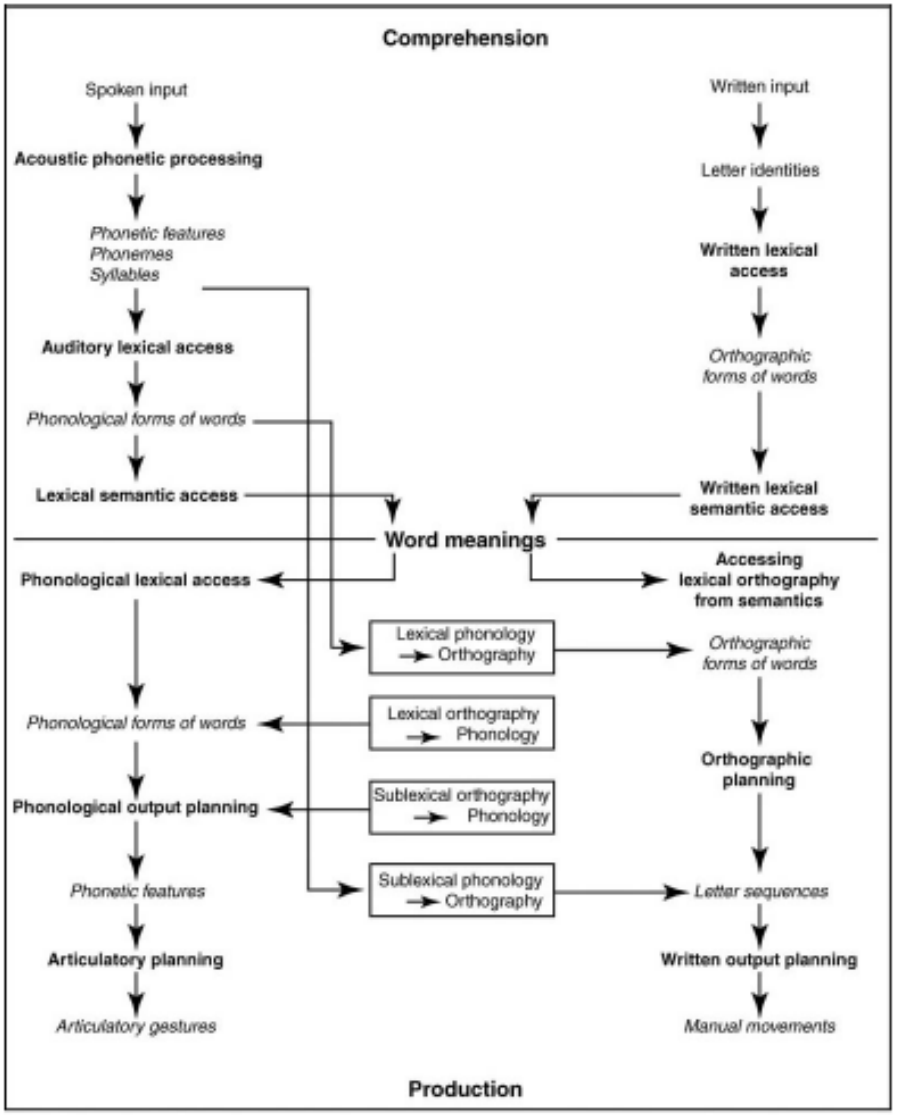


The waggle dance of honeybees follows a figure eight. Direction is encoded into the dance as the angle of the waggle runs left or right of vertical on the comb, which corresponds to the angle to the food relative to the sun's azimuth in the field.

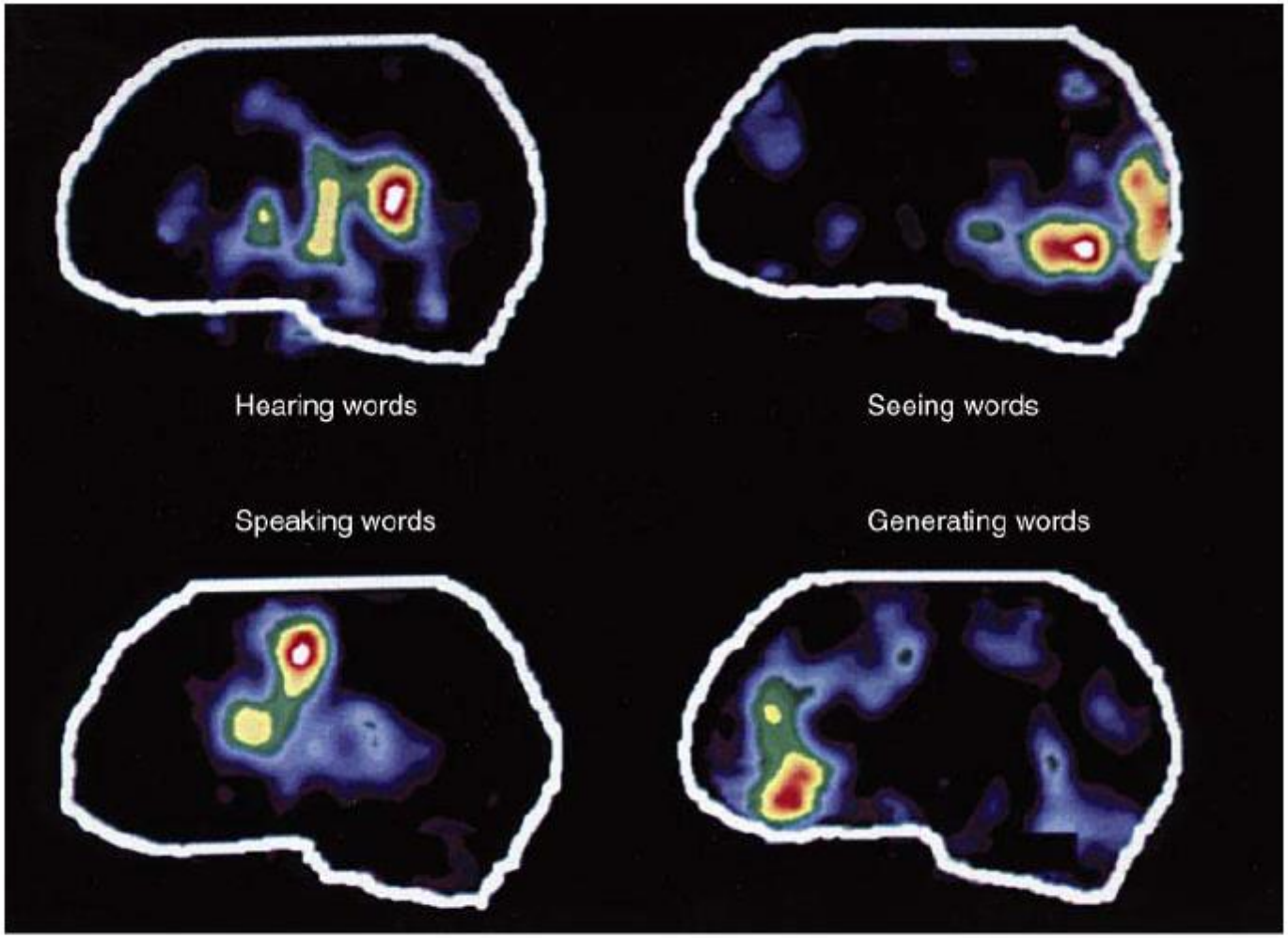


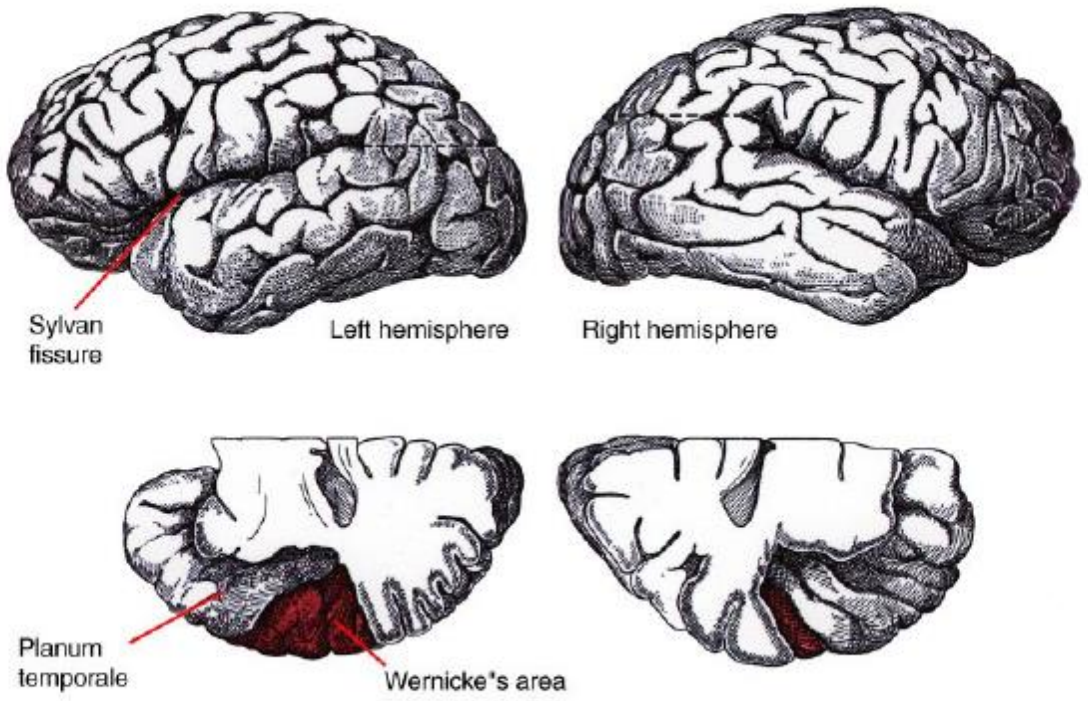


Birdsong development in most species is characterized by a sensitive period during which a song of the species must be heard. Later, during subsong (preparation for singing), the bird practices making notes and assembles them into the correct order and pattern (A). Birds not allowed to hear their species' song sing a schematic version of the song (B and C); birds deafened before subsong cannot sing (D). [Caplan and Gould, 2003].

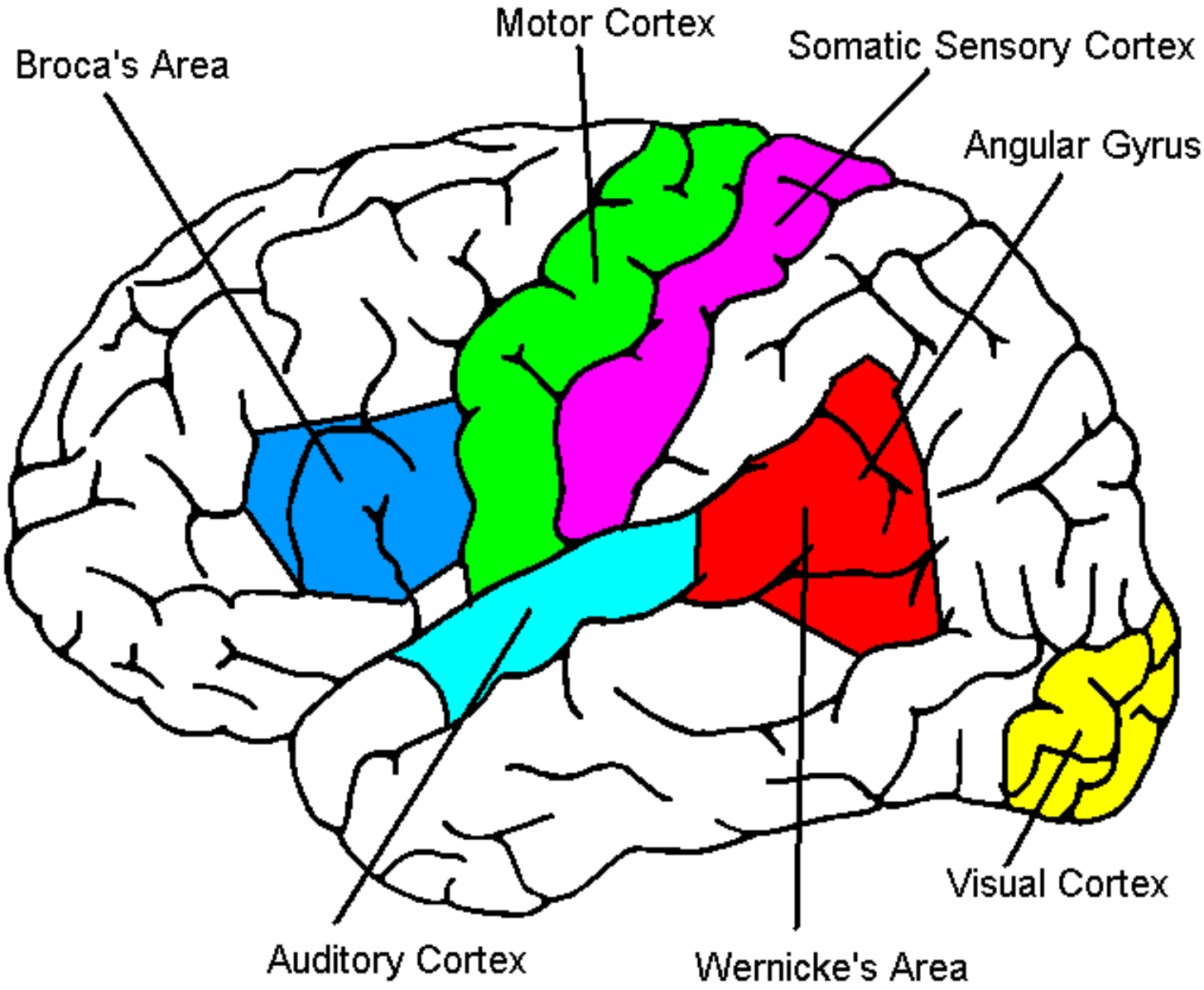


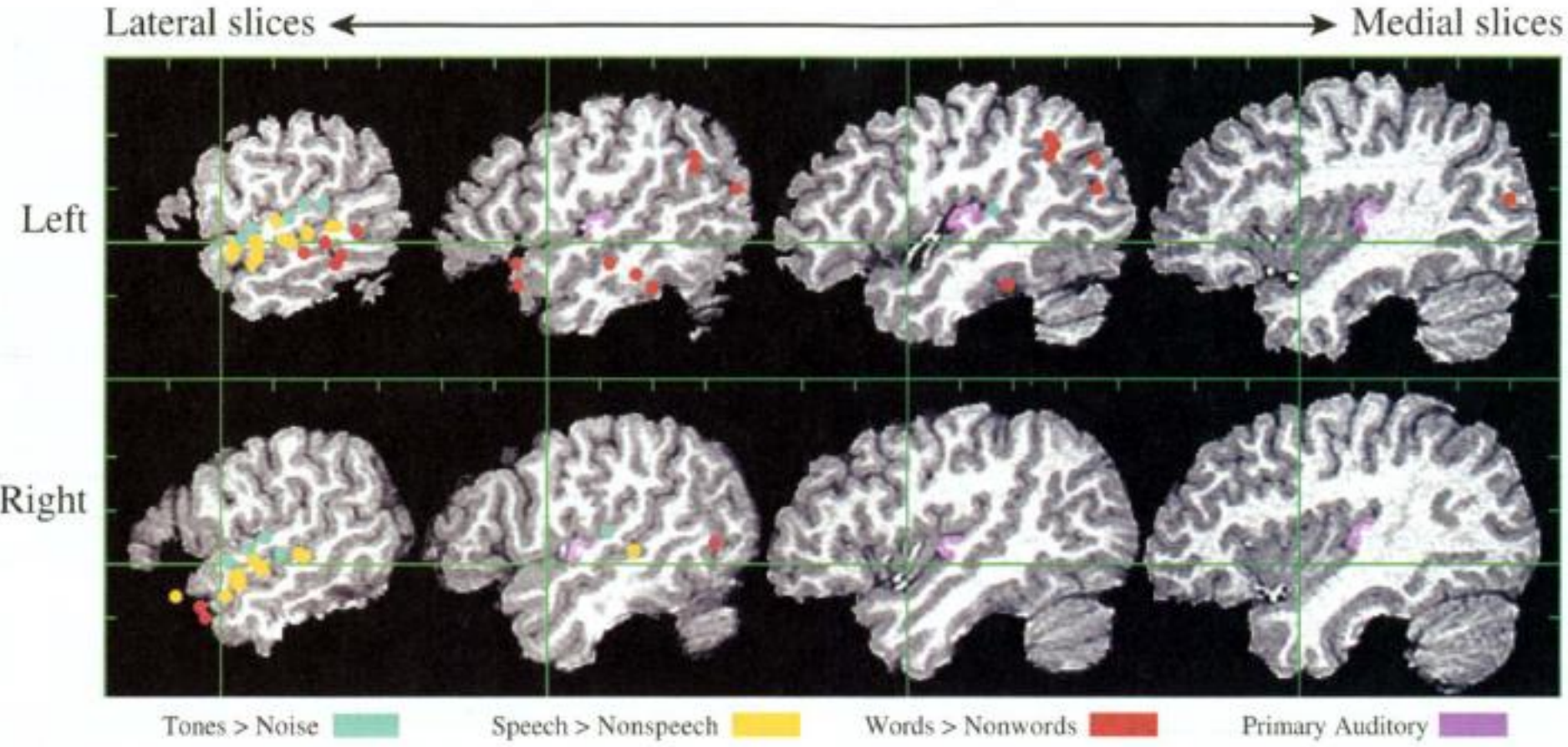
A model of the major psycholinguistic operations involved in processing simple words (Caplan and Gould, 2003)

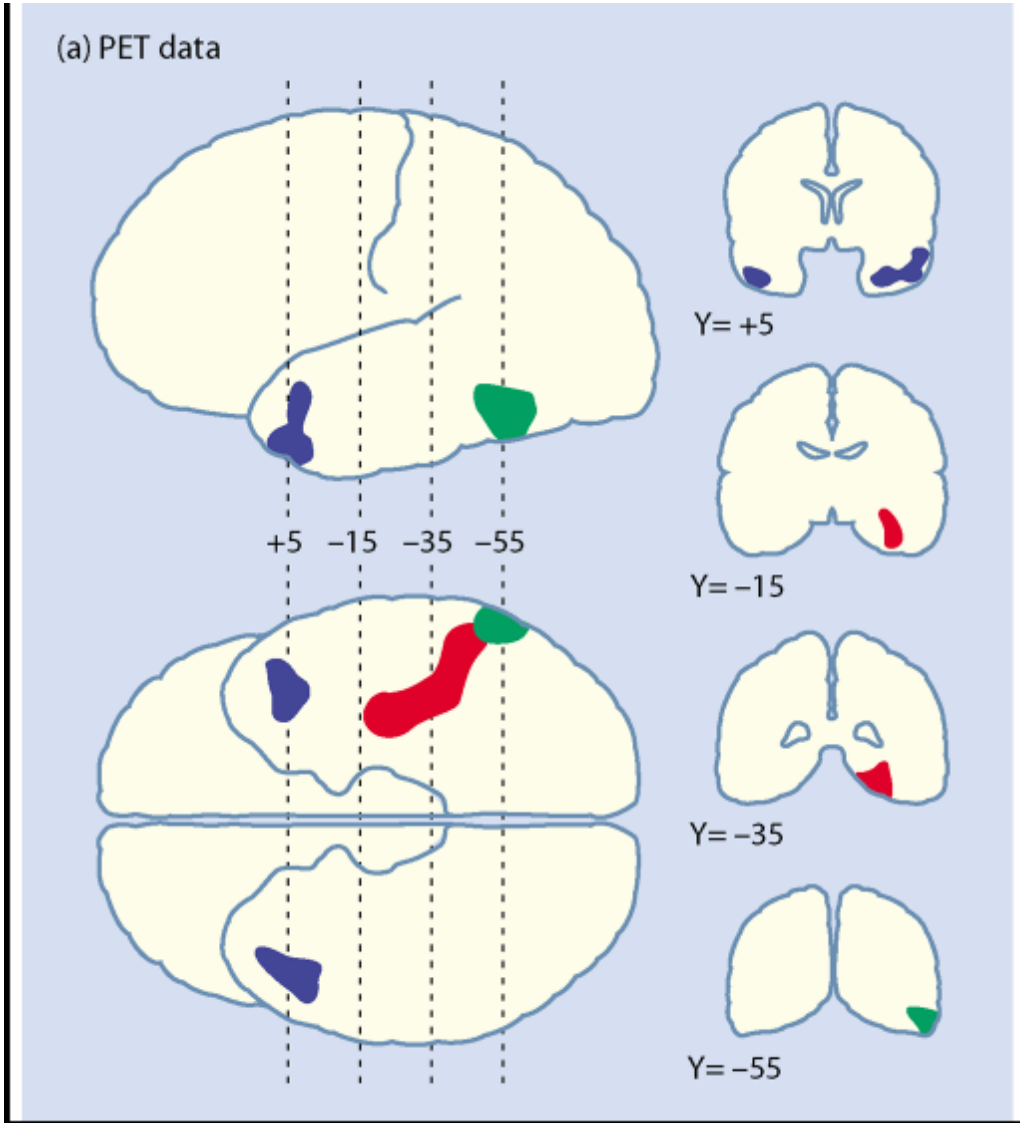




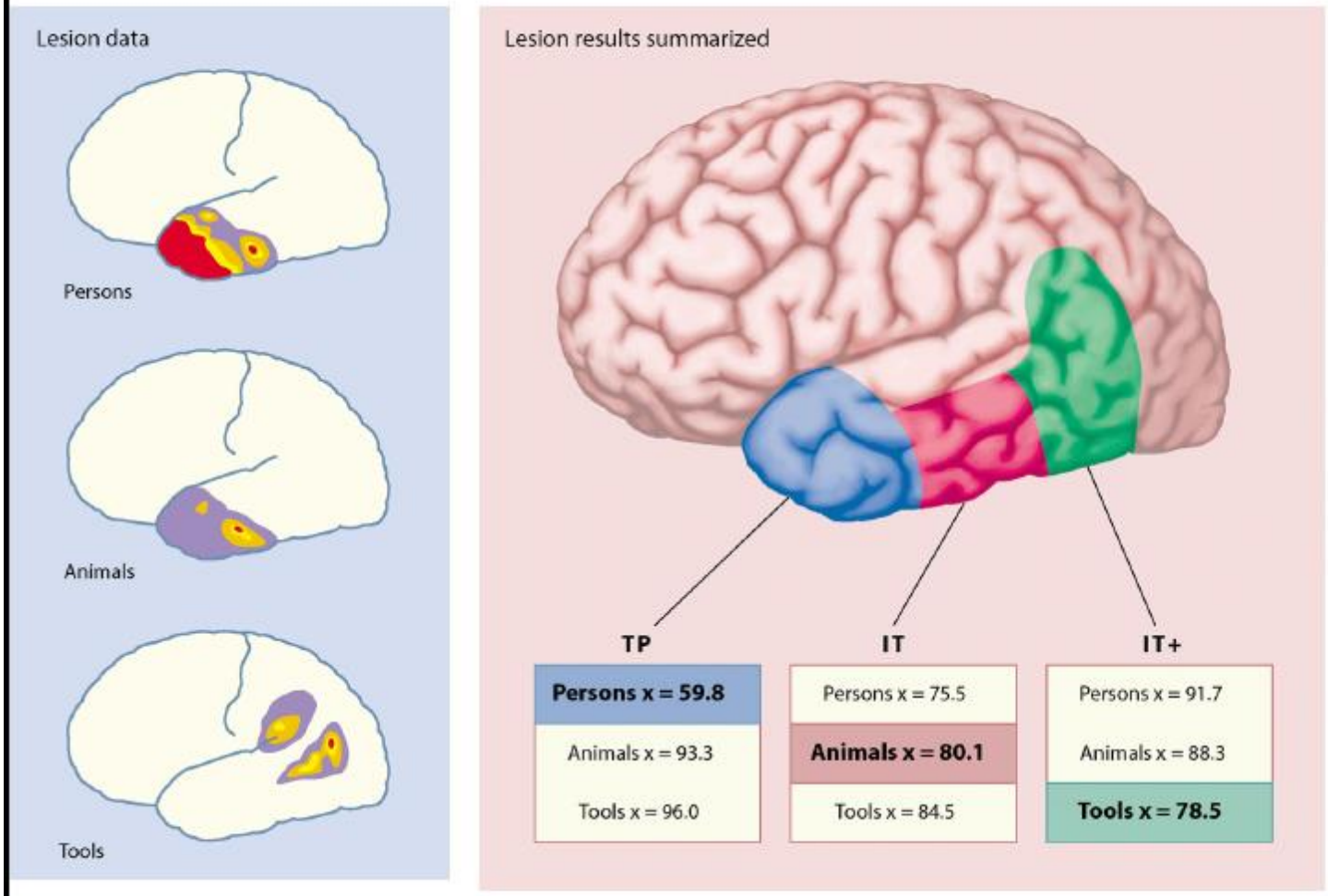
Depiction of a horizontal slice through the brain showing asymmetry in the size of the planum temporale related to lateralization of language


Broca's Area
Motor Cortex
Somatic Sensory Cortex
Angular Gyrus
Visual Cortex
Auditory Cortex
Wernicke's Area


Lateral slices
Medial slices
Left
Right
Tones > Noise
Speech > Nonspeech
Words > Nonwords
Primary Auditory



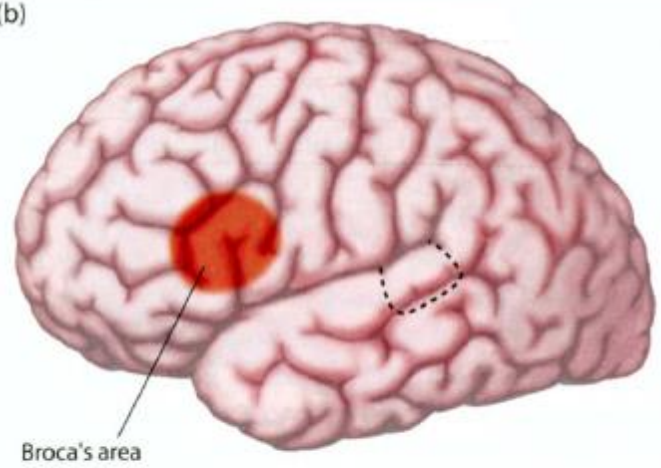
PET activations in neurologically unimpaired subjects during naming of persons, animals or tools (Damasio et al., 1996)



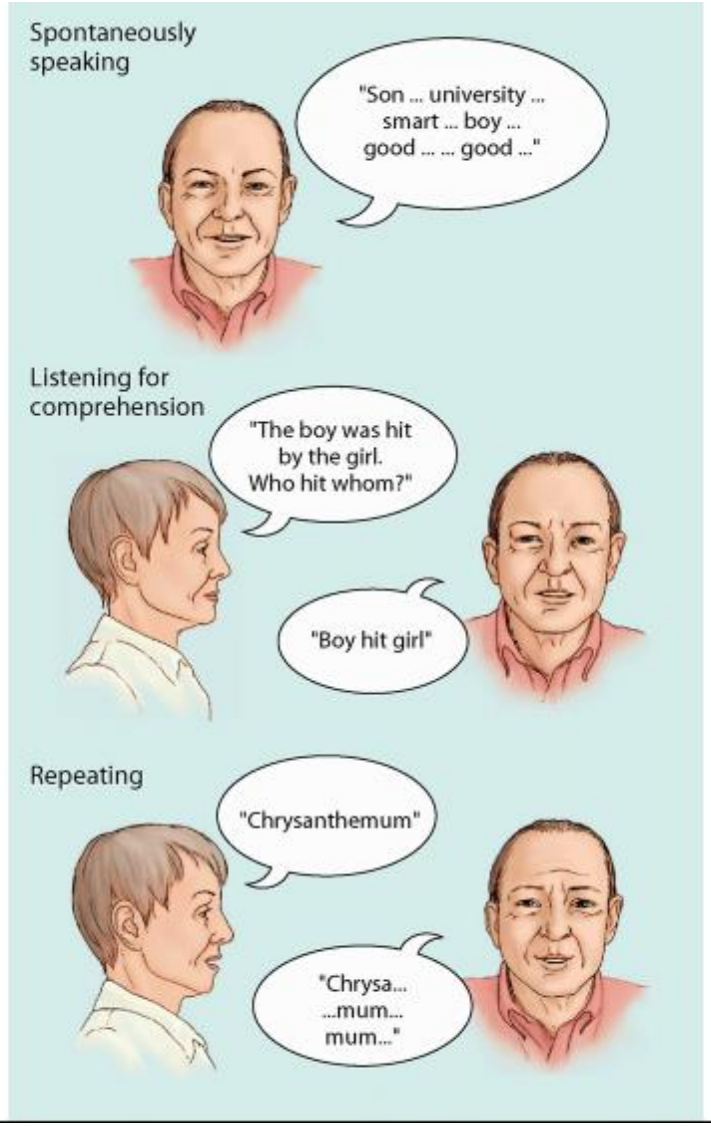
Location of brain lesions that are correlated with selective deficits in anming persons, animals or tools (Damasio et al., 1996).

(a)

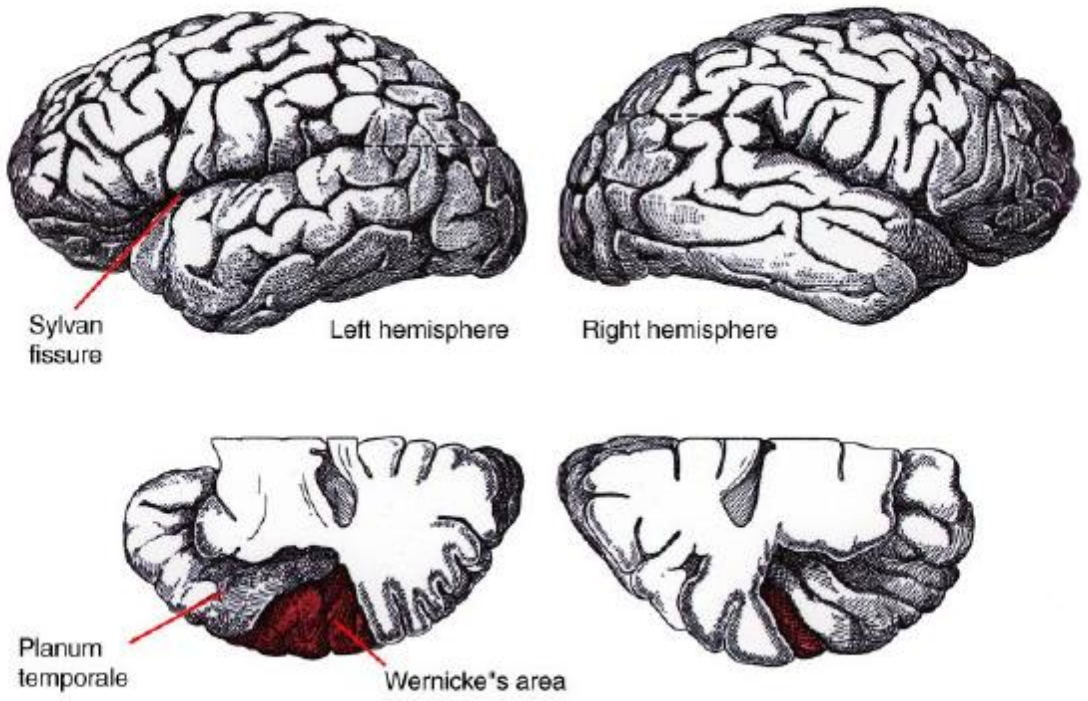
(b)



Broca's aphasia

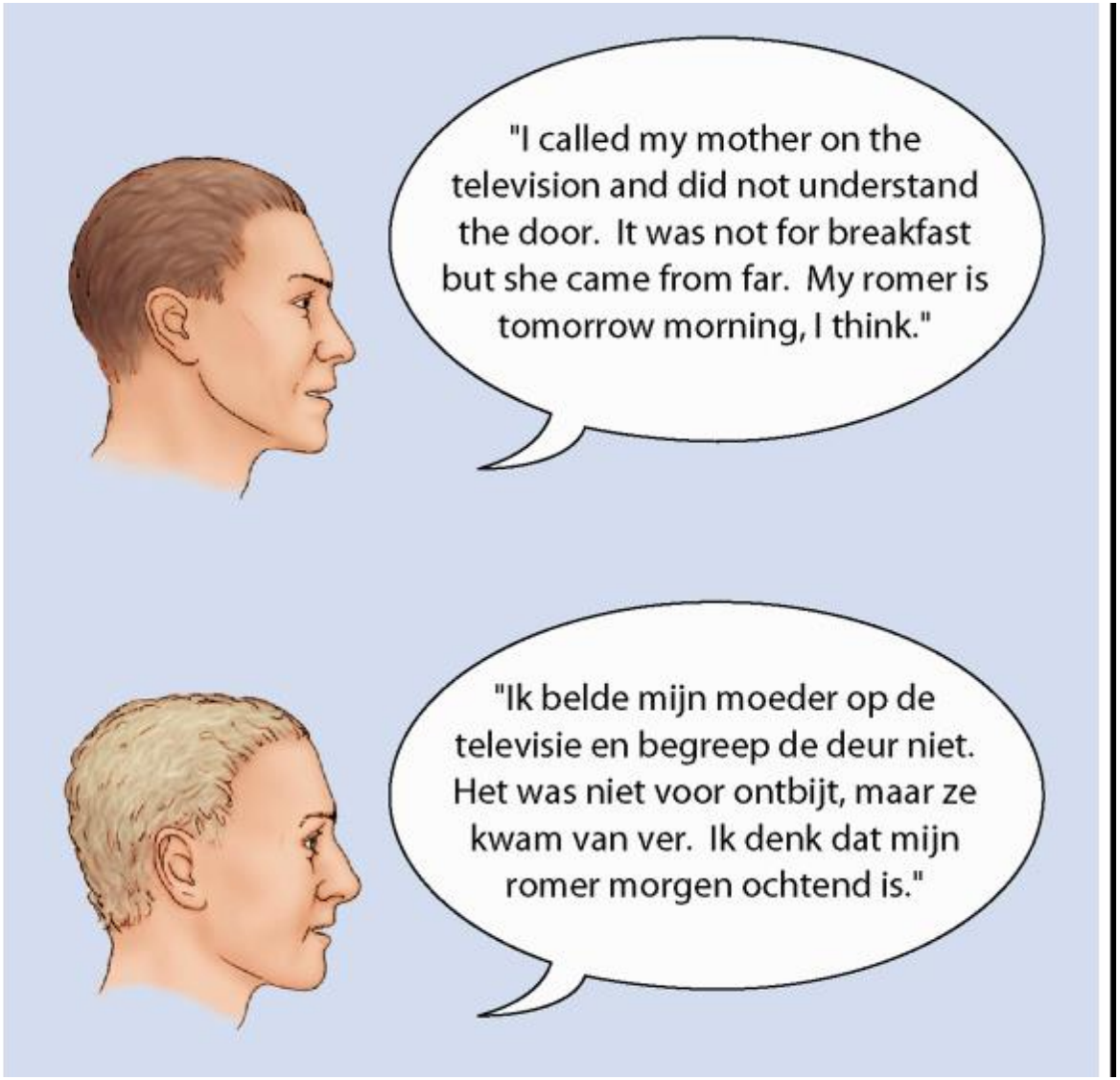


Video

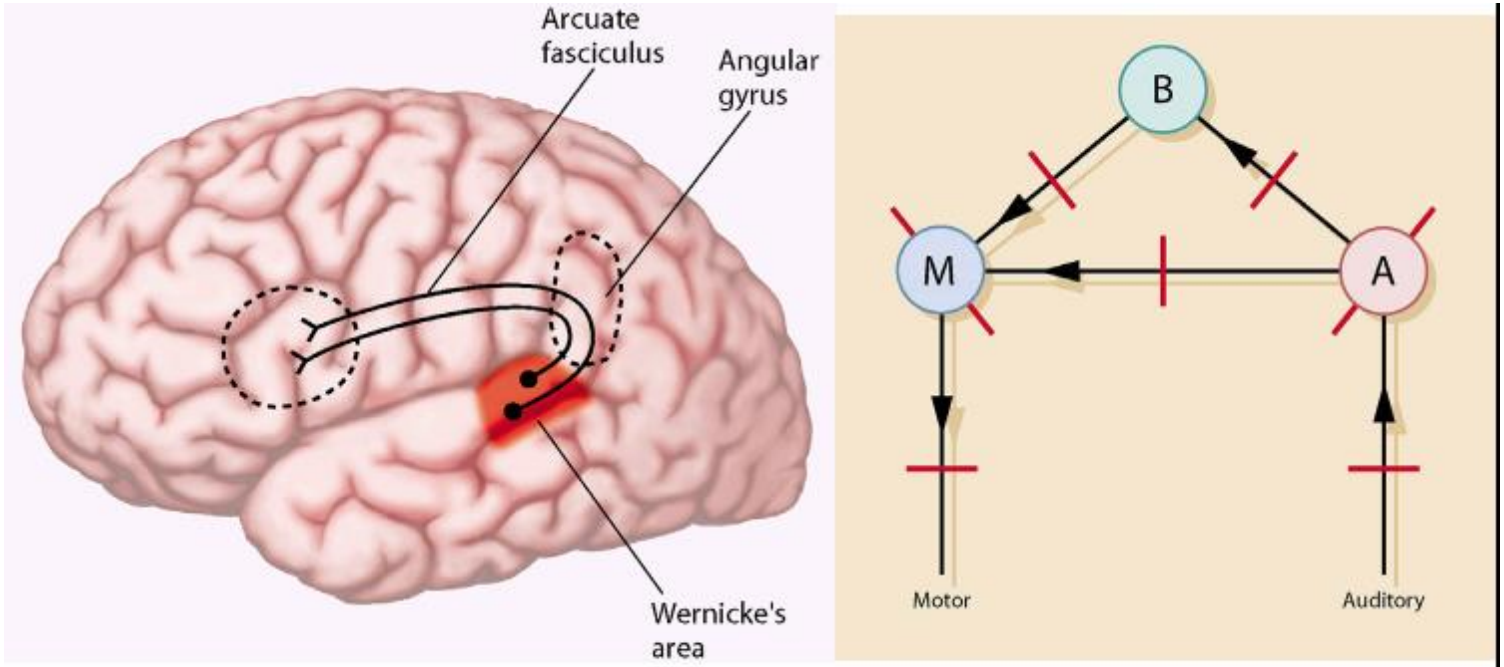


Depiction of a horizontal slice through the brain showing asymmetry in the size of the planum temporale related to lateralization of language

Wernicke's aphasia

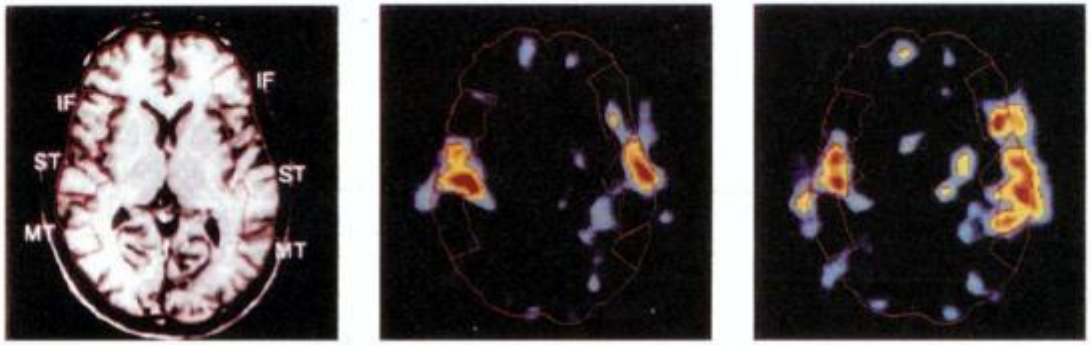


Video

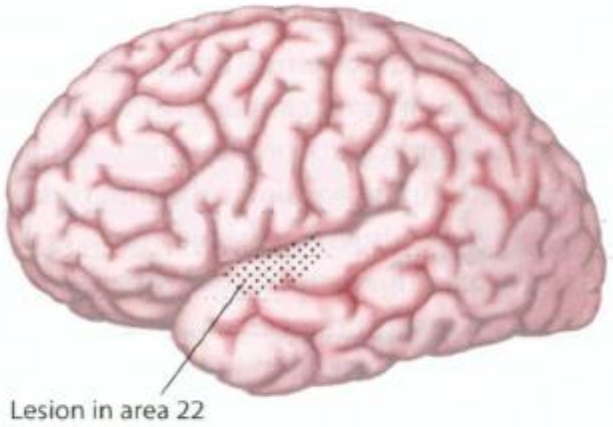


Wenicke-Lichtheim-Geschwind model of language processing. The area that stores permanent information about word sounds is represented by *A* (*Wernicke area*). The speech planning and programming area is represented by *M* (*Broca area*). Conceptual information is stored in area *B (supramarginal, angular gyri)*. From this model it was predicted that lesions in the three main areas, or in the connections between the areas, or the inputs to or outputs from these areas, could account for seven main aphasic syndromes (Caplan et al., 1994; Gazzaniga, 2002).

(a)



(b)



(a) PET activations in the anterior portion of the SDTG related to syntactic processing. (b) Lesions in the anterior STG that lead to deficits in syntactic processing (Gazzaniga)

HIERARCHICAL BRAINS SYSTEMS FOR WORD RECOGNITION:

First, the stream of auditory information proceeds from auditory cortex in Heschl's gyri to the superior temporal gyrus (STG). Here, no distinction is made between speech and non-speech sounds.

Distinction is made between speech and non-speech sounds in the adjacent superior temporal sulcus (STS), but no lexical-semantic information is processed in this area. From the STS, the information proceeds to the middle and inferior temporal gyri, where phonological and lexical-semantic aspect of word is processed.
The next stage involves analysis in the angular gyrus.

Broca area may be important for processing syntactic information.
Another area for syntactic processing is area 22 in STG.

SUBSTRATES OF SPEECH PRODUCTION:

Basal temporal regions of the left hemisphere, left frontal operculum (Broca). The articulation of words involves the posterior part of Broca (area 44), bilateral activation of motor cortex, the SMA and the insula.

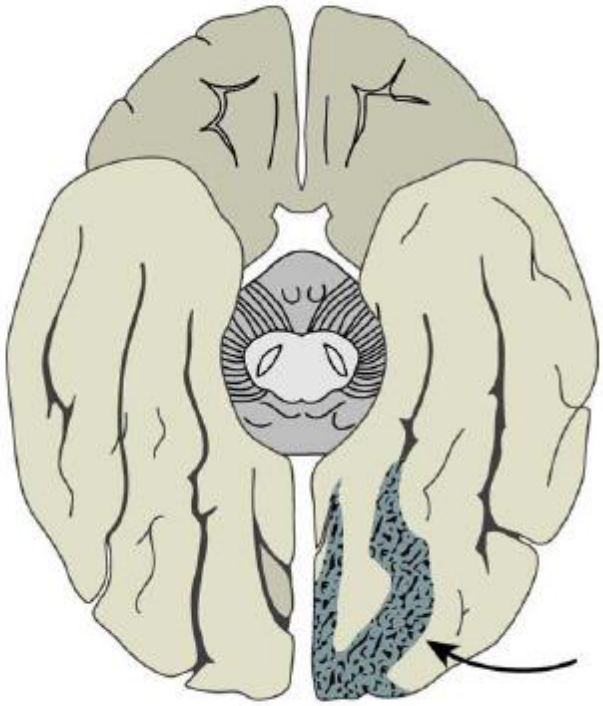


Diagram from Dejerine's 1892 paper showing the lesion that results in pure alexia. The lesion is shown from the inferior surface of the brain. It has destroyed the left visual cortex and interrupted fibers from the right visual cortex on their way to language centers in the left hemisphere

Broca's aphasia	speech output is slow, effortful, often misarticulated, missing function words, agrammatism	Disturbance in the speech planning and production mechanism	Posterior aspect of the IFG, insula, portions of the basal ganglia
Wernicke's aphasia	Fluent-sounding speech, composed of meaningless strings of words, sounds and jargon, the inability to name objects	Disturbance of the permanent representations of the sound structures of word	Posterior half of the STG, junction between the parietal and temp. lobes, including supramarginal and angular gyri, the white matter underlying W's area
Conduction aphasia	Disturbance of repetition and spontaneous speech (phonemic paraphasia)	Disconnection between the sound patterns of words and the speech production mechanism	Lesion in the arcuate fasciculus and/or cortico-cortical connections between W's and B's areas
Transcortical sensory aphasia	Disturbance of single word comprehension with relatively intact repetition	Disturbance in activation of word meanings despite normal recognition of auditory presented words	White matter tracts connecting parietal lobe to temporal lobe or portions of inferior parietal lobule
Transcortical motor apahasia	Disturbance of spontaneous speech, similar to Broca's aphasia with relatively preserved repetition, comprehension	Disconnection between conceptual representations of words and sentences and the motor speech production system	White matter tracts deep to Broca's area connecting to parietal lobe

Pure motor speech disorder	Disturbance of articulation, apraxia of speech, dysarthria, anarthria, aphemia	Disturbance of articulatory mechanisms	Outflow tracts from motor cortex
Pure word deafness	Disturbance of spoken word comprehension repetition	Failure to access spoken words impaired	Input tracks from auditory system to Wernicke;s area
Anomic aphasia	Disturbance in the production of single words, nouns. Intact comprehension, repetition	Disturbance of concepts, and or the sound pattern of words	Inferior parietal lobe or connections between parietal lobe and temporal lobe
Global aphasia	Major disturbance in all language functions	Disrupting of all language processing components	Large portion of the perisylvian association cortex
Isolation of the language zone	Disturbance of both spontaneous speech (sparce, halting speech) and comprehension, with some preservation of repetition, echolalia	Disconnection between concepts and both representations of word sounds and the speech production mechanisms	Cortex just outside the perisylvian association cortex

Learning and memory

Forms of memory

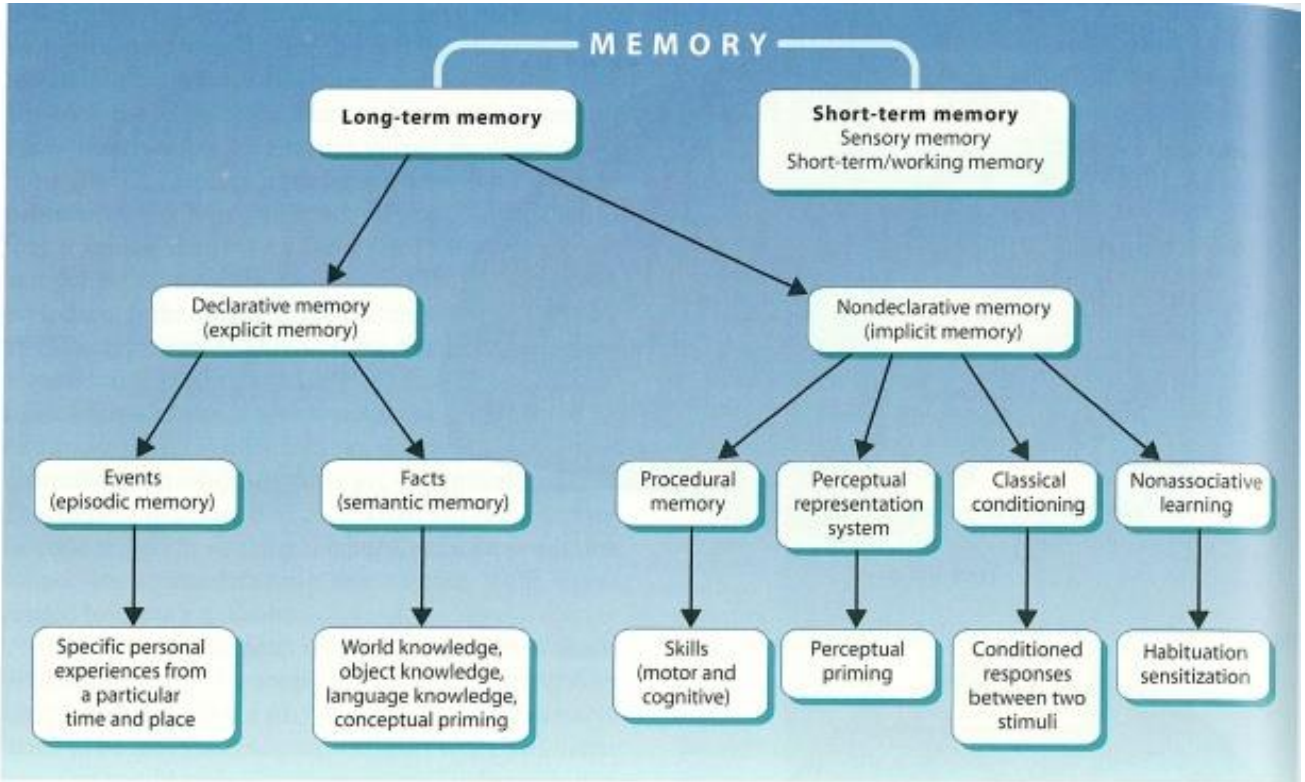
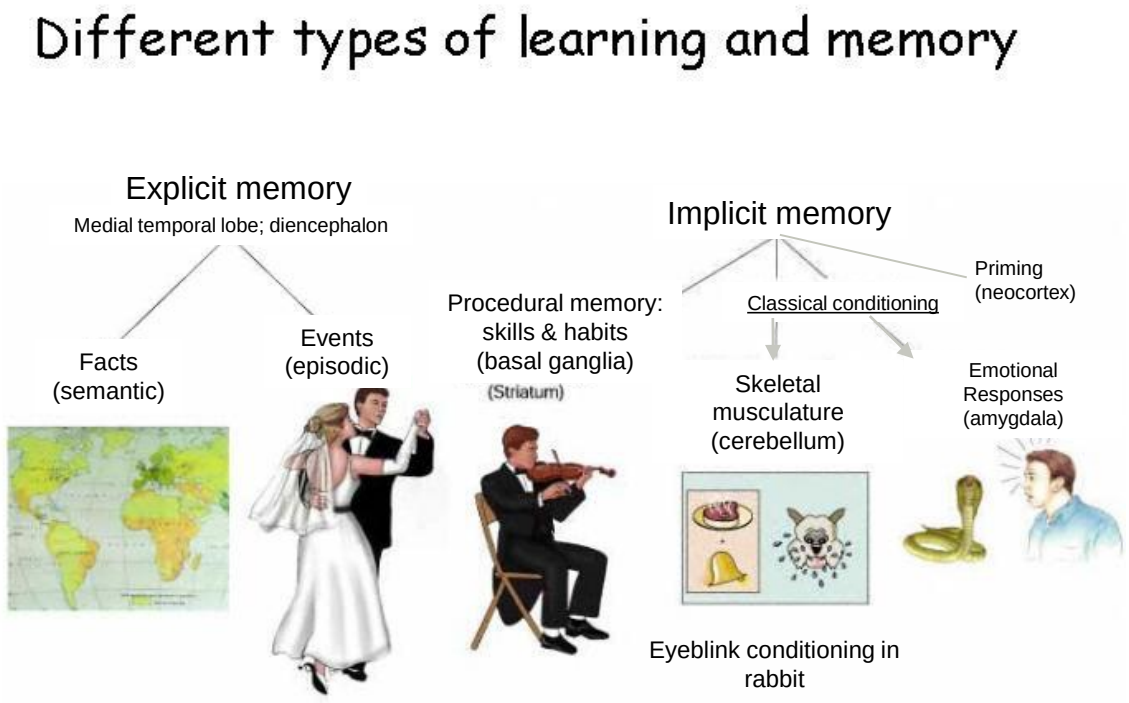


Figure 8.9 The hypothesized structure of human memory diagramming the relationship among different forms of memory.

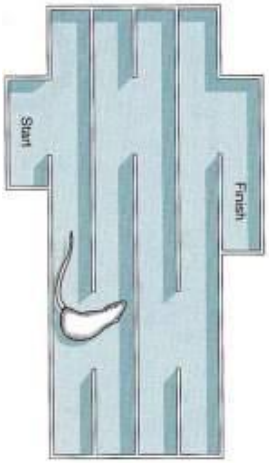
Different types of learning & memory rely on different brain structures



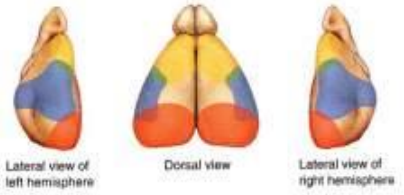
Neuroscience of memory

- Karl Lashley (1950) searched for the *engram*, the physical location of a memory.
- He destroyed progressively larger areas of monkey brain tissue after training them on a task.
- The monkeys retained the memory, suggesting it was distributed to many parts of the brain, a principle known as *equipotentiality*.

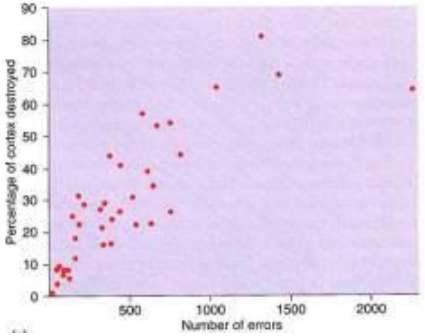
Lashley's Search for the Engram in the 1920s



Rats are trained to run through a maze without entering blind alleys.



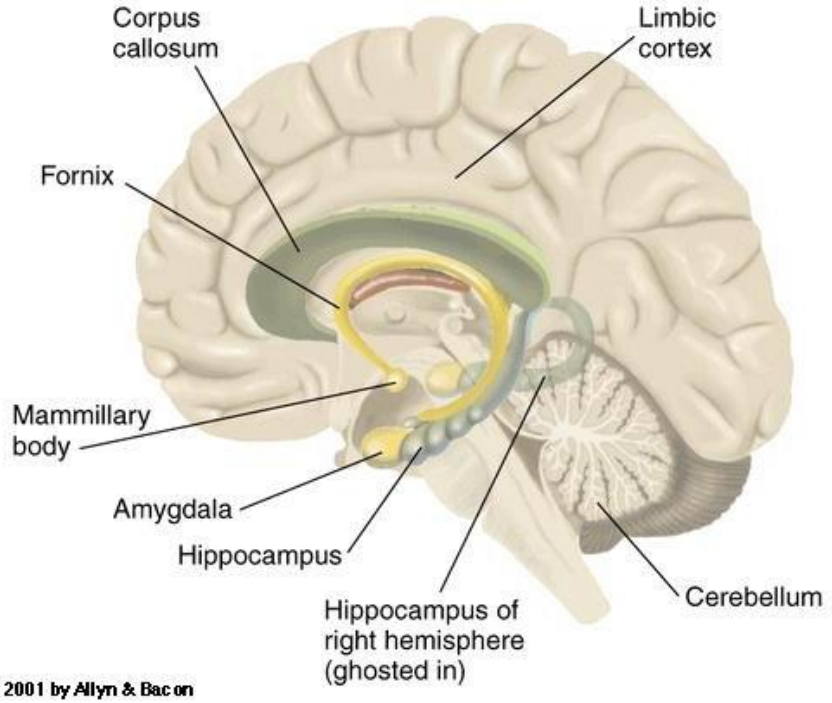
After training, cortical lesions are made. Three different lesion locations are shown in red, blue, and yellow



Errors are associated with the size rather than the locus of the lesion.

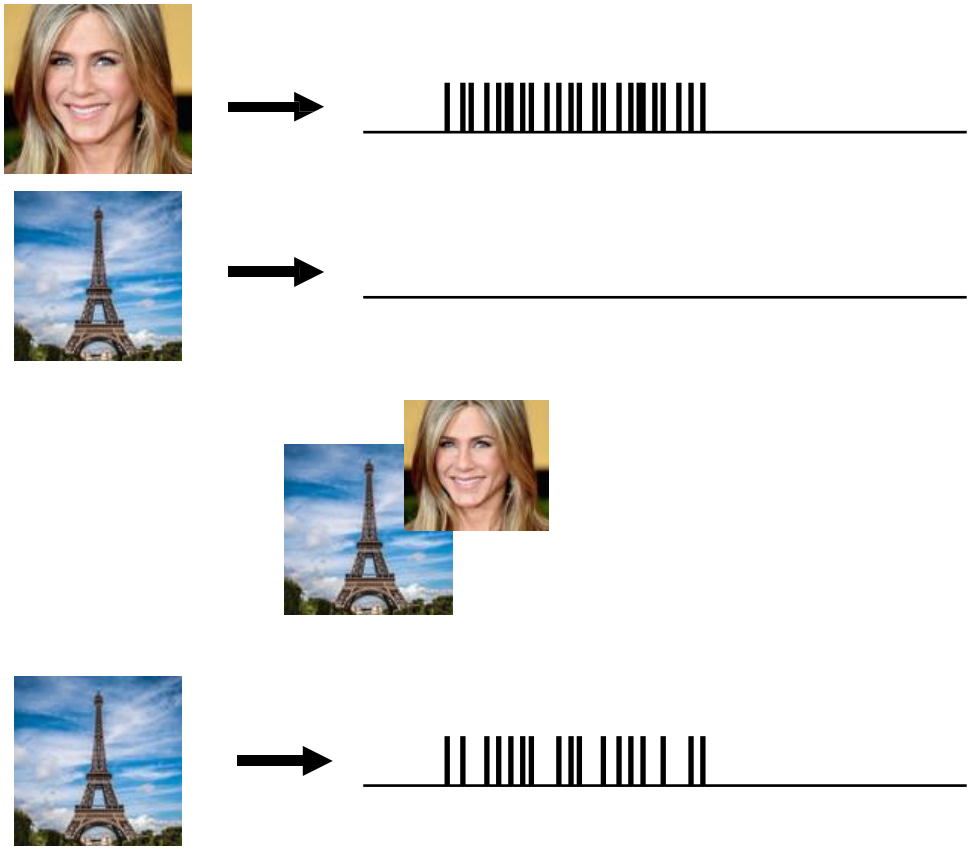
The Hippocampus

- Responsible for consolidation: the transfer of information from short-term to long-term memory.
- Damage to the hippocampus can cause anterograde amnesia, see H.M.
- ≠ retrograde amnesia

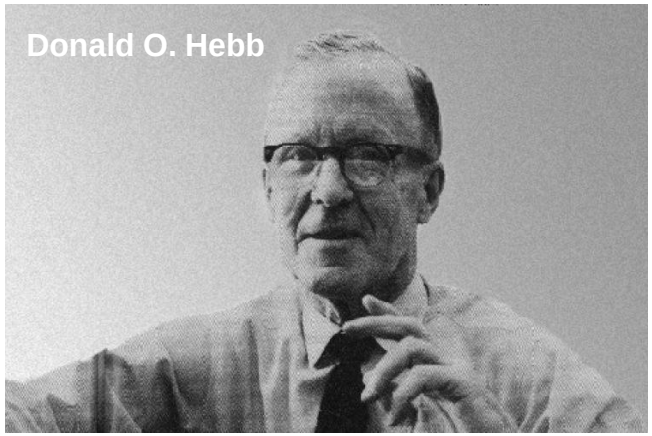


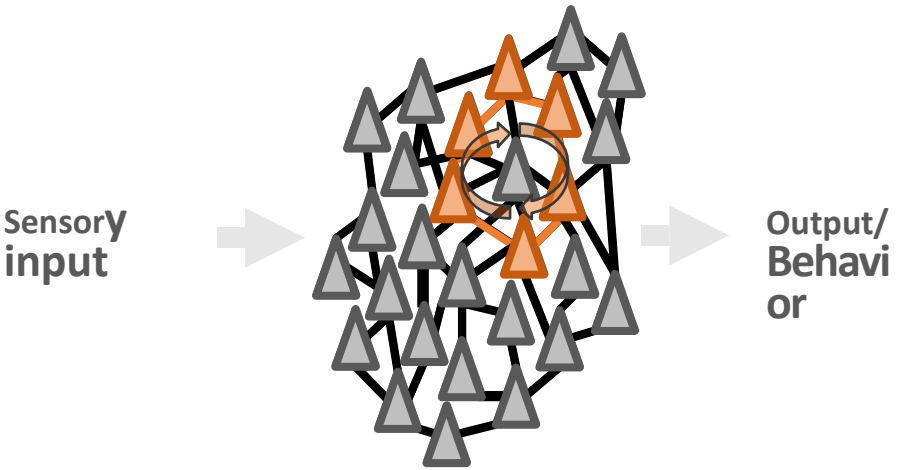
Hippocampus: Concept cells

Hippocampus: concept cells



Hebb's ‚Cell Assemblies‘





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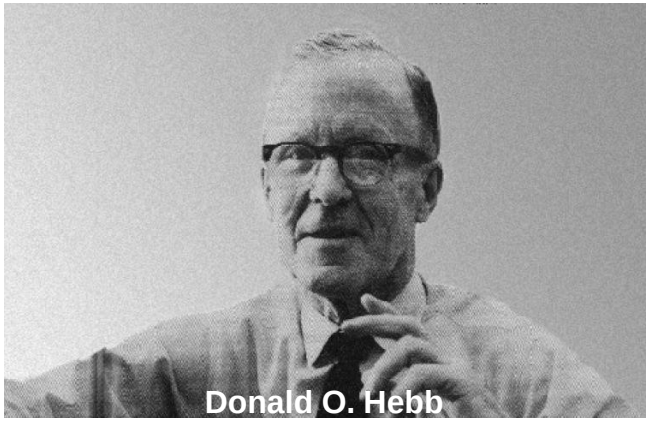
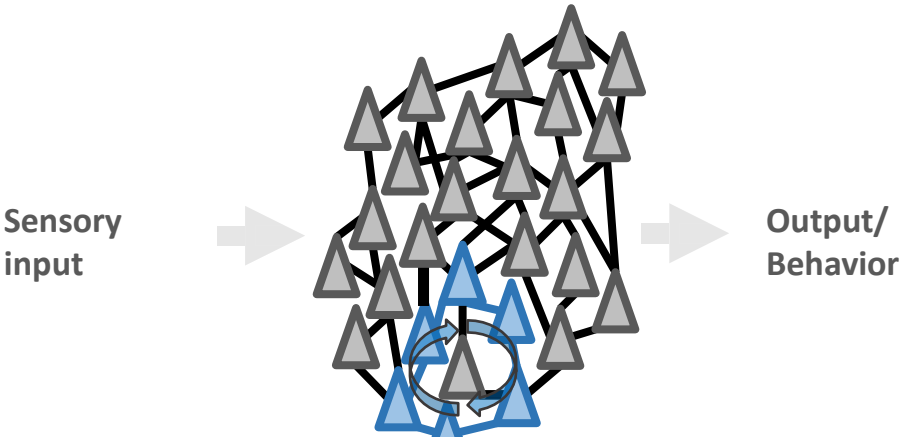
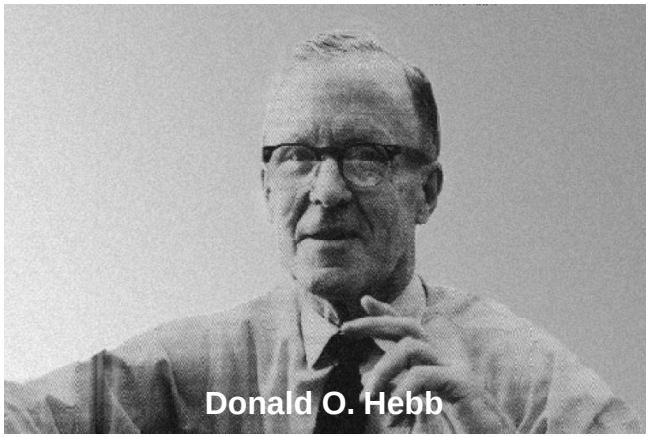
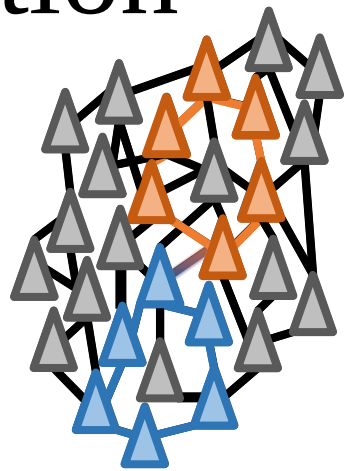
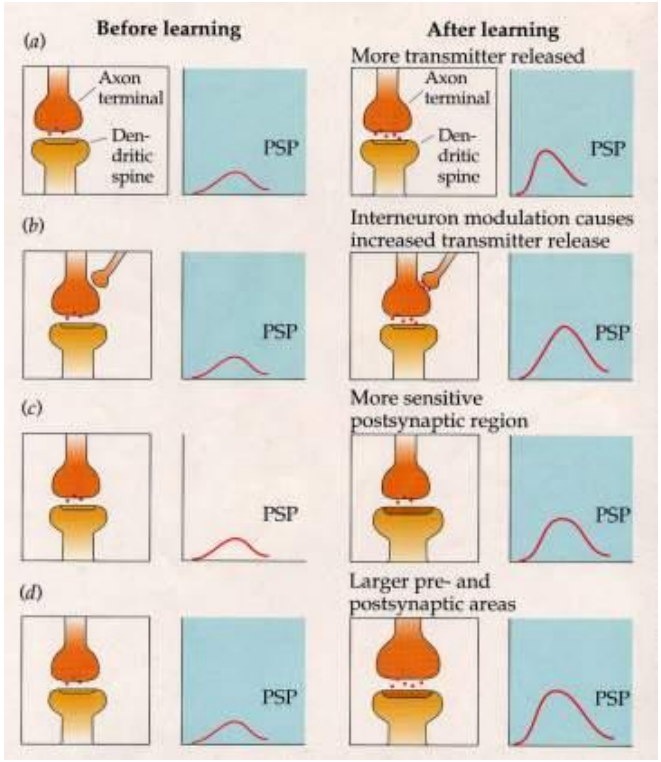


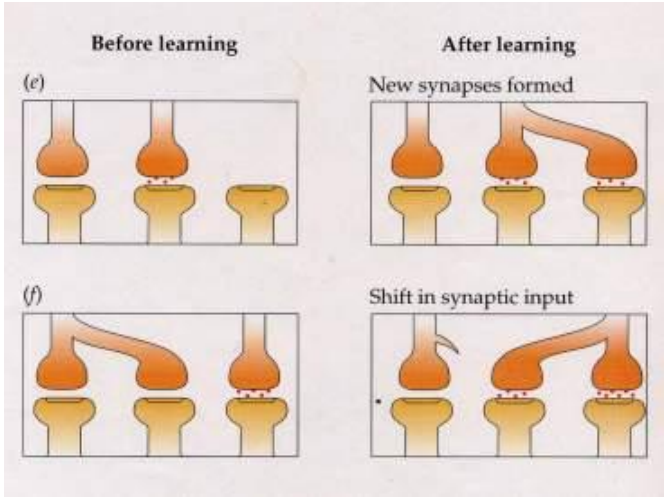


Hebb's theory of consolidation

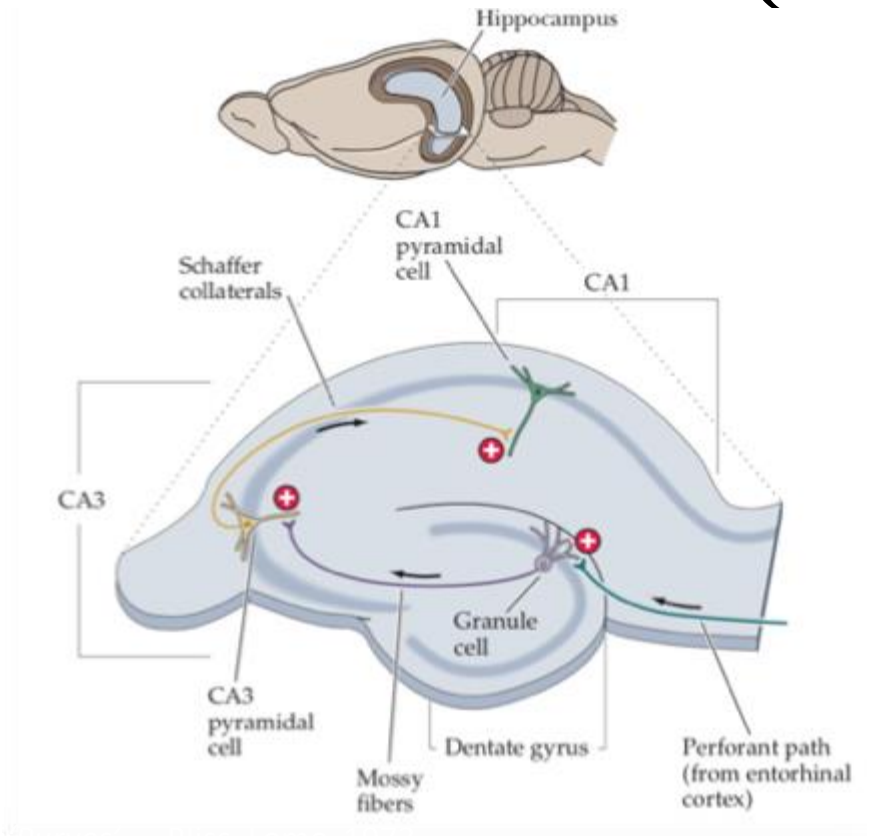


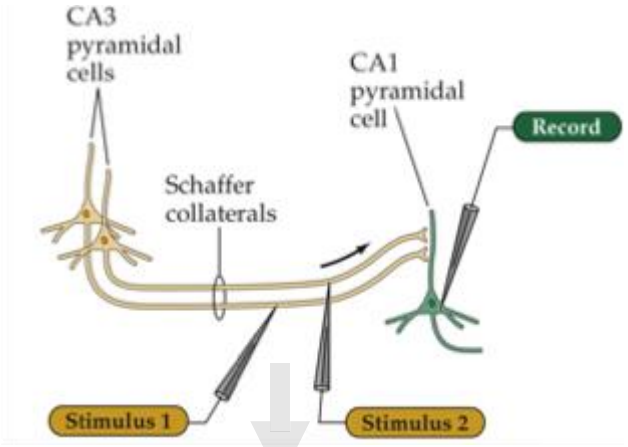


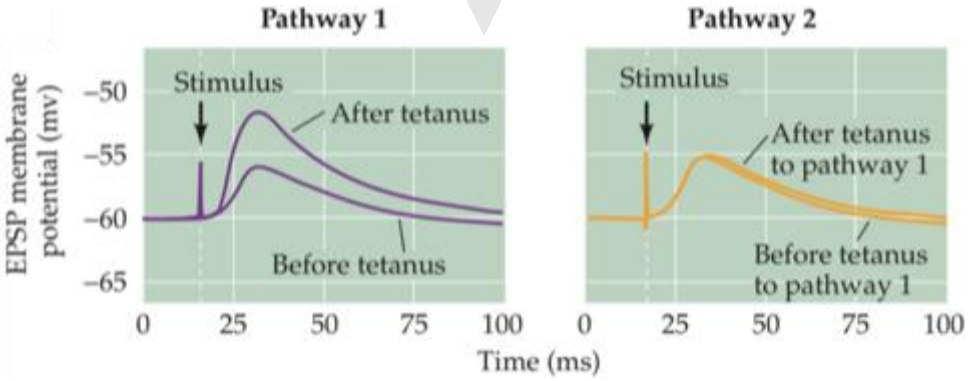

Before learning
After learning
(a)
Axon terminal
Den-dritic spine
PSP
More transmitter released
(b)
Interneuron modulation causes increased transmitter release
(c)
More sensitive postsynaptic region
(d)
Larger pre- and postsynaptic areas


Before learning
After learning
(e)
New synapses formed
(f)
Shift in synaptic input

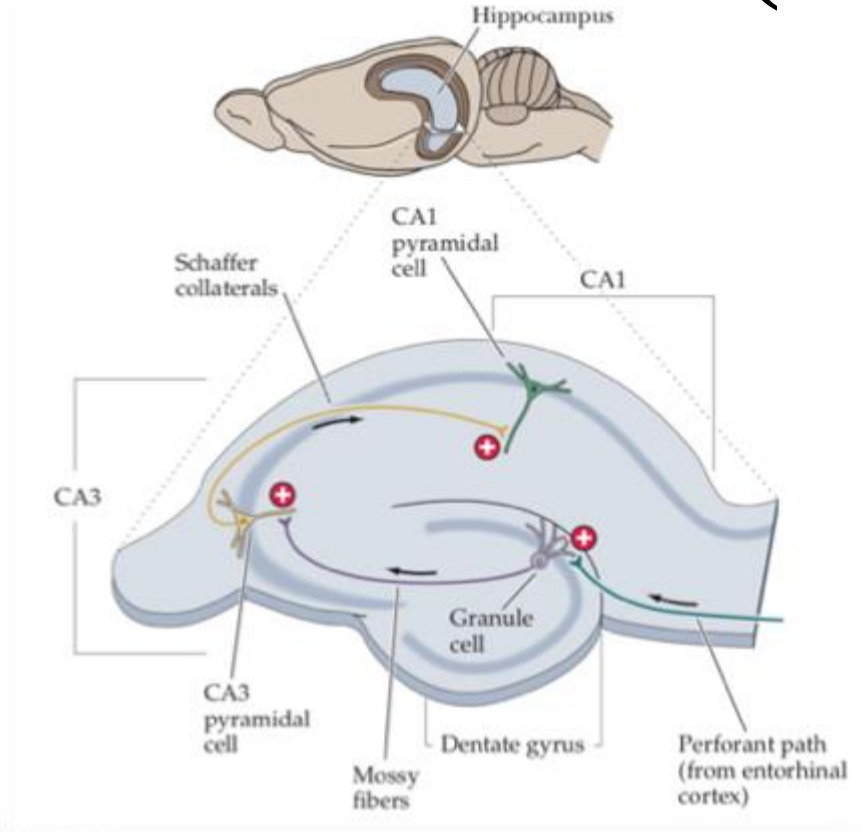
Long Time Potentiation(LTP)

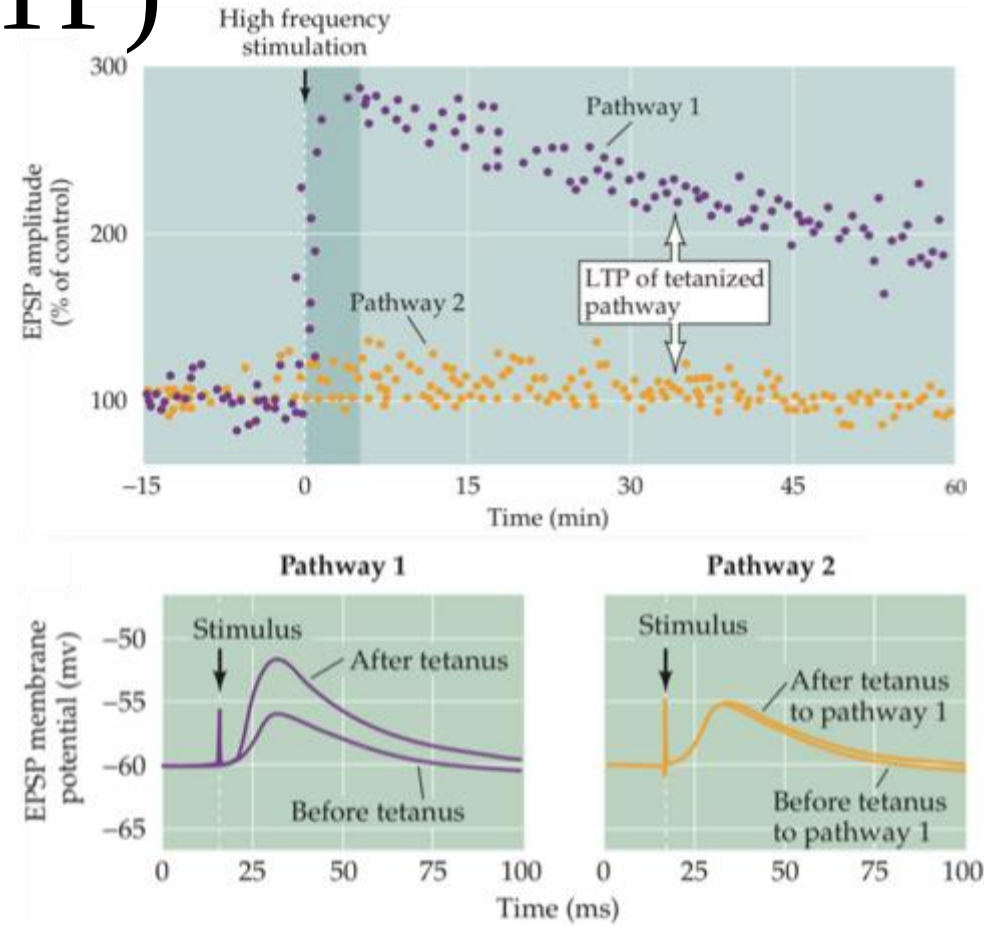




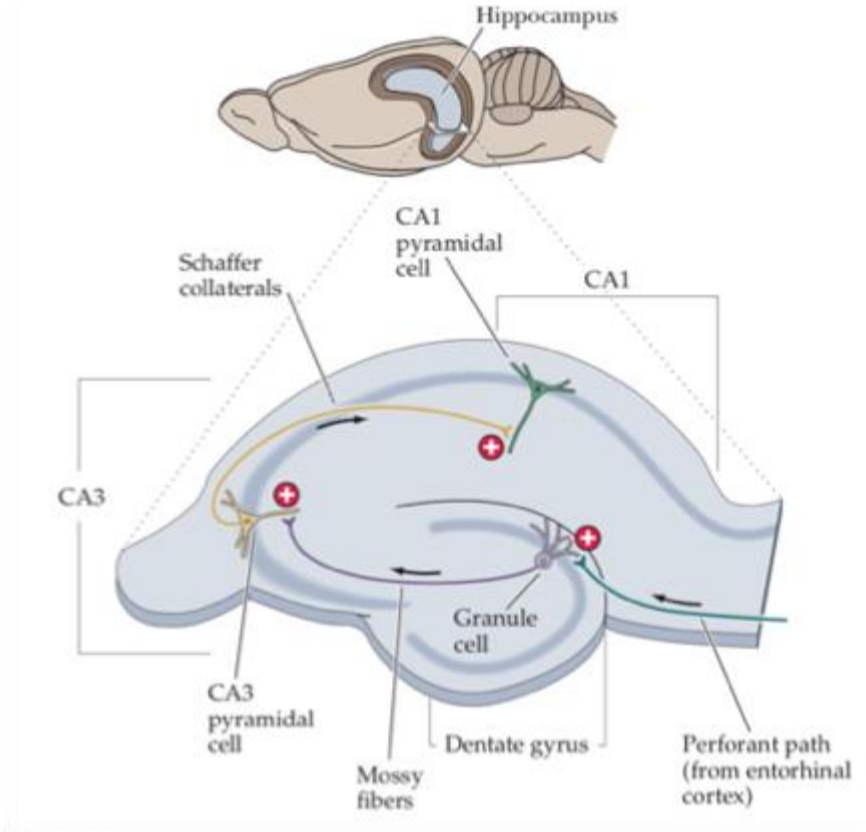


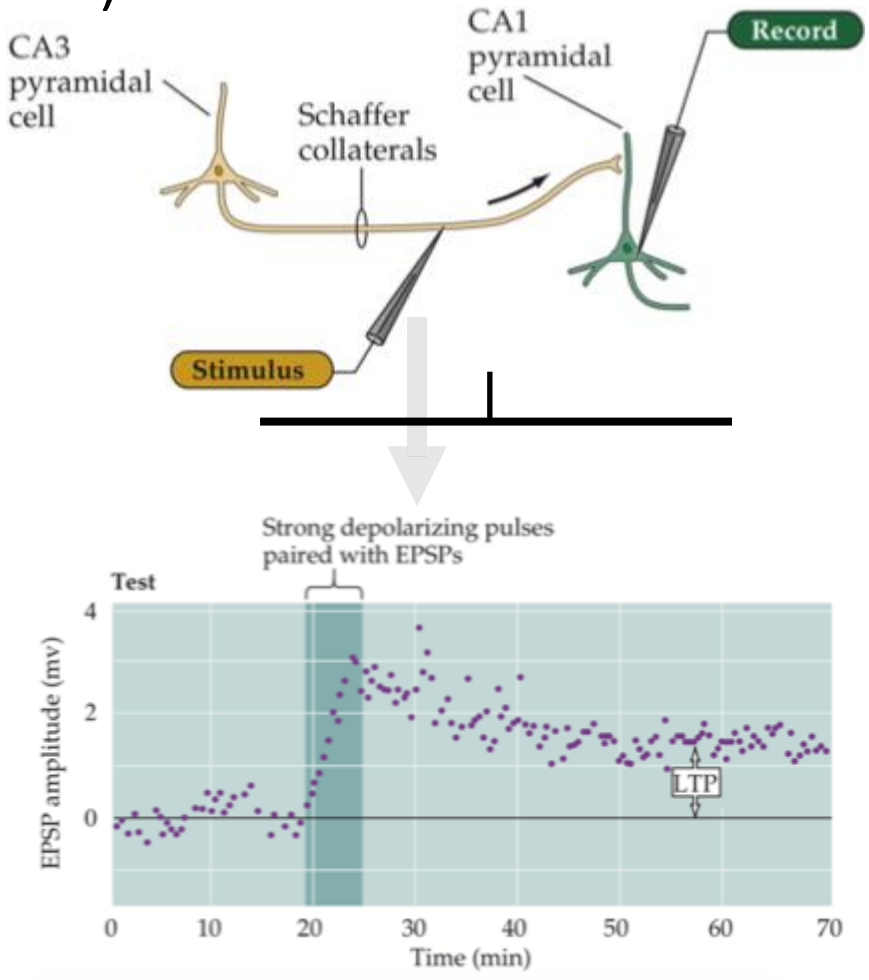
Long Time Potentiation(LTP)



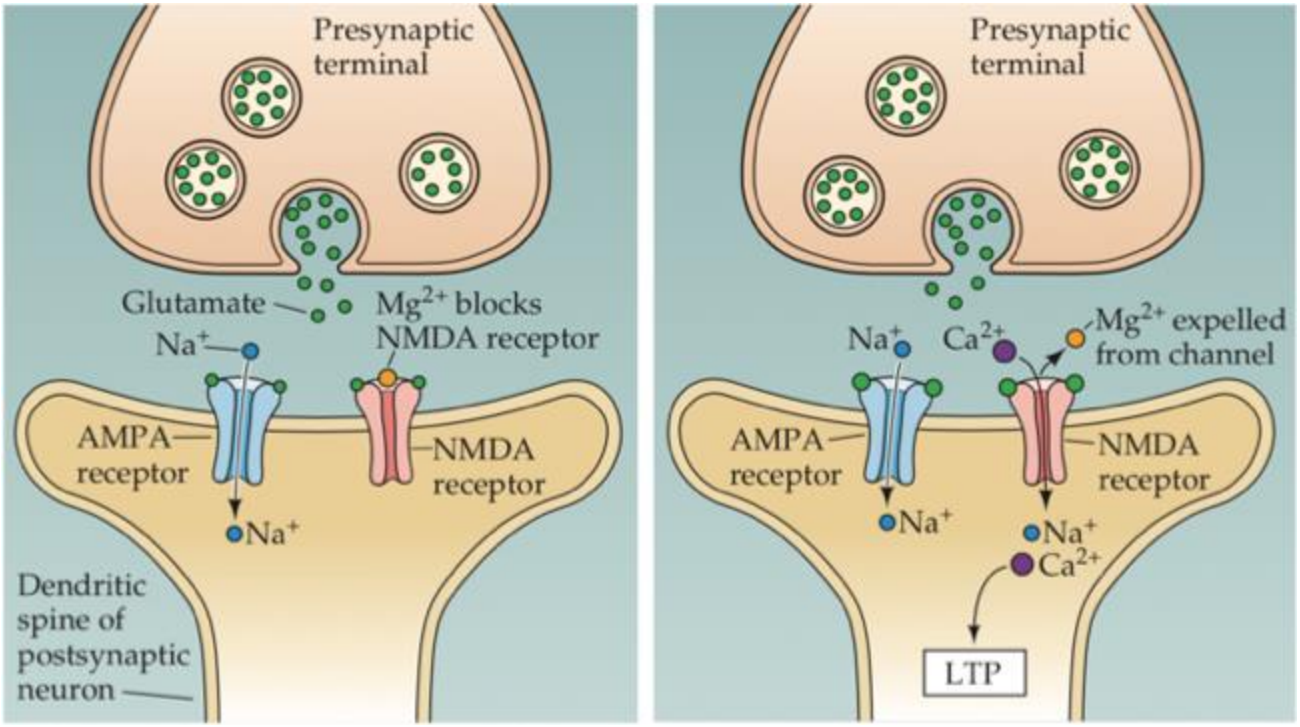


Long Time Potentiation(LTP)

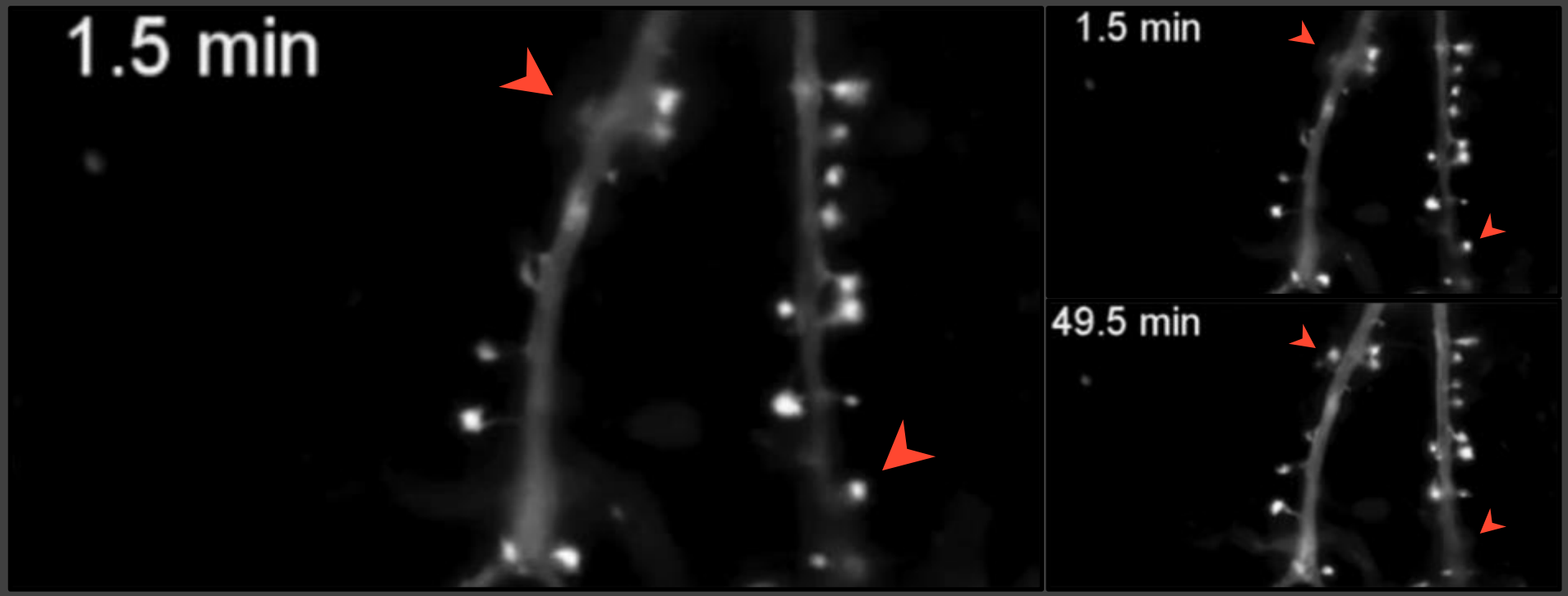




NMDA Receptors are coincidence detectors



Formation and loss of synaptic spines



Michael J Schell, YouTube

Hippocampal primary neurons expressing F-Tractin-GFP, played at 180x real time