

LANGUAGE and APHASIAS

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.

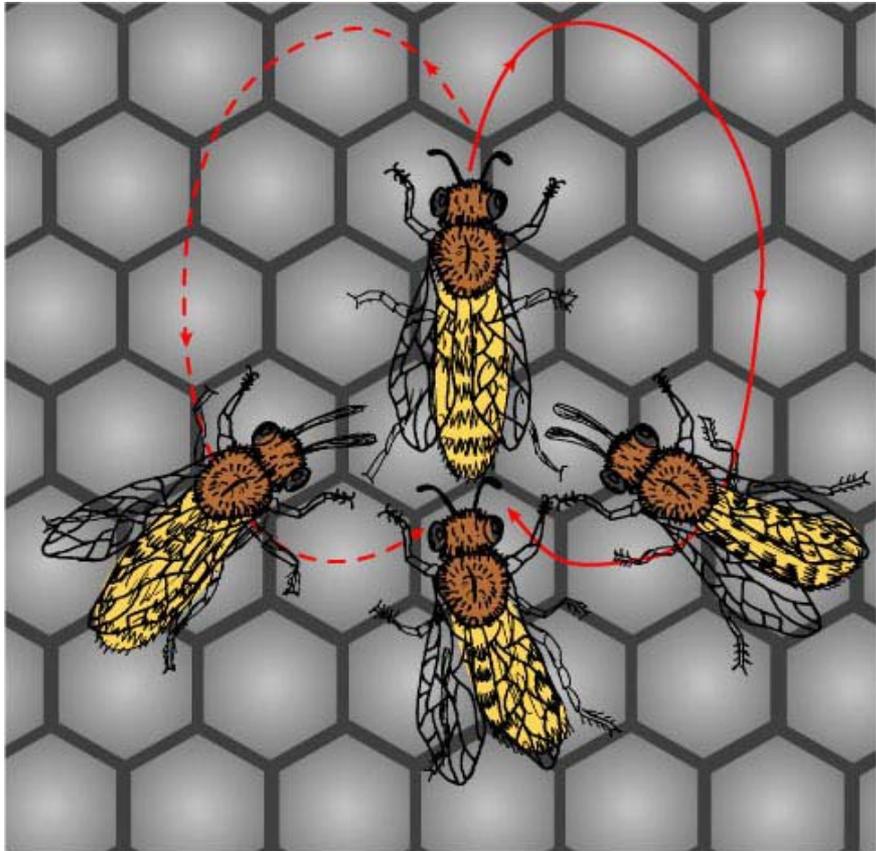
Human language requires synchronization of fine movements with cognitive activity (breathing, articulation, vocal control, manual and facial gesture, hearing, planning, memory). Role of basal ganglia and 'mirror neurons'; sign language.

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'

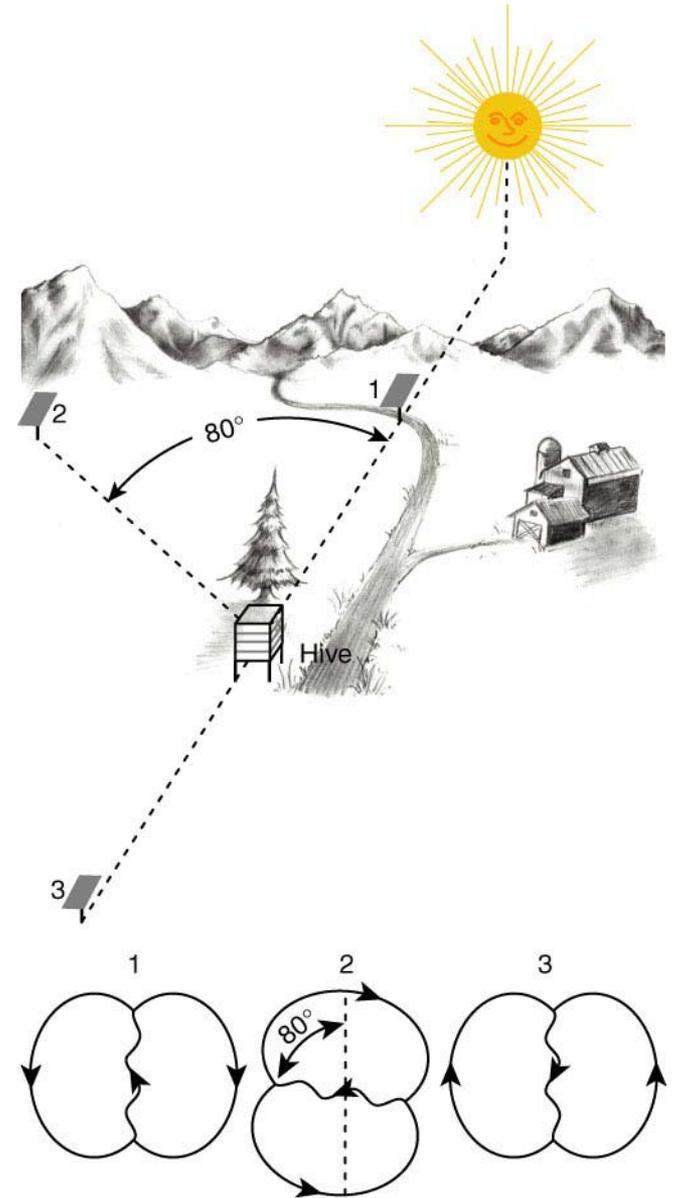
Pinker-Bloom: language evolved by natural selection

Innate knowledge and learning in the development of language abilities

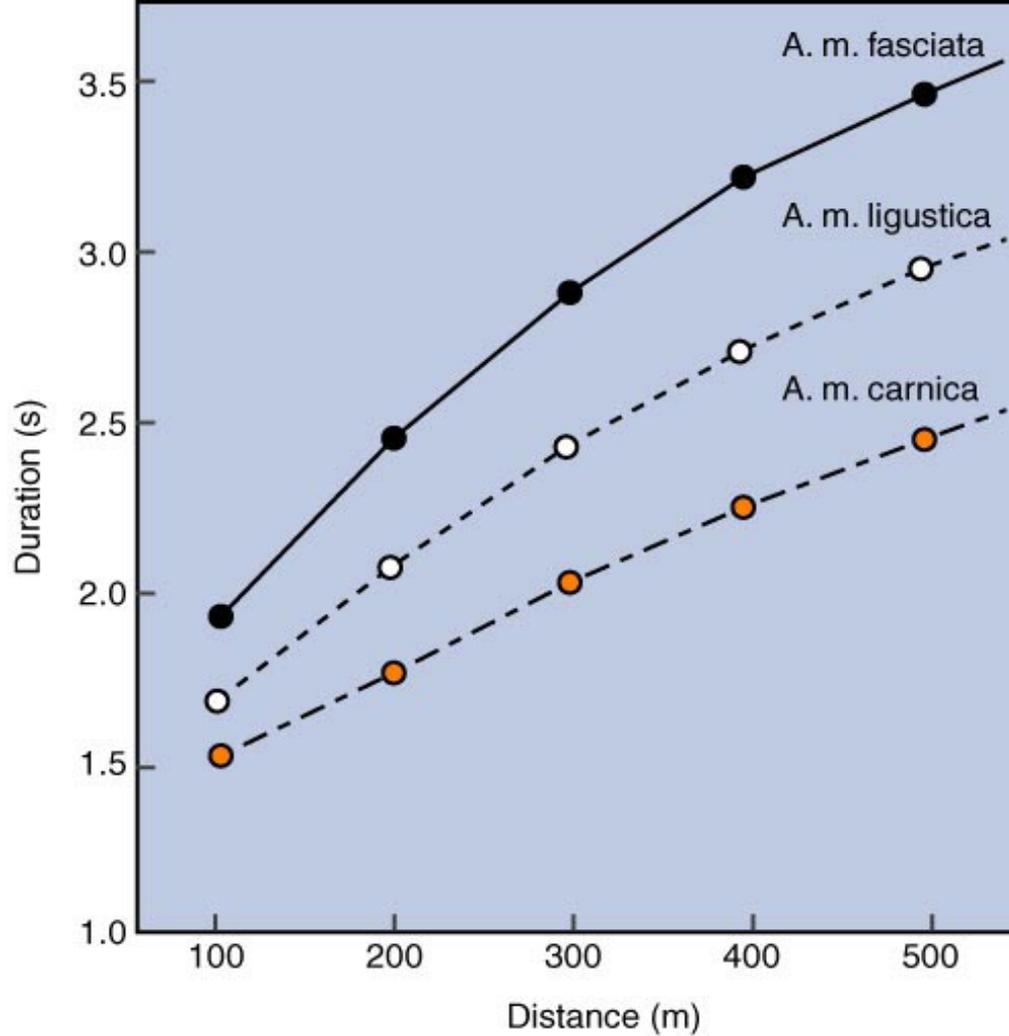


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The waggle dance of honeybees follows a figure eight. Direction is encoded into the dance as the angle of the waggle runs left or right of vertical on the comb, which corresponds to the angle to the food relative to the sun's azimuth in the field.

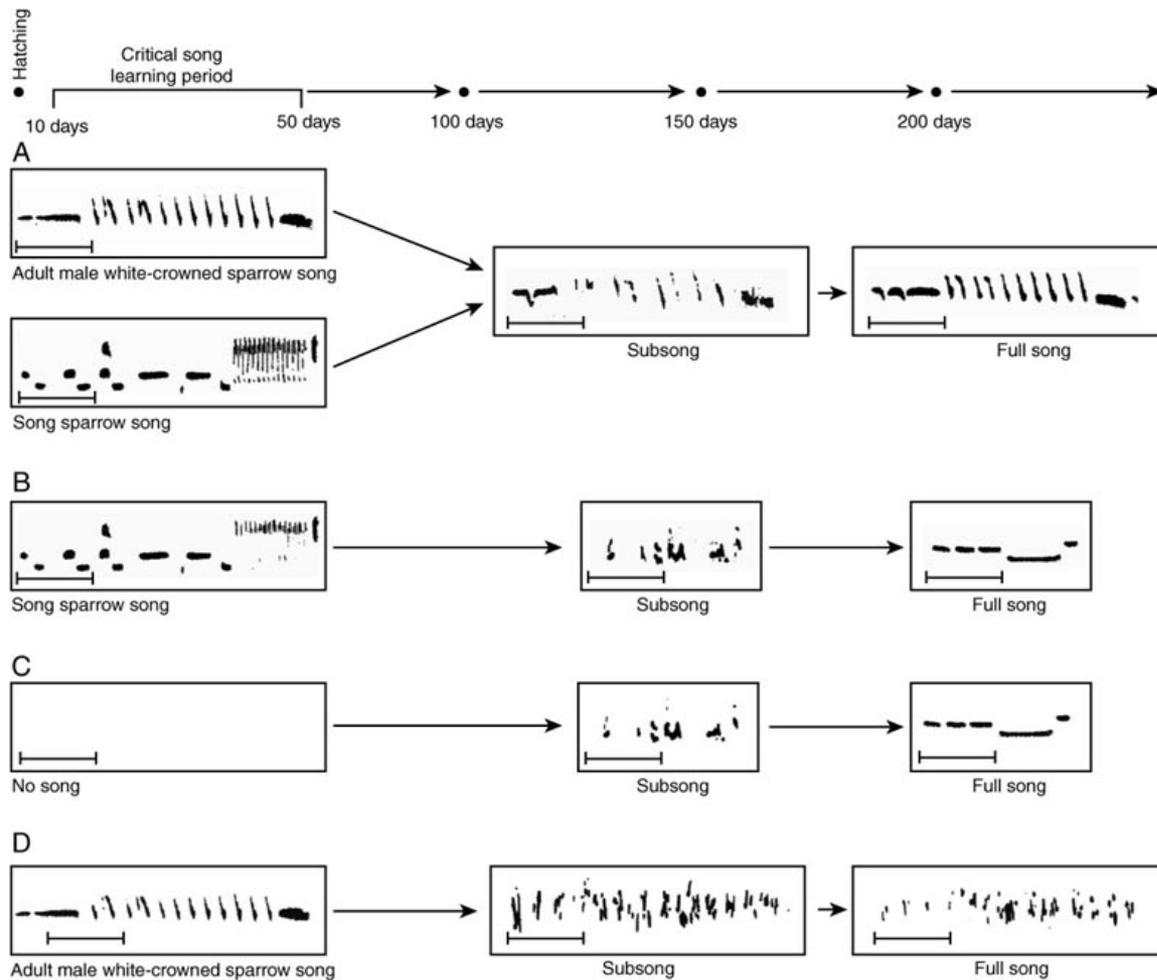


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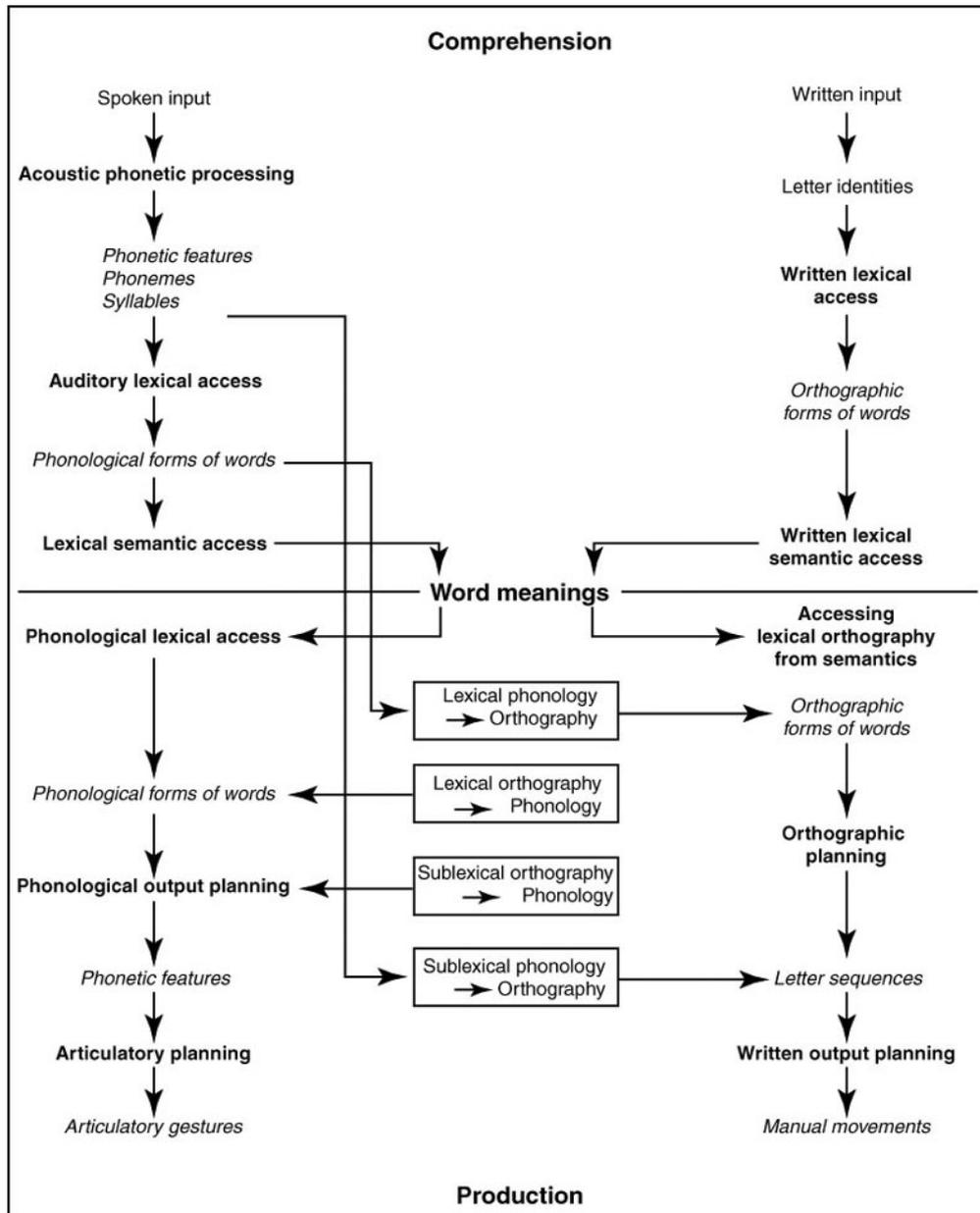
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Distance is encoded as the duration of the waggle run. Different subspecies have different dialects.

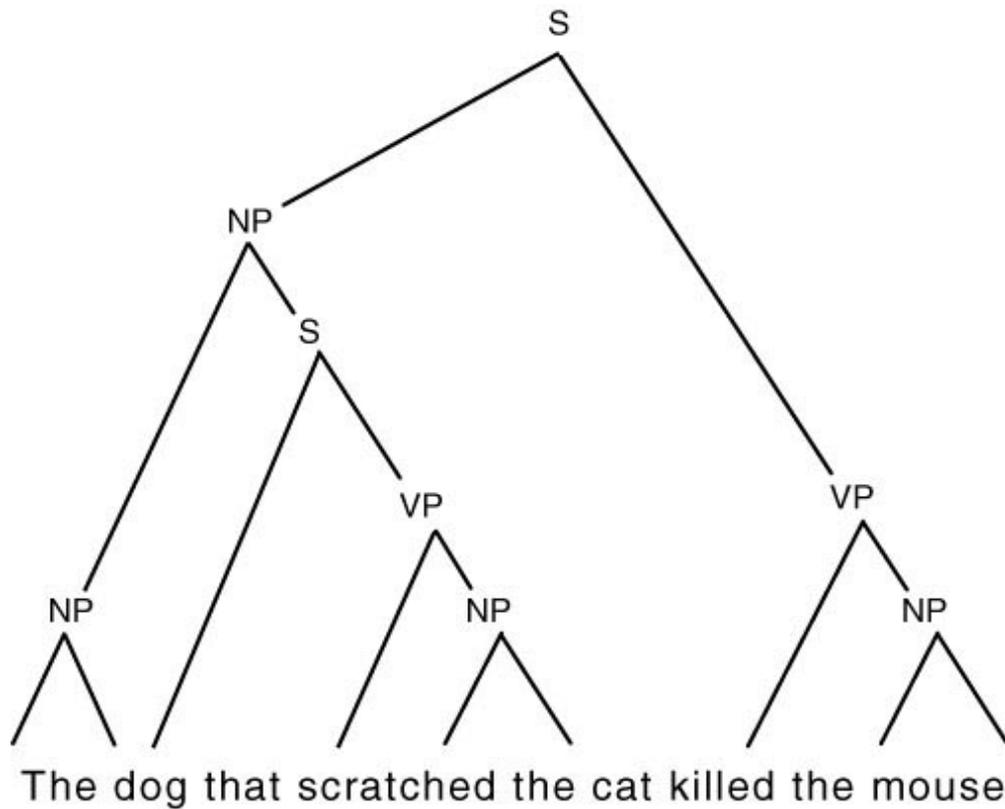


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Birdsong development in most species is characterized by a sensitive period during which a song of the species must be heard. Later, during subsong (preparation for singing), the bird practices making notes and assembles them into the correct order 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].

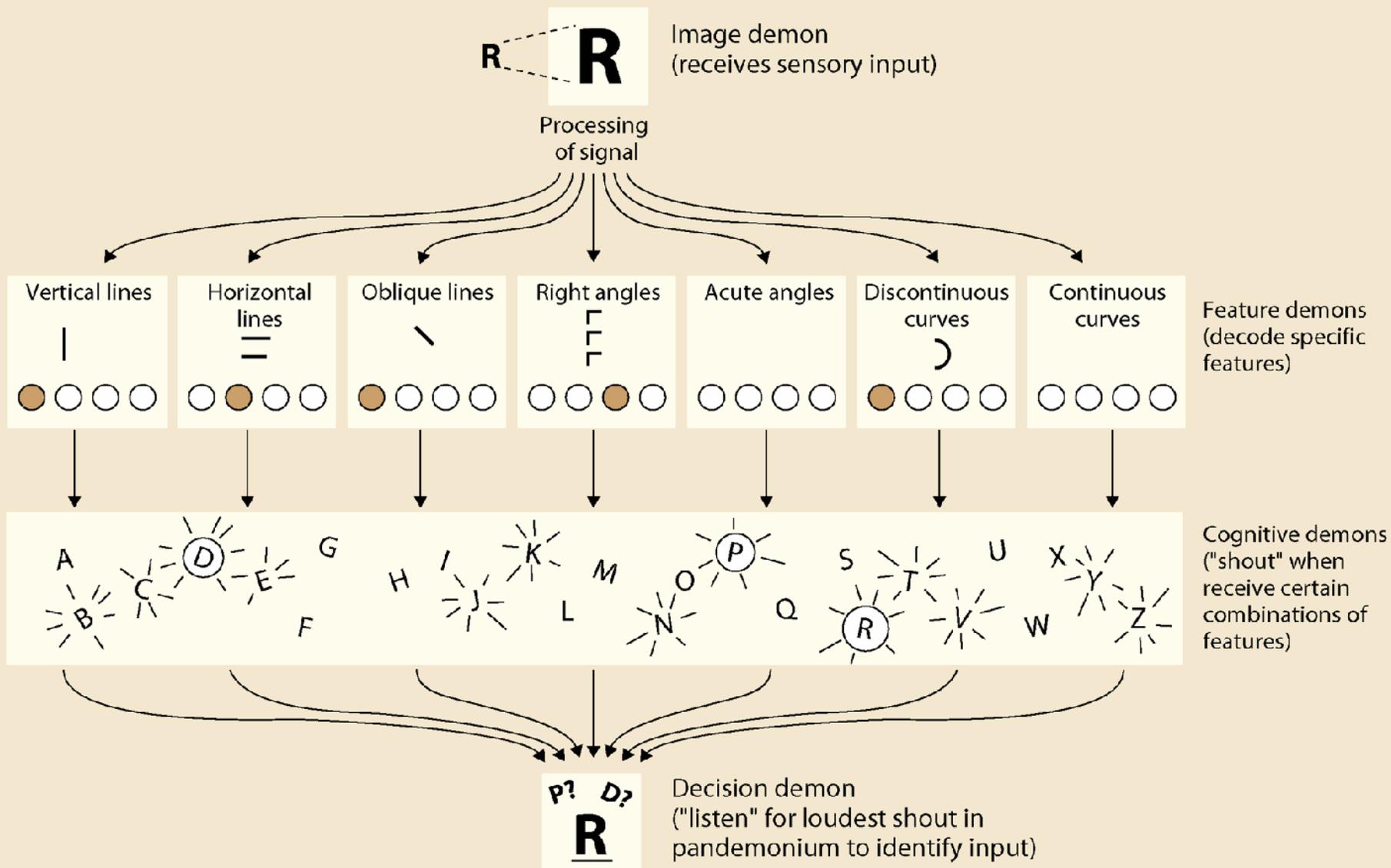


A model of the major psycholinguistic operations involved in processing simple words (Caplan and Gould, 2003)

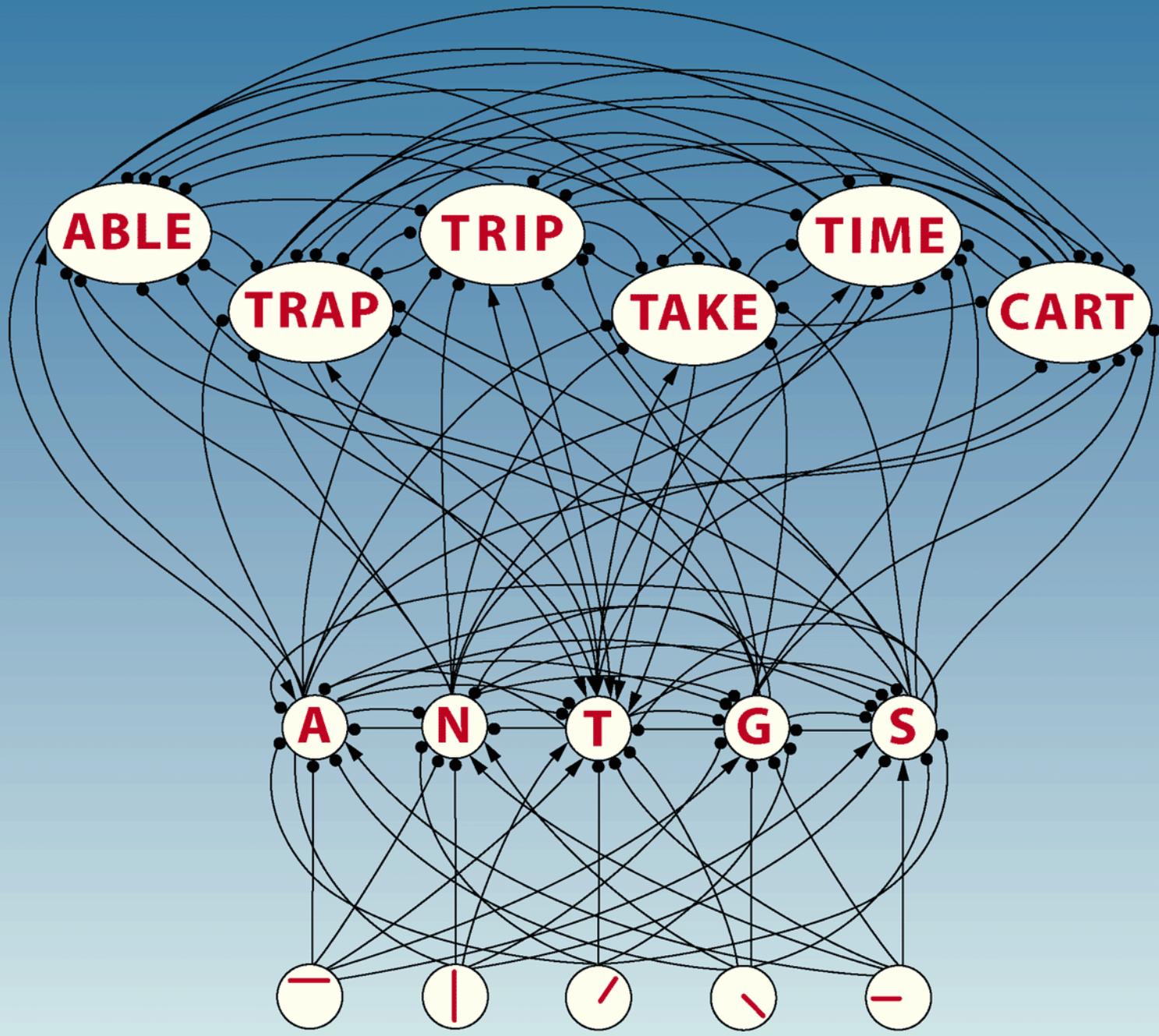


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Syntactic structure of the sentence "The dog that scratched the cat killed the mouse" indicating the hierarchical structure responsible for its meaning. S=sentence; NP=noun phrase; VP=verb phrase;



The model of Selfridge (1959) for letter recognition. For written input, the reader must recognize a pattern that starts with the analysis of the sensory input. The sensory input is stored temporarily in iconic memory by the image demon, and a set of feature demons decode the iconic representations. The cognitive demons are activated by the representations of letters with these features, and the representations that best matches the input is then selected by the decision demon (Coren et al., 1994; Gazzaniga, 2002).



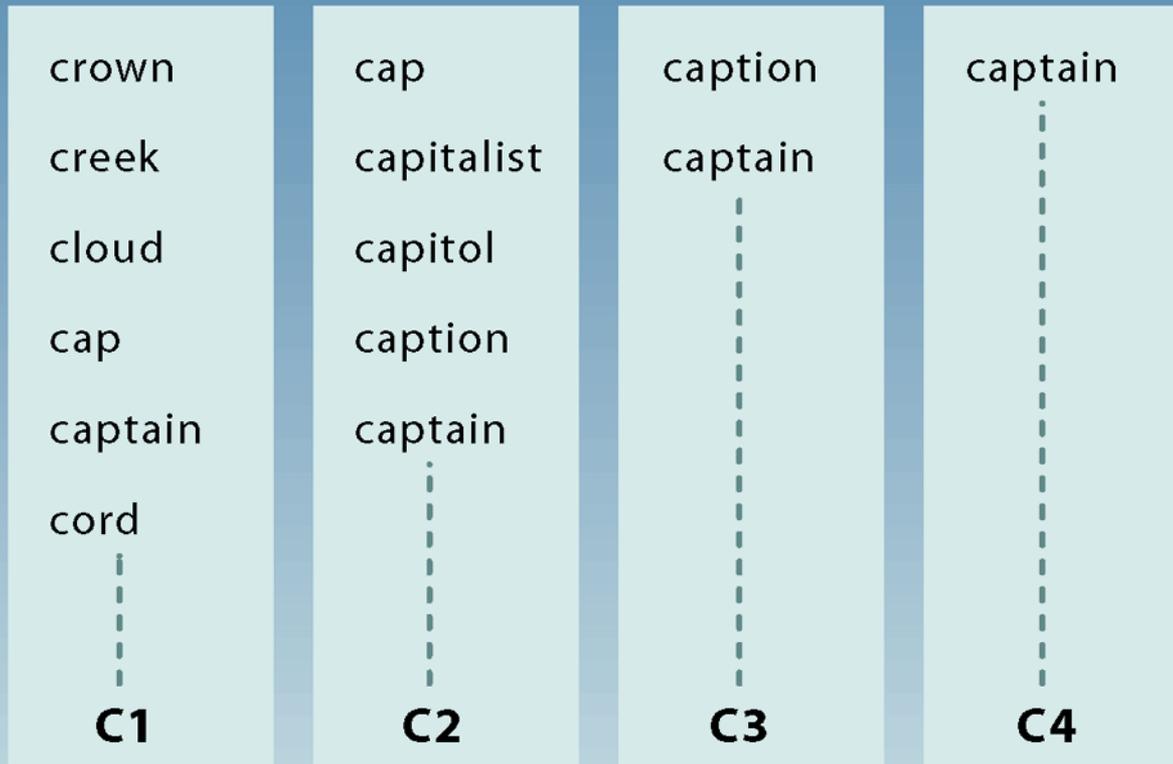
Connectionist network model for word recognition. Nodes in each layer can influence the activational status in the other layers by excitatory (arrows) or inhibitory (lines) connections (McClelland and Rumelhart, 1981).

Context:

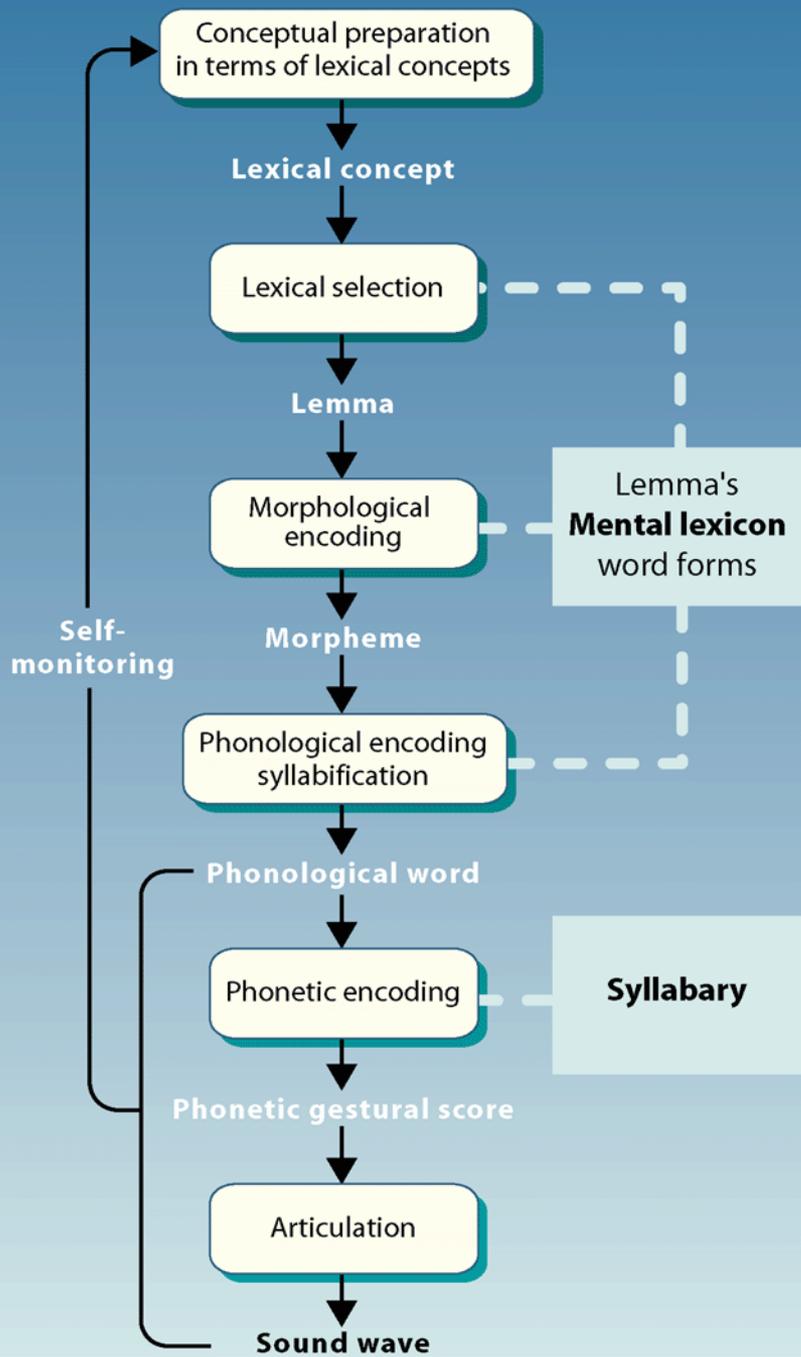
They always obeyed their...

Input:

/c/ /a/ /p/ /t/ /a/ /i/ /n/

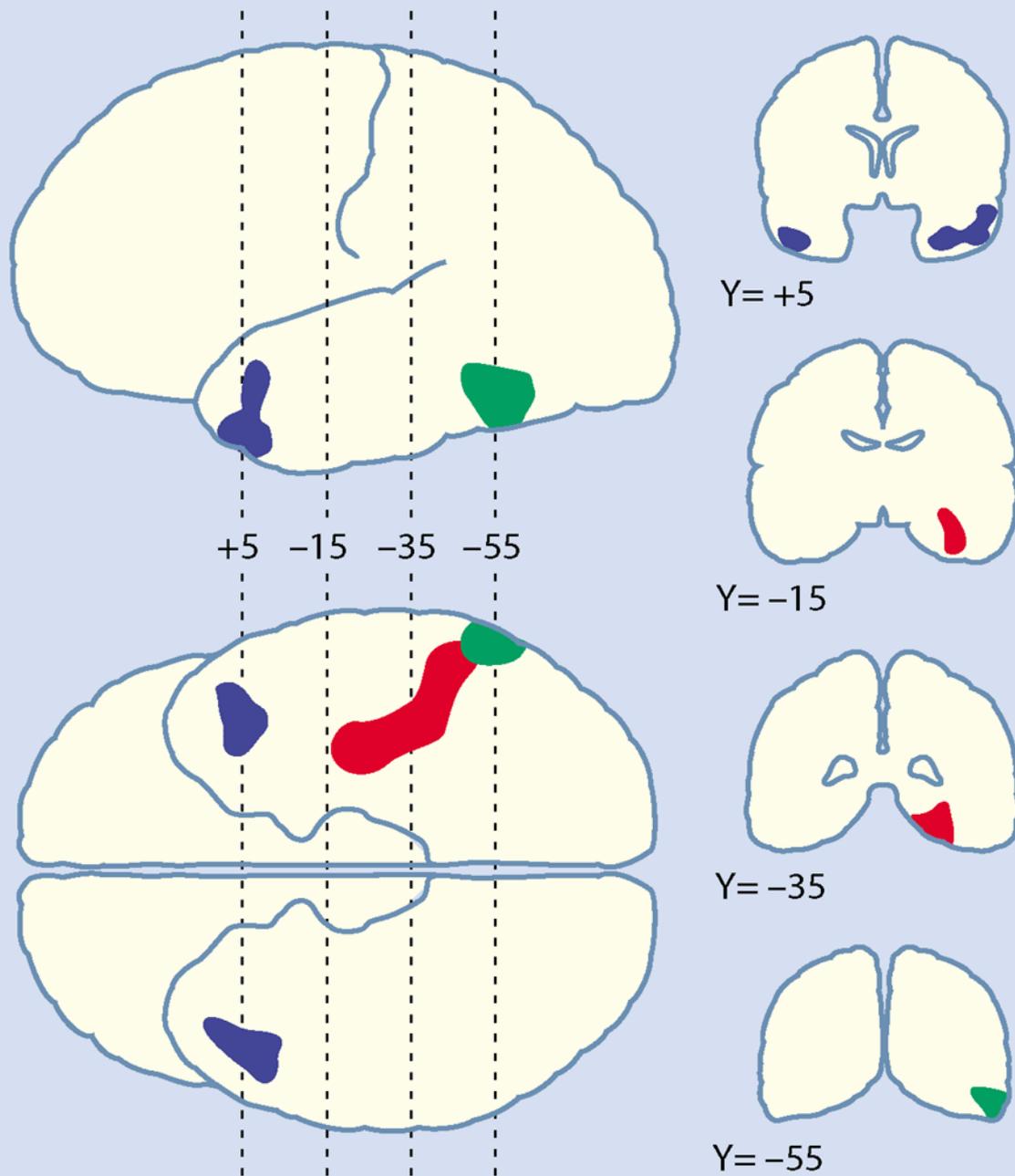


Cohort model of spoken word recognition. Initially all words that start with the same initial sound are activated (C1). As time progresses, fewer competitors match with the actual speech signal and are eliminated from the cohort, until only the actual candidate remains (Gazzaniga, 2002).



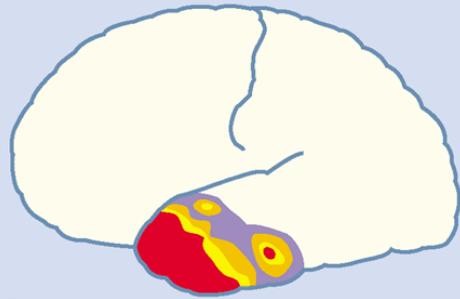
Outline of the theory of speech production developed by Levelt (1989). Word production proceeds through stages of conceptula preparation, lexical selection, morphological and phonological encoding, and articulation. Speakers monitor their own speech by making use of their comprehension system.

(a) PET data



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

Lesion data



Persons

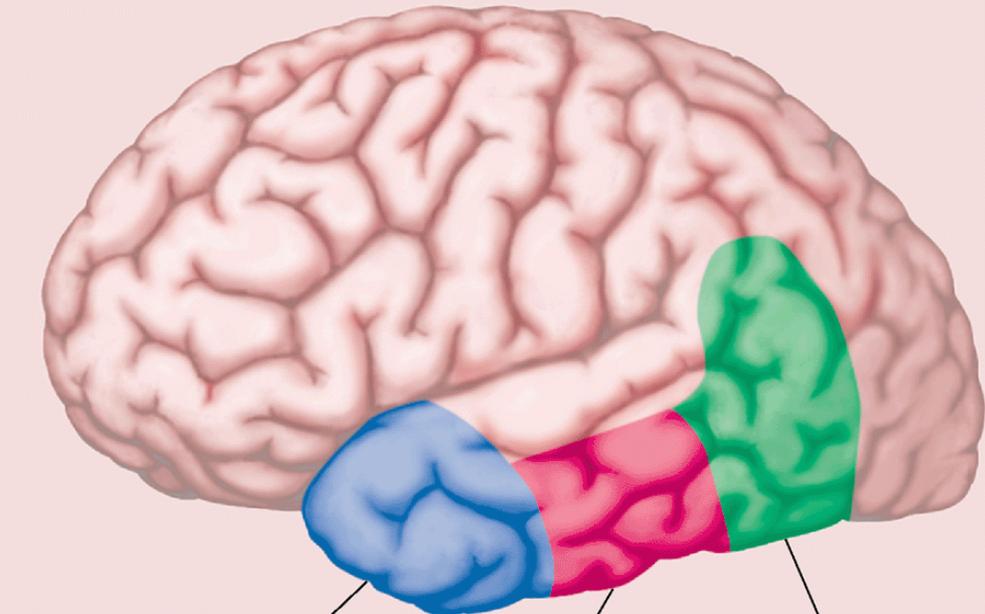


Animals



Tools

Lesion results summarized



TP

Persons x = 59.8
Animals x = 93.3
Tools x = 96.0

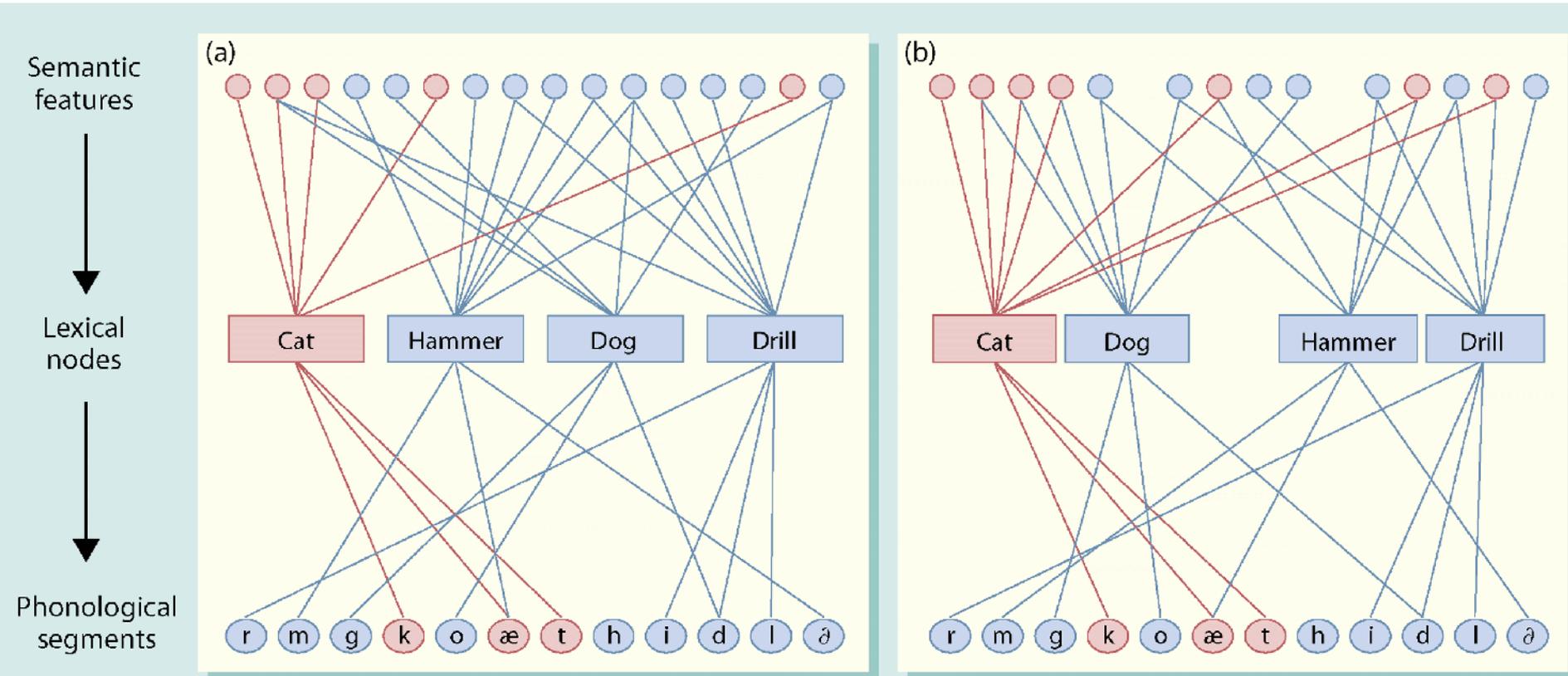
IT

Persons x = 75.5
Animals x = 80.1
Tools x = 84.5

IT+

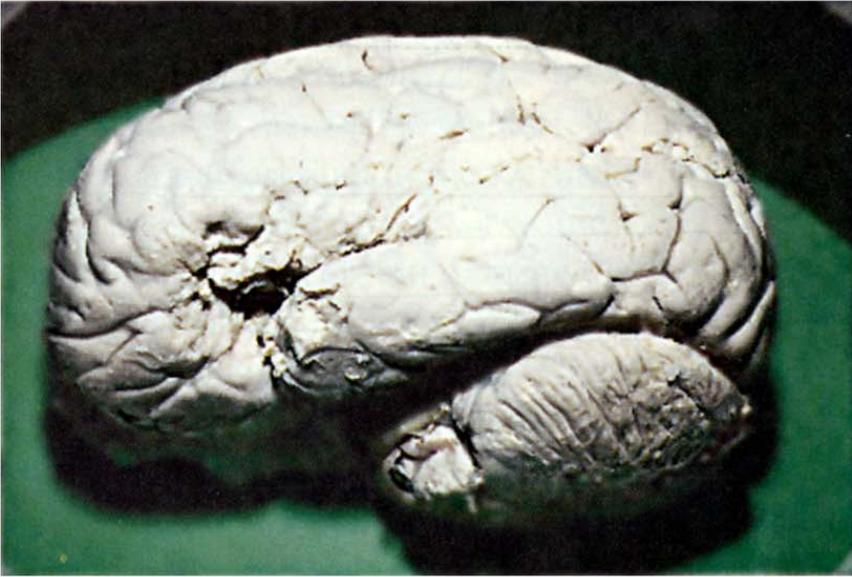
Persons x = 91.7
Animals x = 88.3
Tools x = 78.5

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

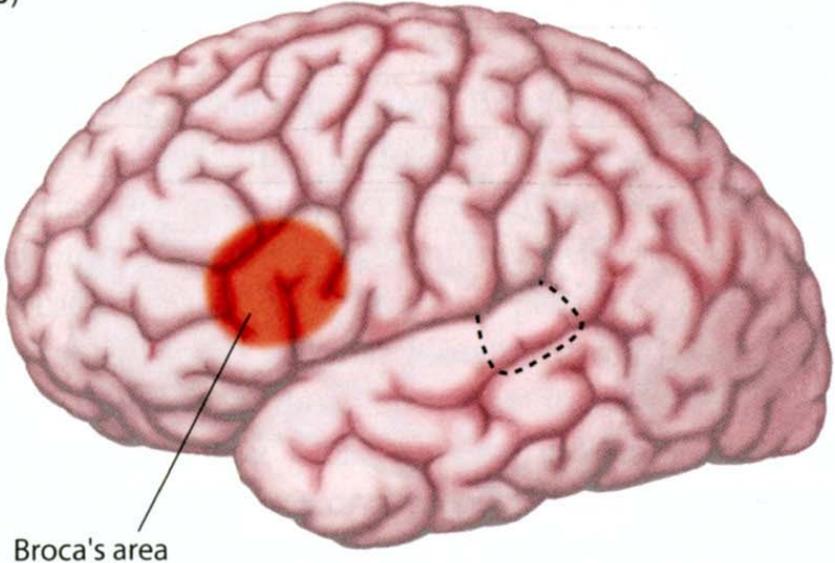


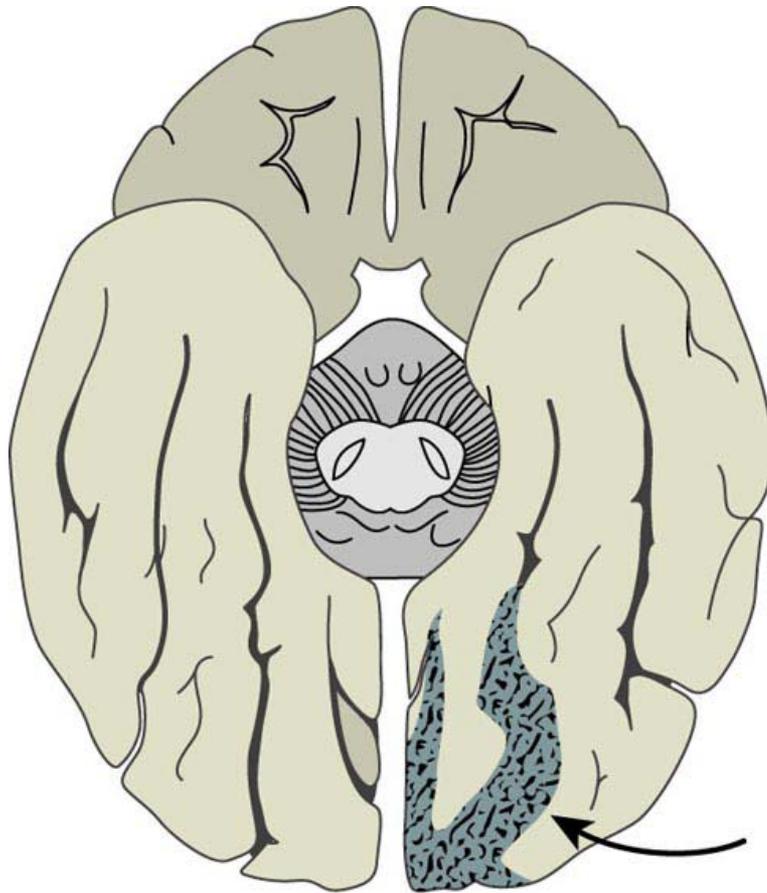
Three levels of representation that are needed in speech production: semantic features, lexical nodes and phonological segments. (a) The semantic features of the word cat (four legs, furry) activate the lexical node of the word cat, which in turn activates the phonological segments of that word. (b) A model that fits the data of Damasio et al. Accordingly, the information at the lexical level is organized to specific semantic categories (e.g., animals versus tools) (Caramazza, 1996; Gazzaniga, 2002).

(a)



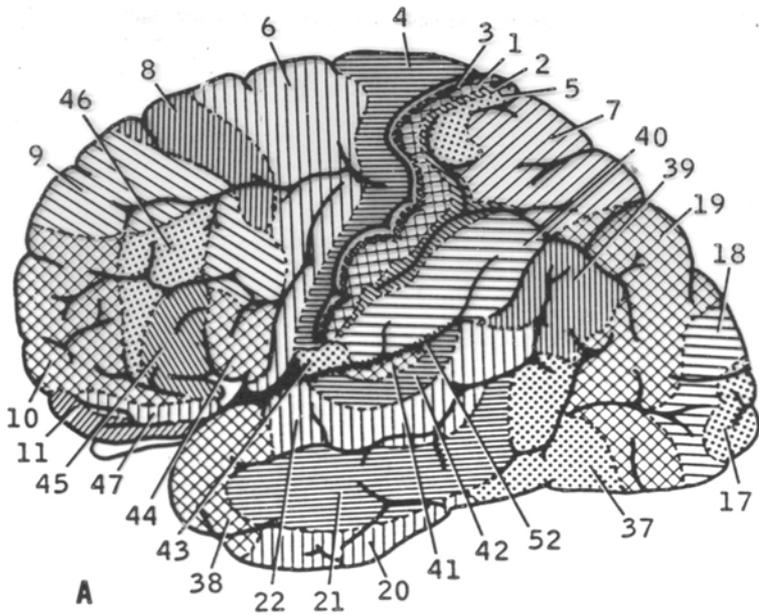
(b)





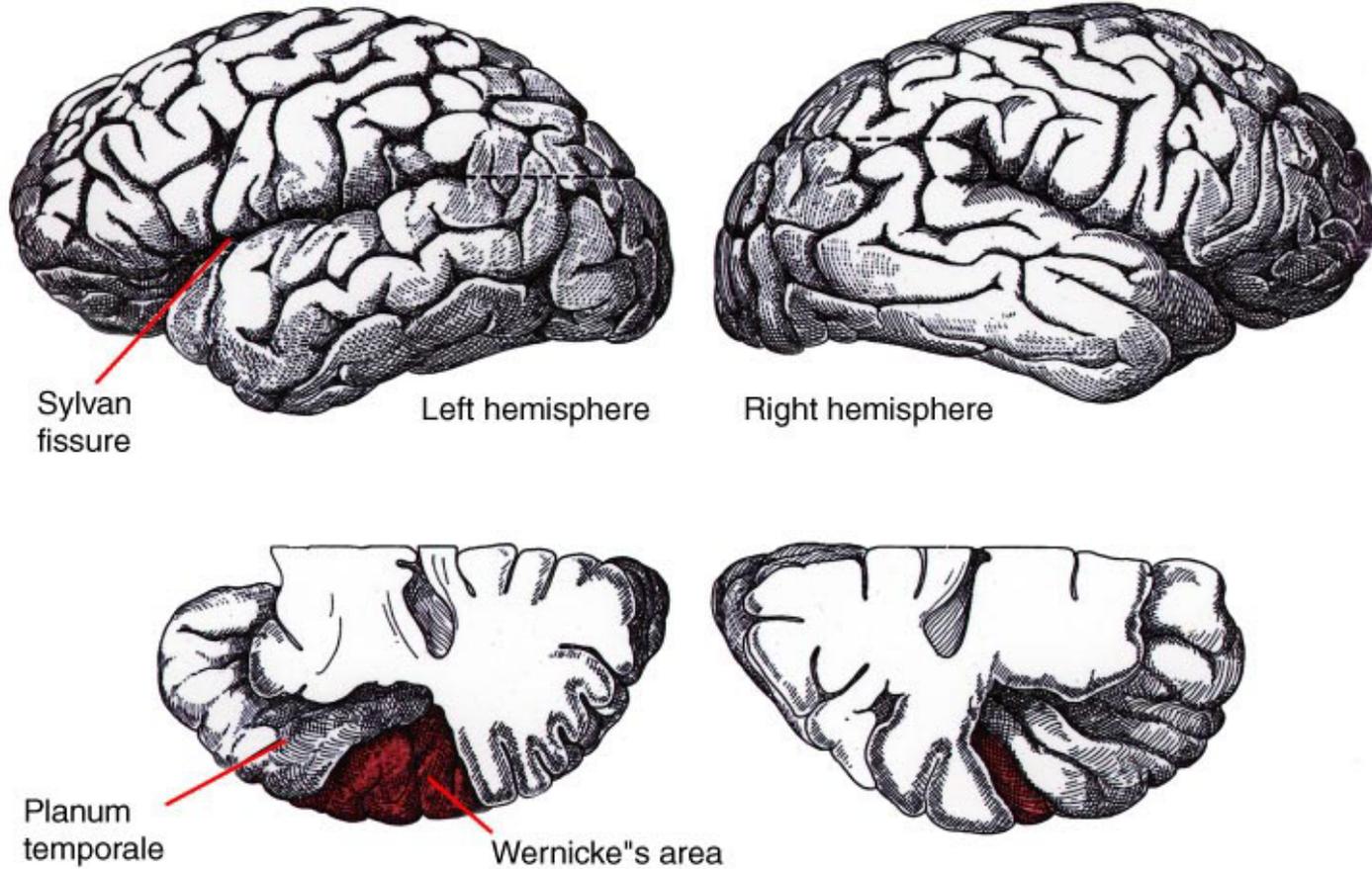
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Diagram from Dejerine's 1892 paper showing the lesion that results in pure alexia. The lesion is shown from the inferior surface of the brain. It has destroyed the left visual cortex and interrupted fibers from the right visual cortex on their way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



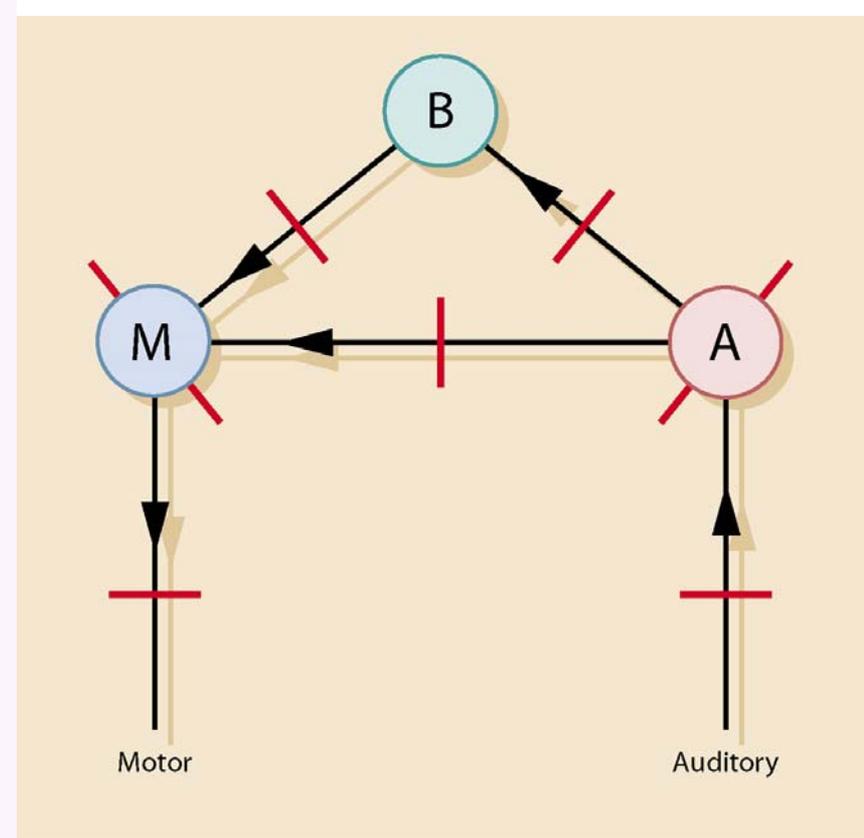
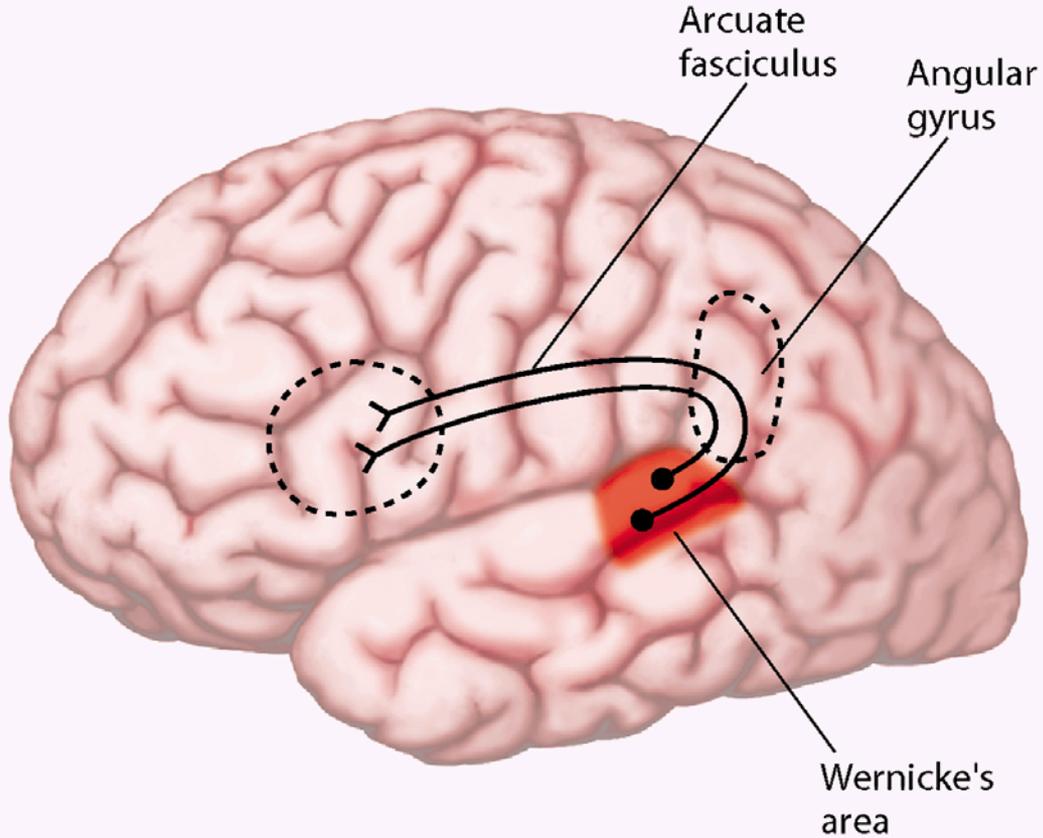
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A depiction of the left hemisphere of the brain showing the main language areas. The area in the inferior frontal lobe is known as Broca's area, and the area posterior tri-lobe area (temporal-parietal-occipital) is known as Wernicke's area. Broca's area is adjacent to the motor cortex and is involved in planning speech gestures. It also serves other language functions, such as assigning syntactic structure. Wernicke's area is adjacent to the primary auditory cortex and is involved in representing and recognizing the sound patterns of words.



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



Wernicke-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).

Broca's aphasia

Spontaneously speaking



"Son ... university ...
smart ... boy ...
good good ..."

Listening for comprehension



"The boy was hit
by the girl.
Who hit whom?"



"Boy hit girl"

Repeating



"Chrysanthemum"

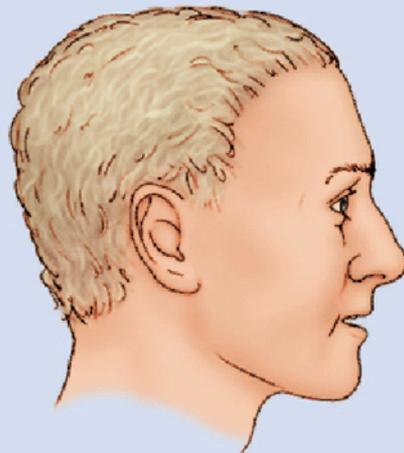


"Chrysa...
...mum...
mum..."

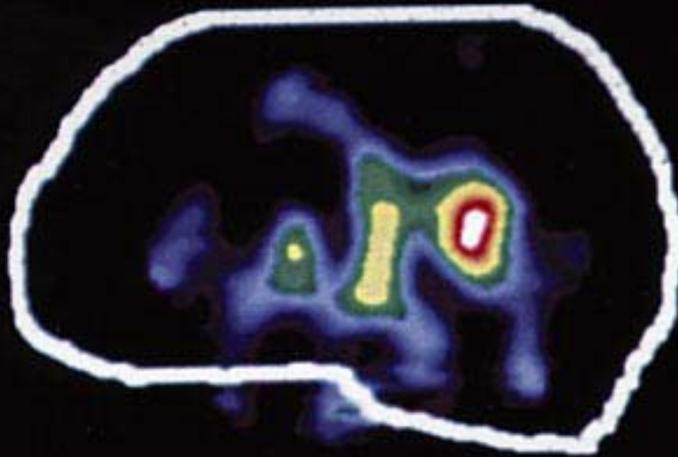
Wernicke's
aphasia



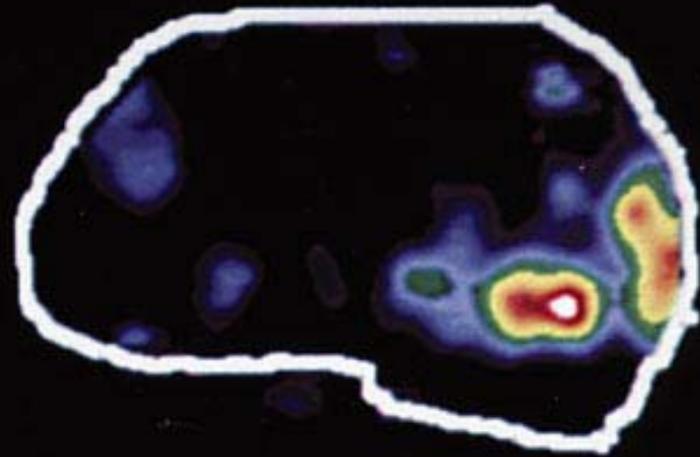
"I called my mother on the television and did not understand the door. It was not for breakfast but she came from far. My romer is tomorrow morning, I think."



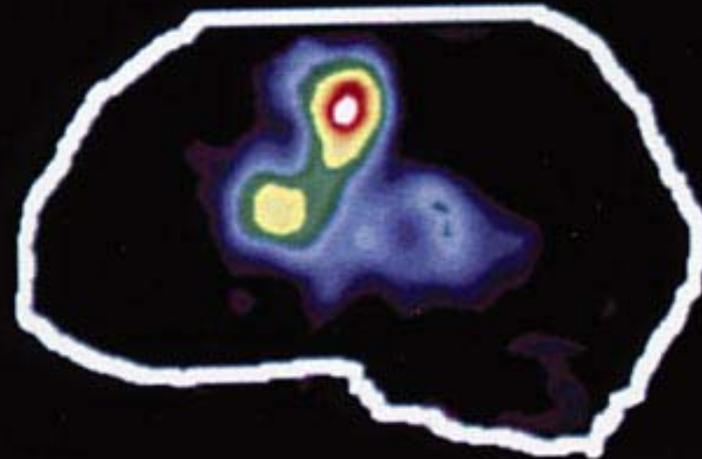
"Ik belde mijn moeder op de televisie en begreep de deur niet. Het was niet voor ontbijt, maar ze kwam van ver. Ik denk dat mijn romer morgen ochtend is."



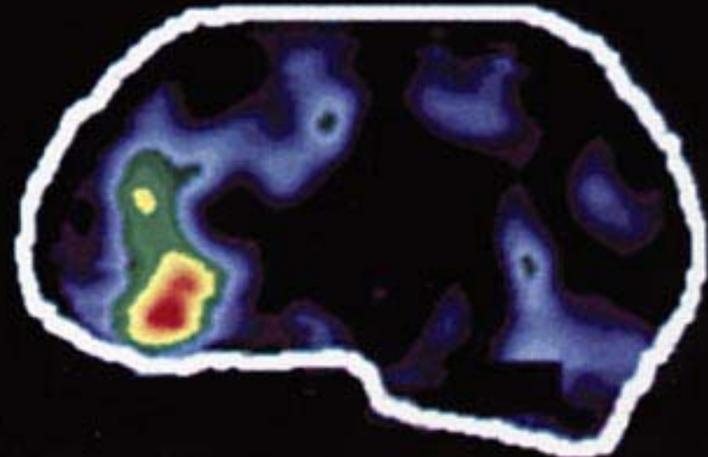
Hearing words



Seeing words

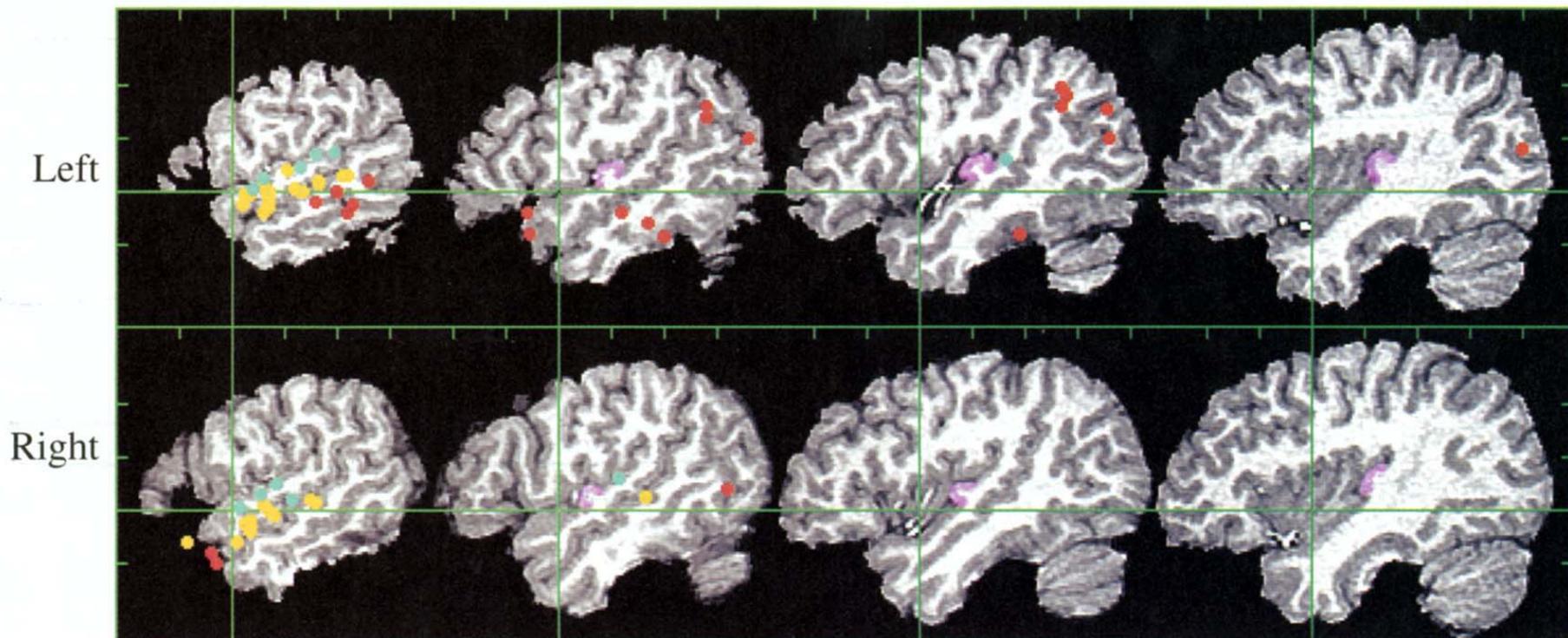


Speaking words



Generating words

Lateral slices ← → Medial slices



Tones > Noise



Speech > Nonspeech



Words > Nonwords



Primary Auditory





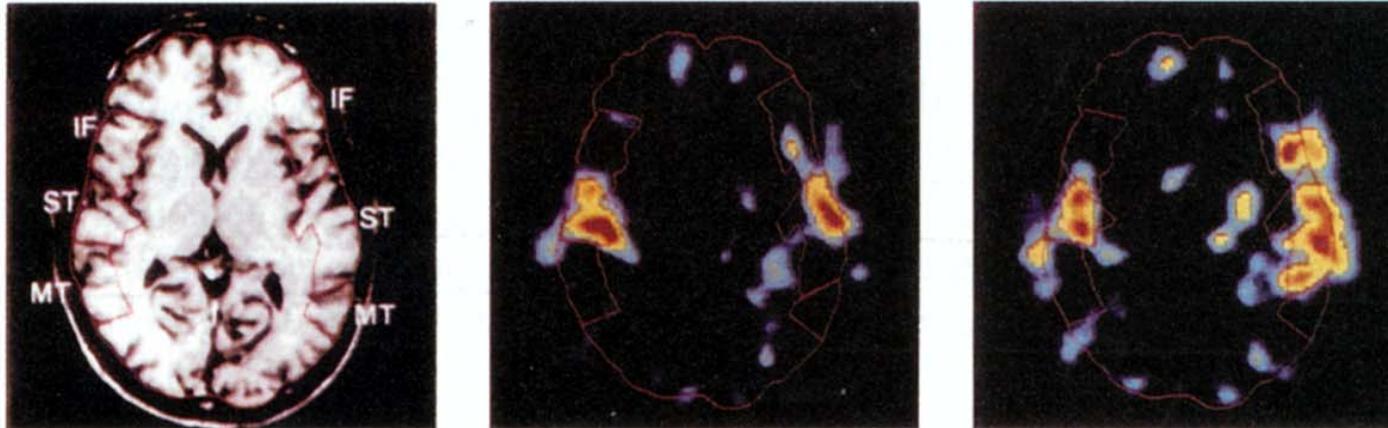
Horizontal

Sagittal

Coronal

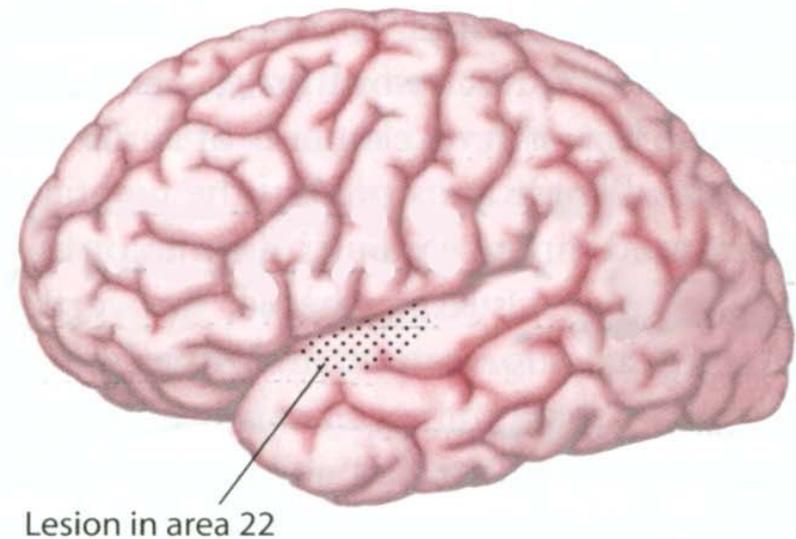
Increased blood flow in Broca's area when subjects are processing complex relative to syntactic structures

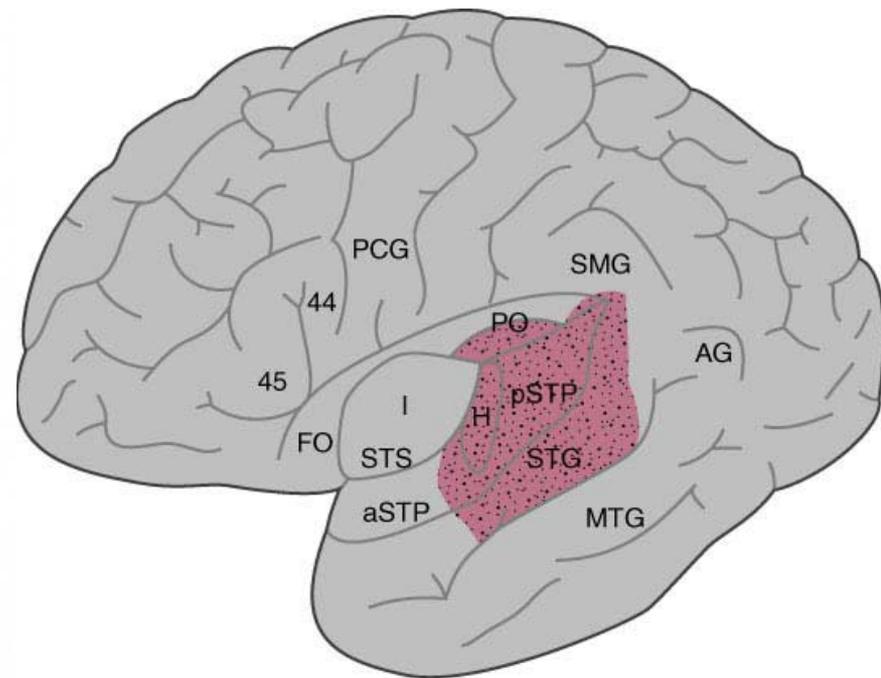
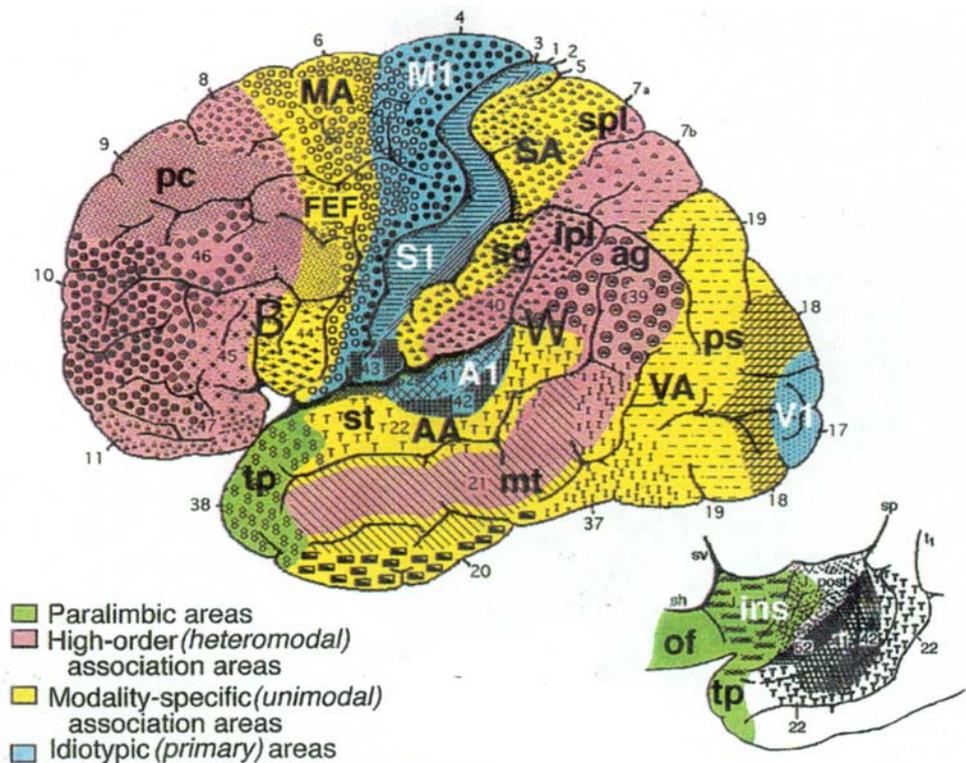
(a)



(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)

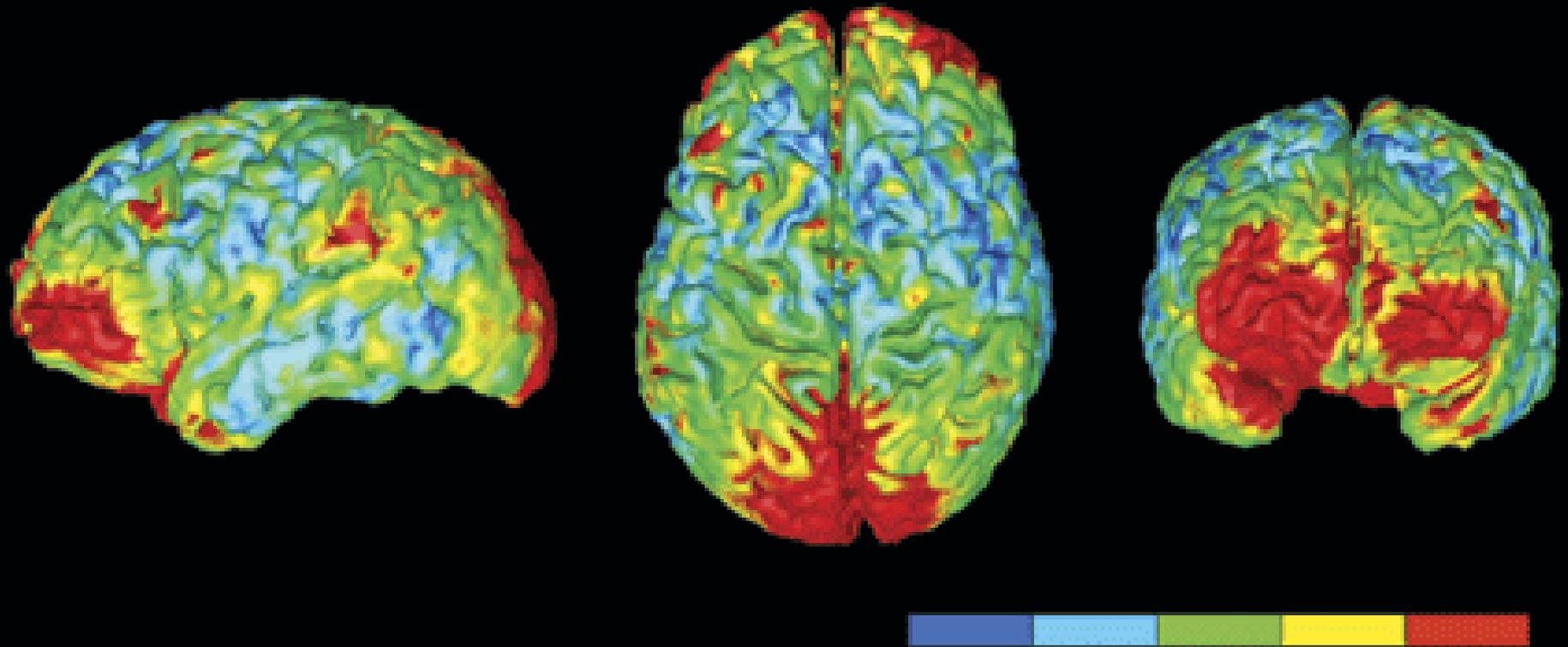
(b)



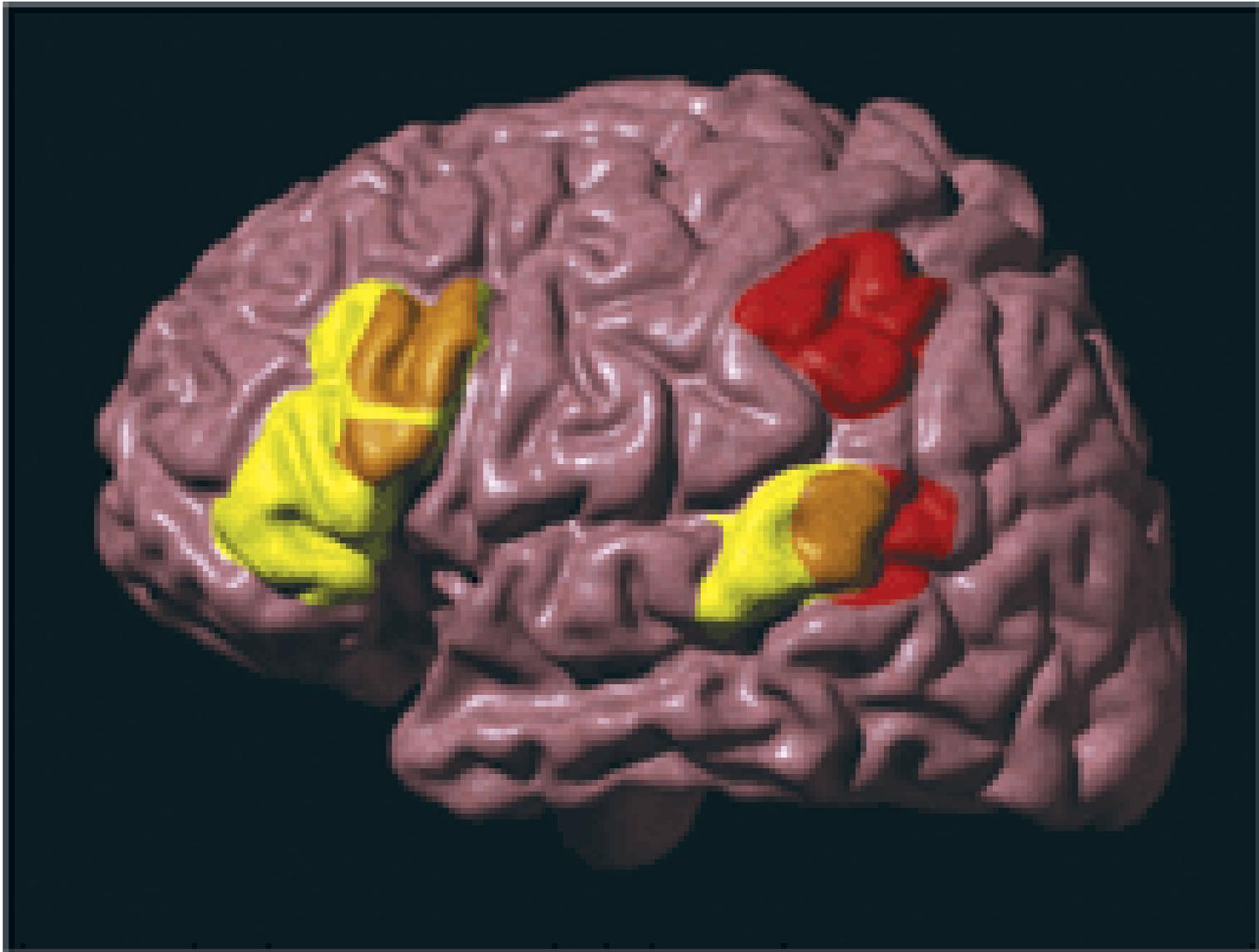


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Depiction of the lateral surface of the brain showing areas involved in the functional neuroanatomy of phonemic processing. HG is Heschl's gyrus, the primary auditory cortex. STP is the superior temporal plane, divided into posterior and anterior areas. STG is the superior temporal gyrus. Traditional theories maintain that pSTP and STG are the loci of phonemic processing. Hickok and Poeppel (2000) argue that these areas in both hemispheres are involved in automatic phonemic processing in the process of word recognition. Other research suggests that more anterior structures, aSTP and the area around the superior temporal sulcus (STS), are involved in these processes. The inferior parietal lobe (AG, angular gyrus; SMG, supramarginal gyrus) and Broca's area (areas 44 and 45) are involved in conscious controlled phonological processes such as rehearsal and storage in short-term memory.



From ape to human. Magnetic resonance images of a bonobo brain are warped onto the shape of a human cortex, viewed from (left to right) the side, top, and front. Red and yellow areas in the temporal region (linked to language) and in the prefrontal and occipital regions had to be stretched the most to reach the human configuration, whereas blue areas are similar in apes and humans (Zilles et al).



Wired for imitation? Classic language areas--Broca's and Wernicke's (yellow)--overlap (orange) with areas critical for imitation (red). A. TOGA/UCLA

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.

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 aphasia	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 (sparse, 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