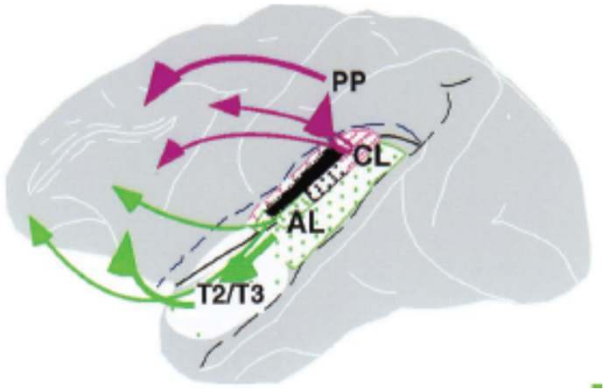
FAV, Talk no. 4, Auditory Cortex,



Petr Maršálek

October 2020

Outline FAV 4

- Thalamus is a gateway through which sensory stimulation gains attention and processing. We can be woken up by strong auditory or visual stimuli.
- Neocortical brain areas have common features (six layers) and distinctions (sensory versus motor, and others).
- Sensory areas are typically divided into ‘primary’ and ‘secondary’, but the functional features of processing order between these remain unclear.
- There are 47 distinct Brodmann areas (by Korbinian Brodmann, 1909).
- Distinct areas enable vocalization: 2 major speech centers, sensory and motor.
- Inter-hemispheric division of labor: when we sing a song, left (dominant) hemisphere maintains lyrics and the other hemisphere contains the melody.
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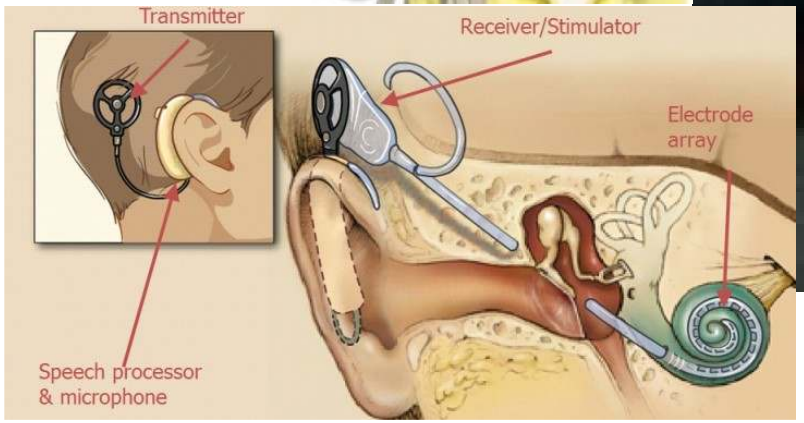
- There are critical developmental periods for speech acquisition – language understanding starts before speech production. Developmental period partly closes in puberty.
- (Families of Indo-European languages, tonal languages, language origin, structure and putative universal grammar et cetera. This is fascinating, but it is mostly beyond scope of these lectures…)
- Hearing loss in ageing progresses across modalities and higher loudness in hearing aid often does not help – is there a need for augmented media?

How Do We Collect Information About Cortex? We Use Electrophysiology, Non-invasive and Invasive.

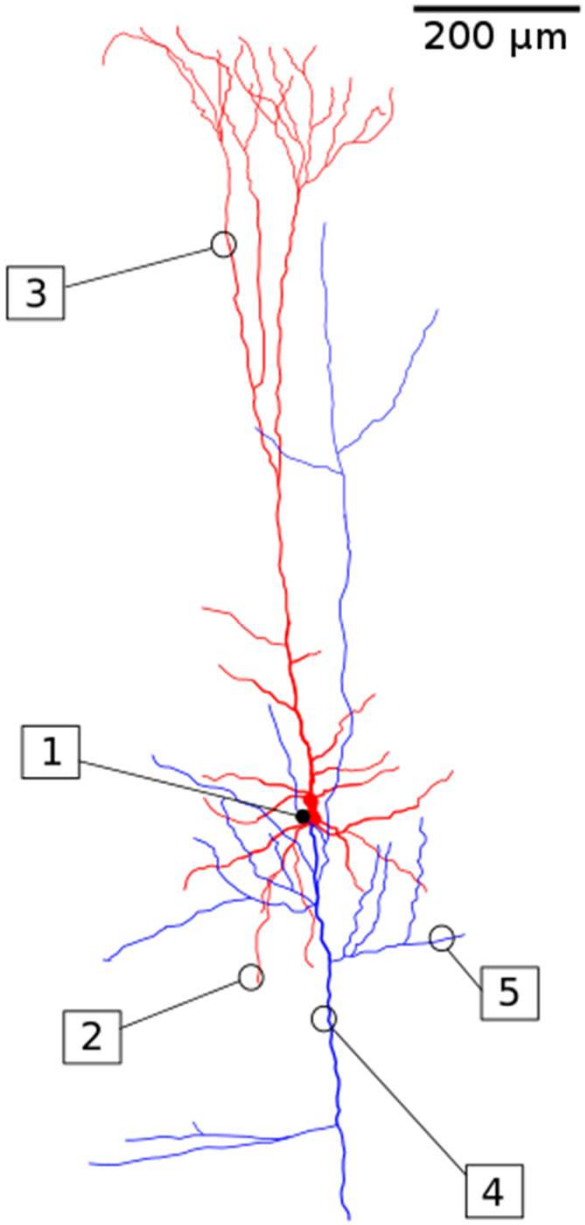


All Conscious Mental Processes Reside in Cerebral Cortex

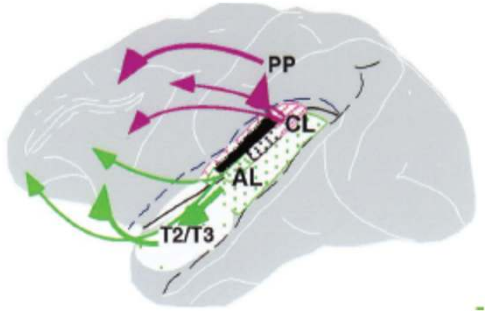
Psycho-Physical and Electro-Encephalo-Graphic Responses of Infants and Small Children

Pyramidal Neuron

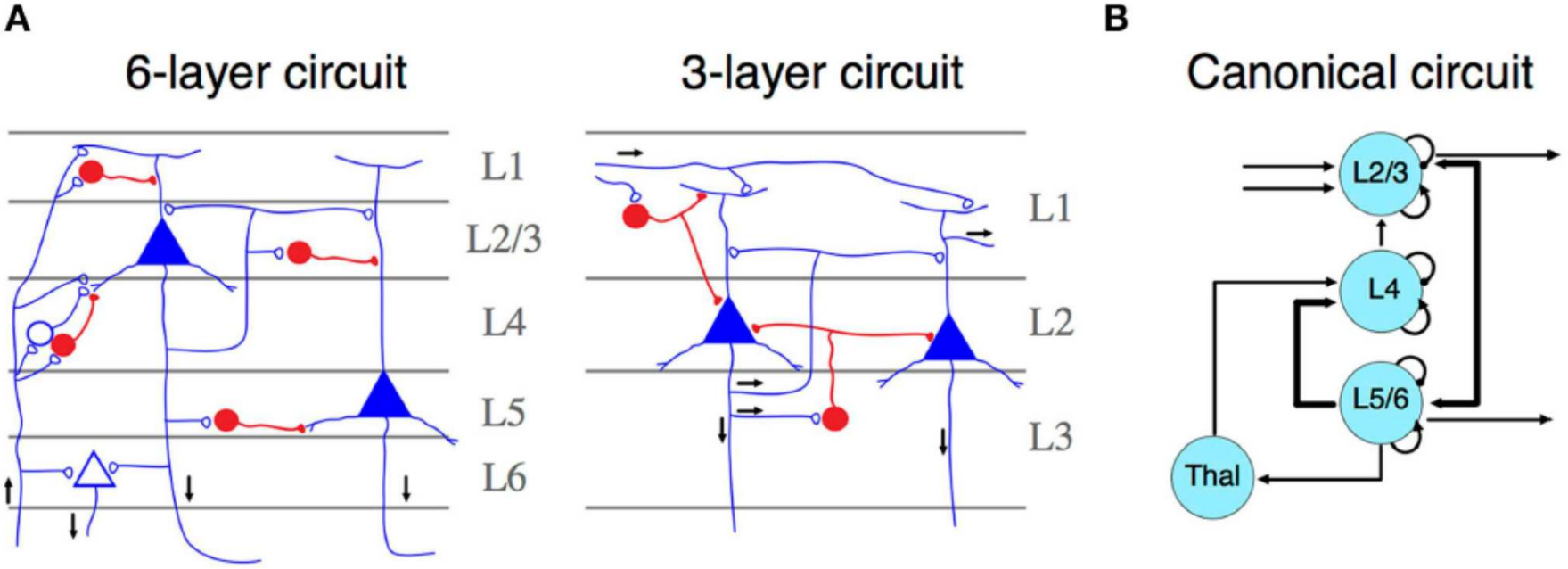
As most neurons, this cell consists of:
[1] cell body
[2] basal dendrites
[3] apical dendrites
[4] principal axon
[5] axon collaterals
Synapses use excitatory neuro-transmitter: glutamate.



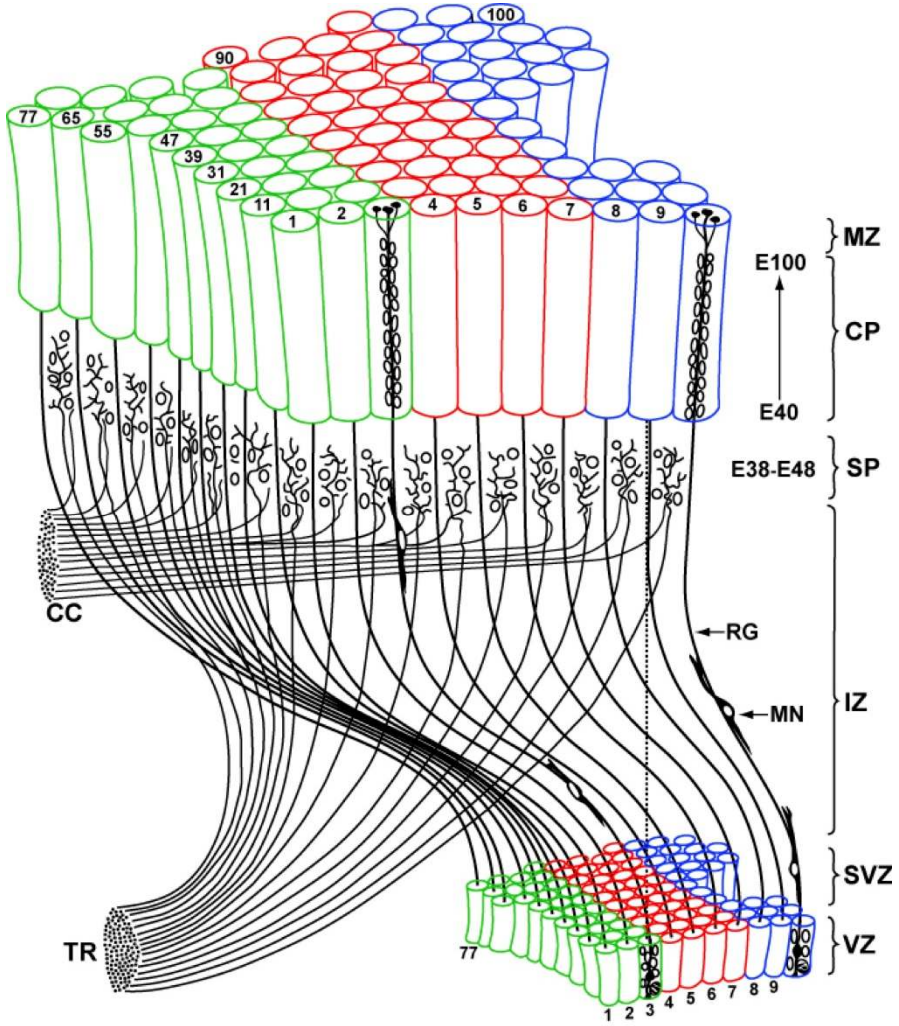
CORTICAL MICROCIRCUIT



Neocortex and Other Cortices (Paleocortex, Olfact. Only: 3 Layers, Archicortex, Olfact. and Hippocampus, 3 or 4 Layers)



Cortex Consists of Columns as Functional Units

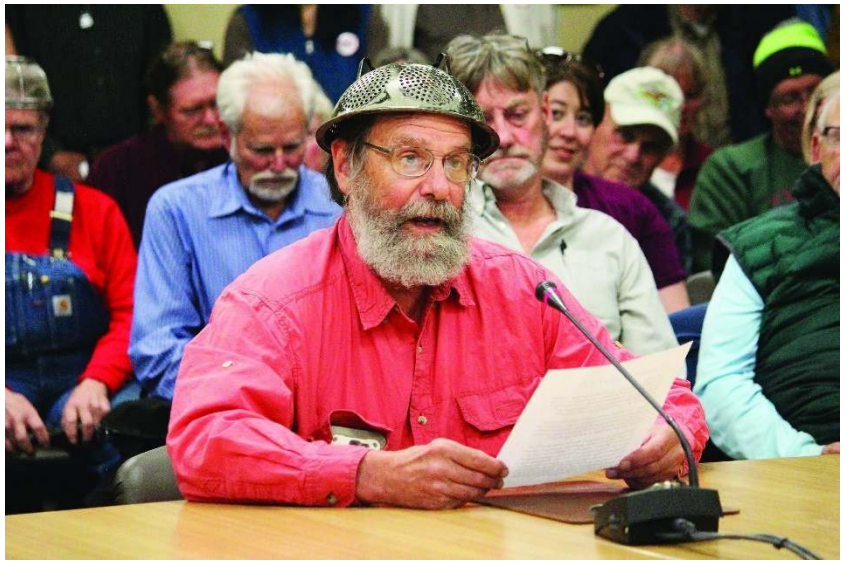


Area of Cerebral Cortex Correlates with the Size and Surface Area of the Mammal

CC = Cortico-Cortical Connections, TR = Thalamic Radiation

Unfolded Human Cerebral Cortex Has Surface Area As Medium Size Pizza

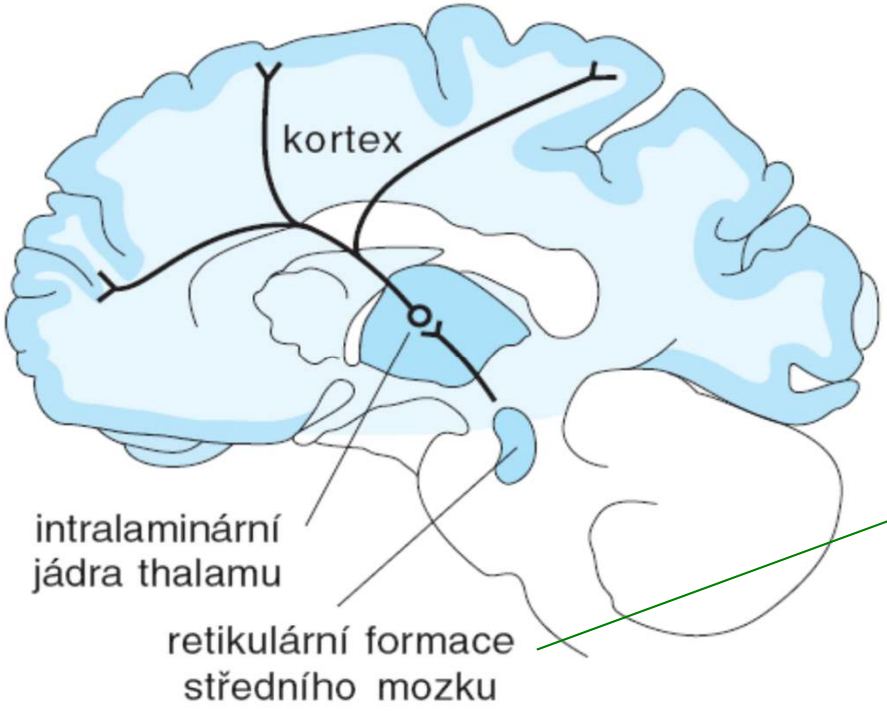
Pastafarian Mission

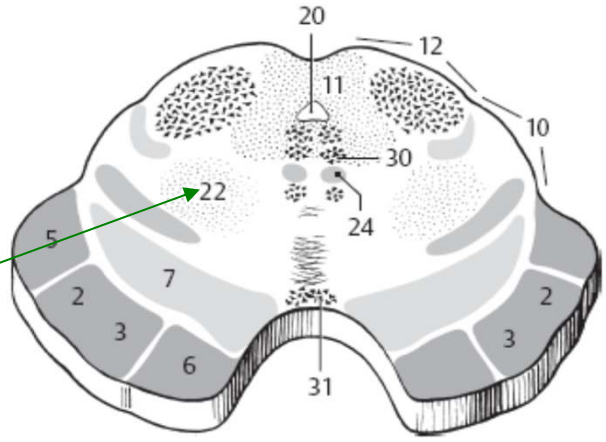


Cerebral Cortex and Other Connected Nuclei

- Reticular Formation
- Sensory Projections
- Motor Projections
- Thalamus
- … Other Sub-Cortical Projections...

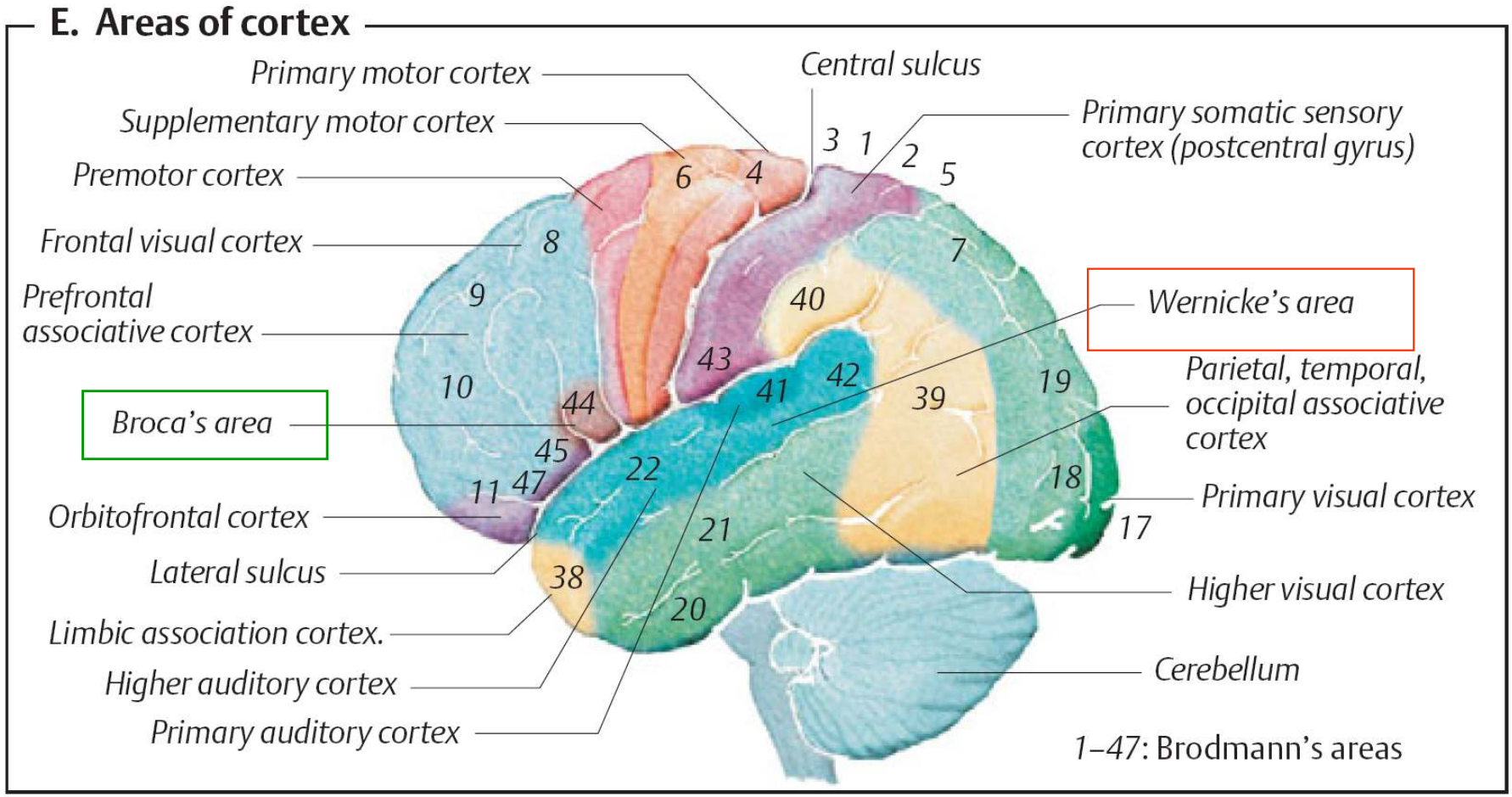
Reticular Formation





C Section through inferior colliculus

Two Main Speech Centers Within the (Brodmann's) Areas



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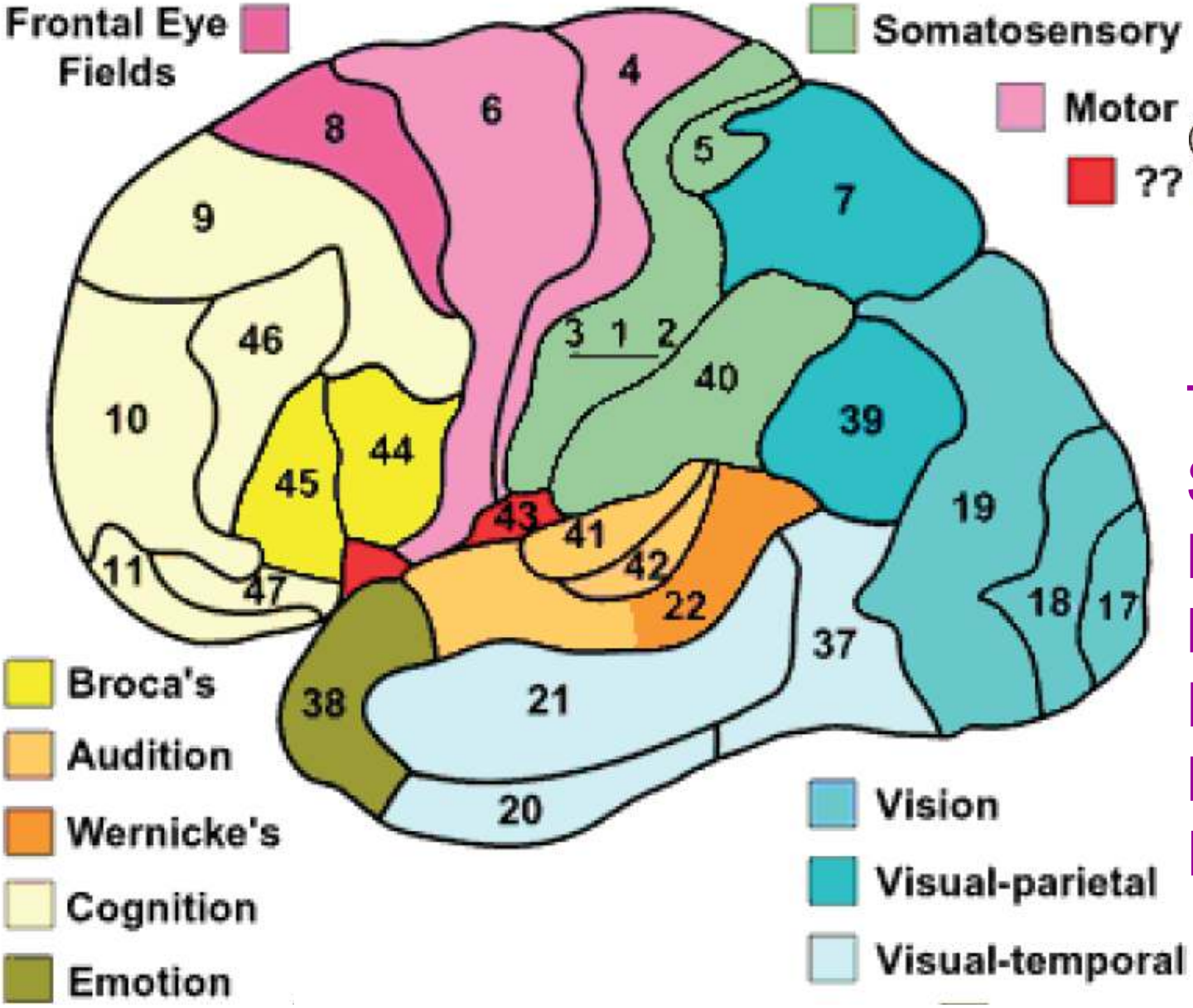
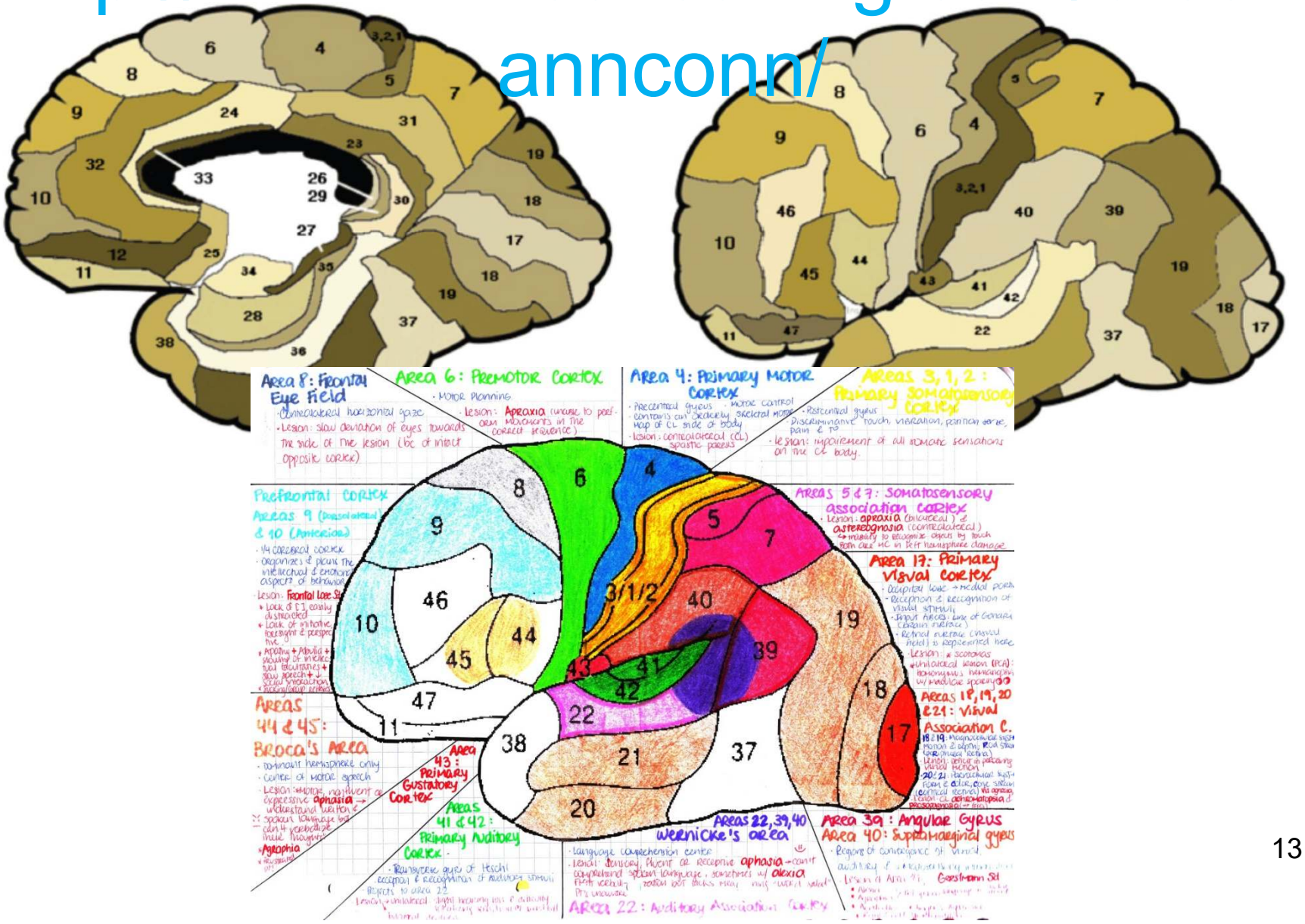
Brodmann Areas (Outer Hemisphere Part)



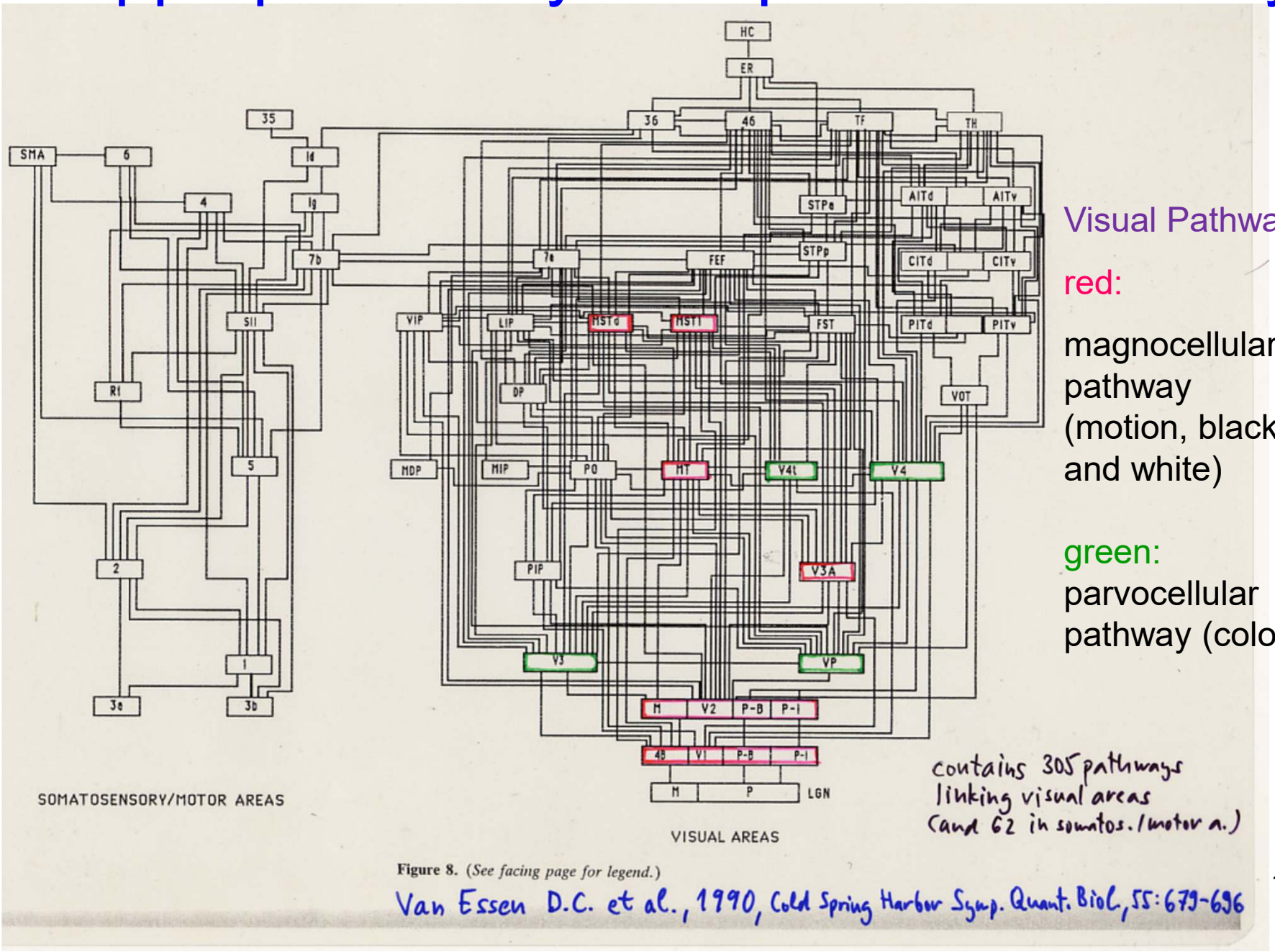
The Least Structured Mammalian Brain is Found in Rodents and Insectivora

Brodmann Areas (Inner and Outer)

http://www.fmriconsulting.com/brodmannconn/



Inappropriate Way to Explain Connectivity…



Visual Pathways

red:

magnocellular pathway (motion, black and white)

green:

parvocellular pathway (color)

contains 305 pathways linking visual areas (and 62 in somatos./motor a.)

Figure 8. (*See facing page for legend.*)

Van Essen D.C. et al., 1990, Cold Spring Harbor Symp. Quant. Biol, 55: 679-696

THIS PANEL IS A SPECULATIVE ATTEMPT TO CLASSIFY BRODMANN AREAS DIFFERENTLY

“Binary Trees of Brodmann Areas” and Beyond Brodmann Areas

- Bit 1: (Left) vs. (Right) Hemisphere
- Bit 2 and 3: (Motor/ Frontal Lobe) (Somatosensory/ Parietal L.)
- Bit 2 and 3: (Auditory/ Temporal L.) (Visual/ Occipital L.)
- Bit 4: (Primary) vs. (Secondary) Sensory projection areas
- Bits 5, 6, 7: subdivisions of visual/ sensory areas
- Sensory Domains: Bits 1 and 7: (Left/ Right) vs. (Bottom/ Top) Extensions, Retinotopy, Spatial Maps
- Bit 8: Temporal encodings: subcortical
- Bit 9: Other modality encodings – Hippocampus (Archi-cortex)/ space navigation, and so on.

Olfactory cortex and Hippocampus (Archi-cortex), Olfacory Bulb (Paleo-cortex), Vestibular Cortex (Part of Temporal lobe), Cortical Projections, Remaining senses: Olfaction, Taste and Touch

What and Where in auditory cortex?

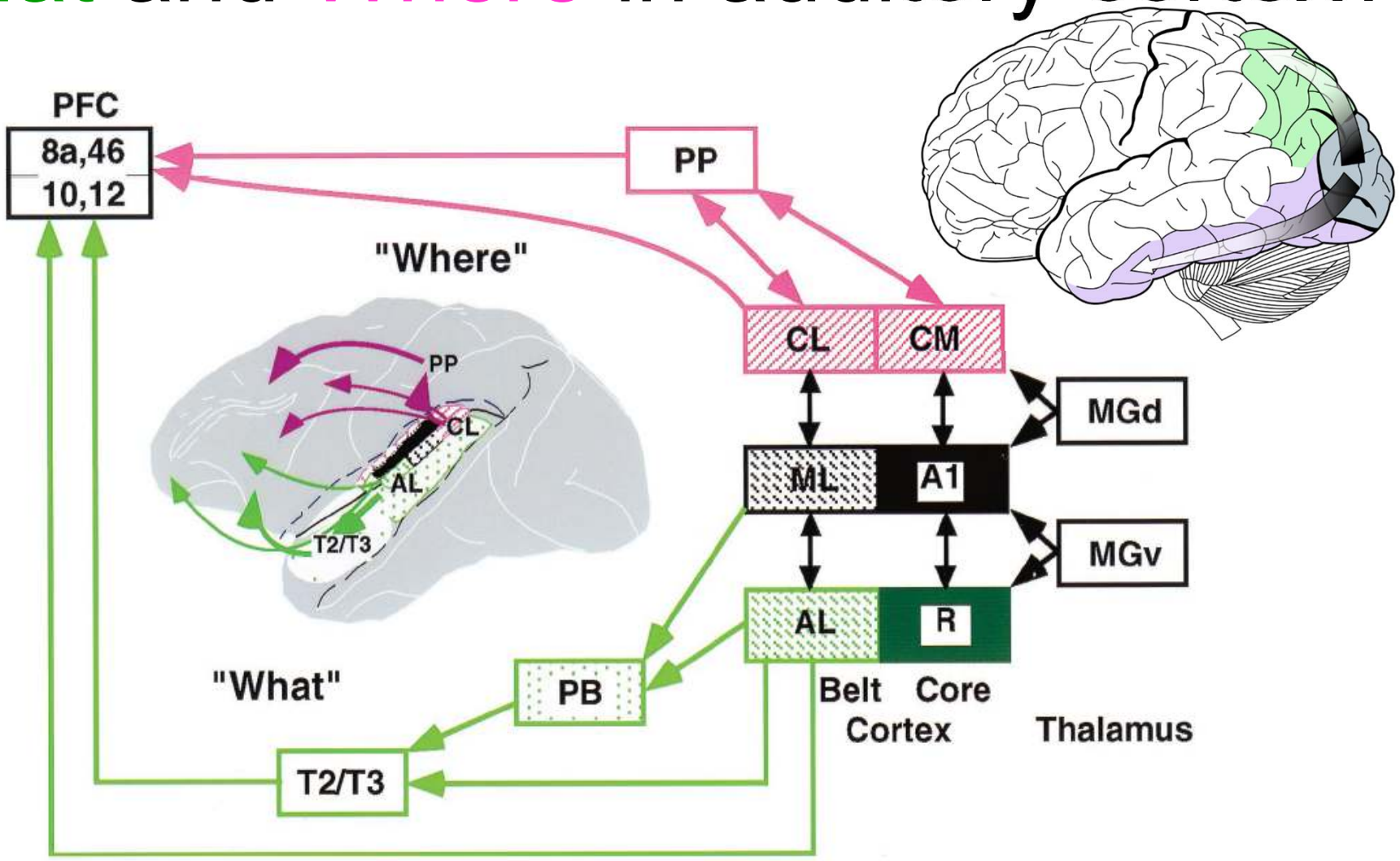
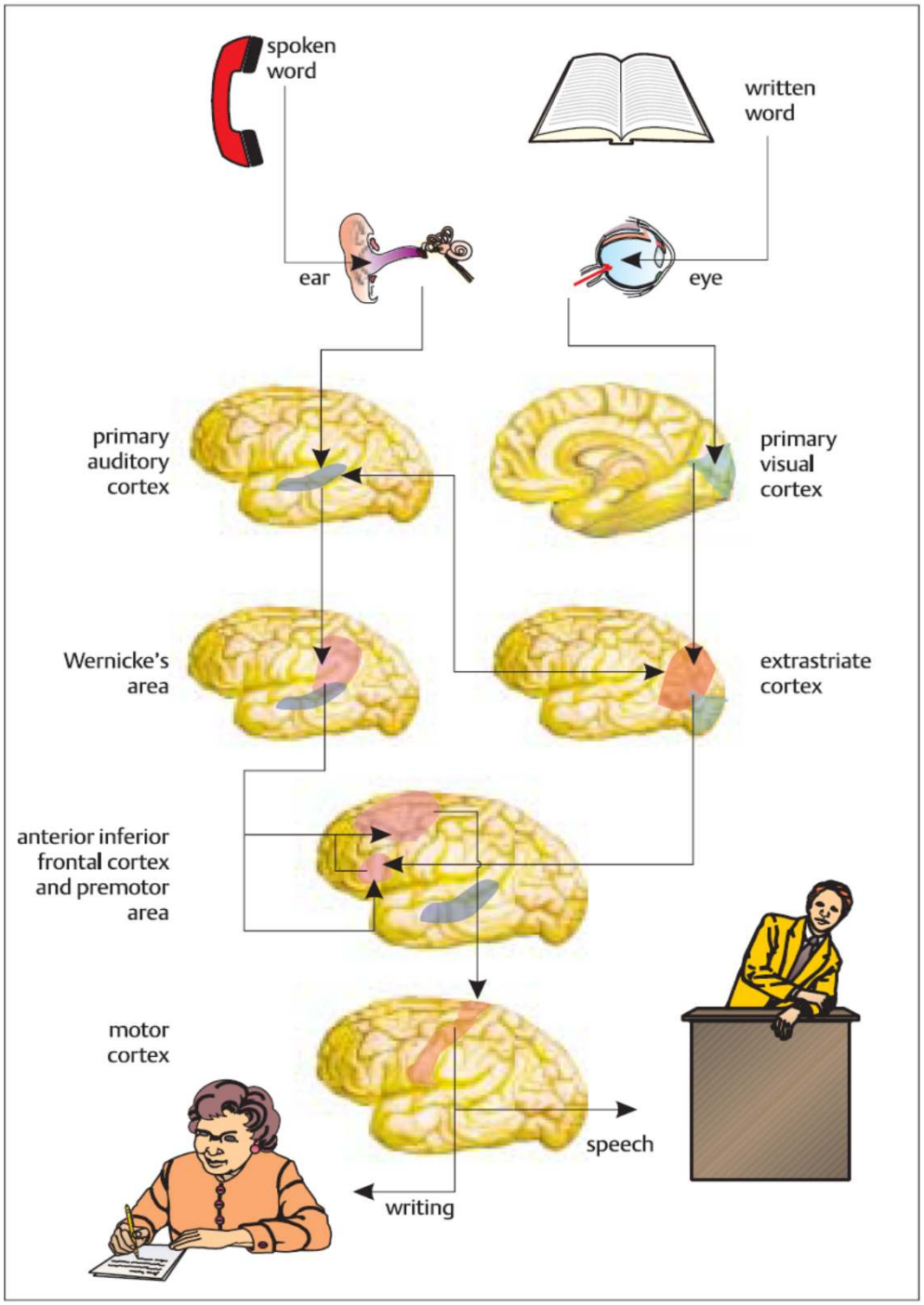
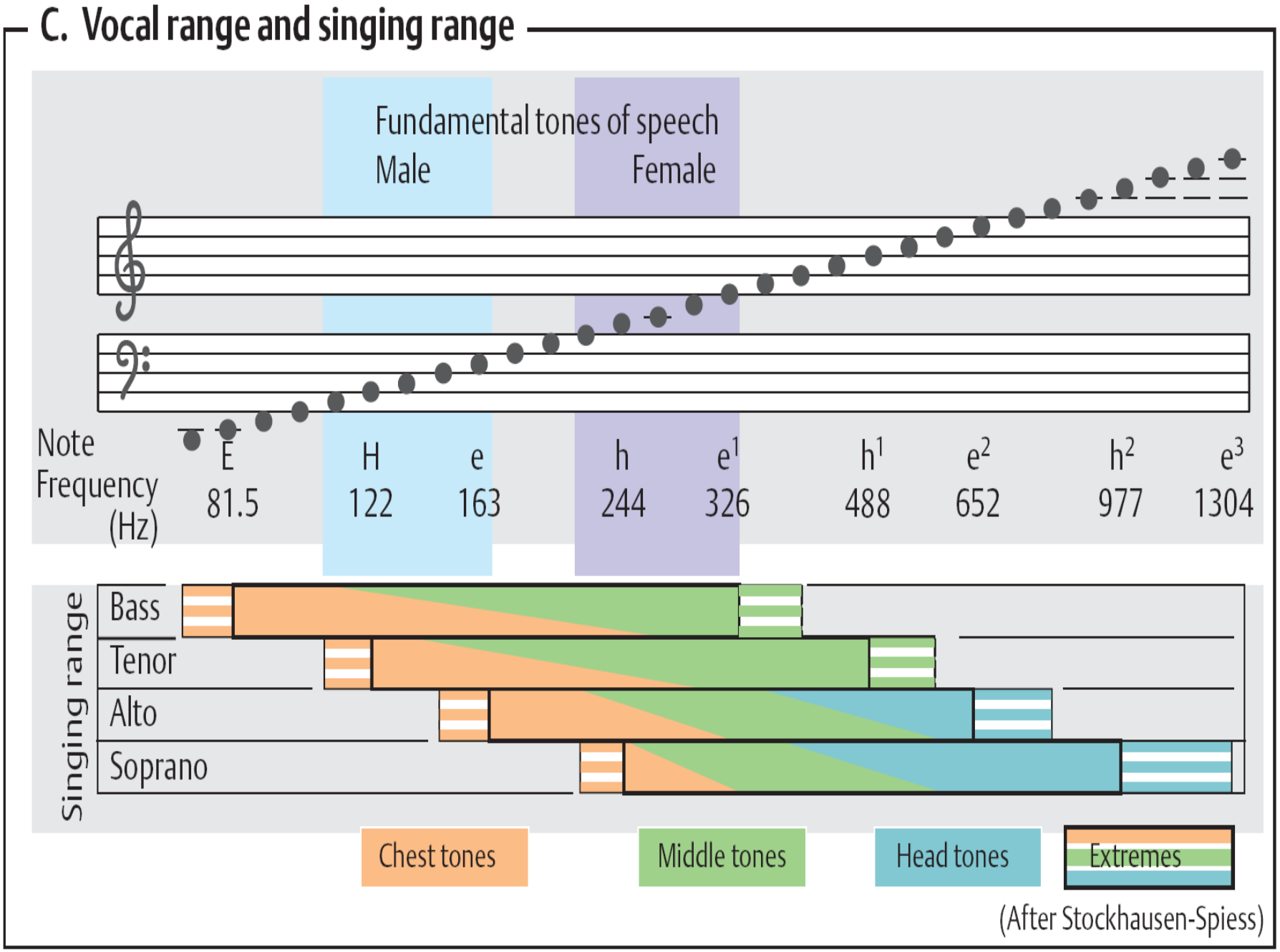


Fig. 6. Schematic flow diagram of "what" and "where" streams in the auditory cortical system of primates. The ventral "what"-stream is shown in green, the dorsal "where"-stream, in red. [Modified and extended from Rauschecker (35); prefrontal connections (PFC) based on Romanski *et al.* (46).] PP, posterior parietal cortex; PB, parabelt cortex; MGd and MGv, dorsal and ventral parts of the MGN.

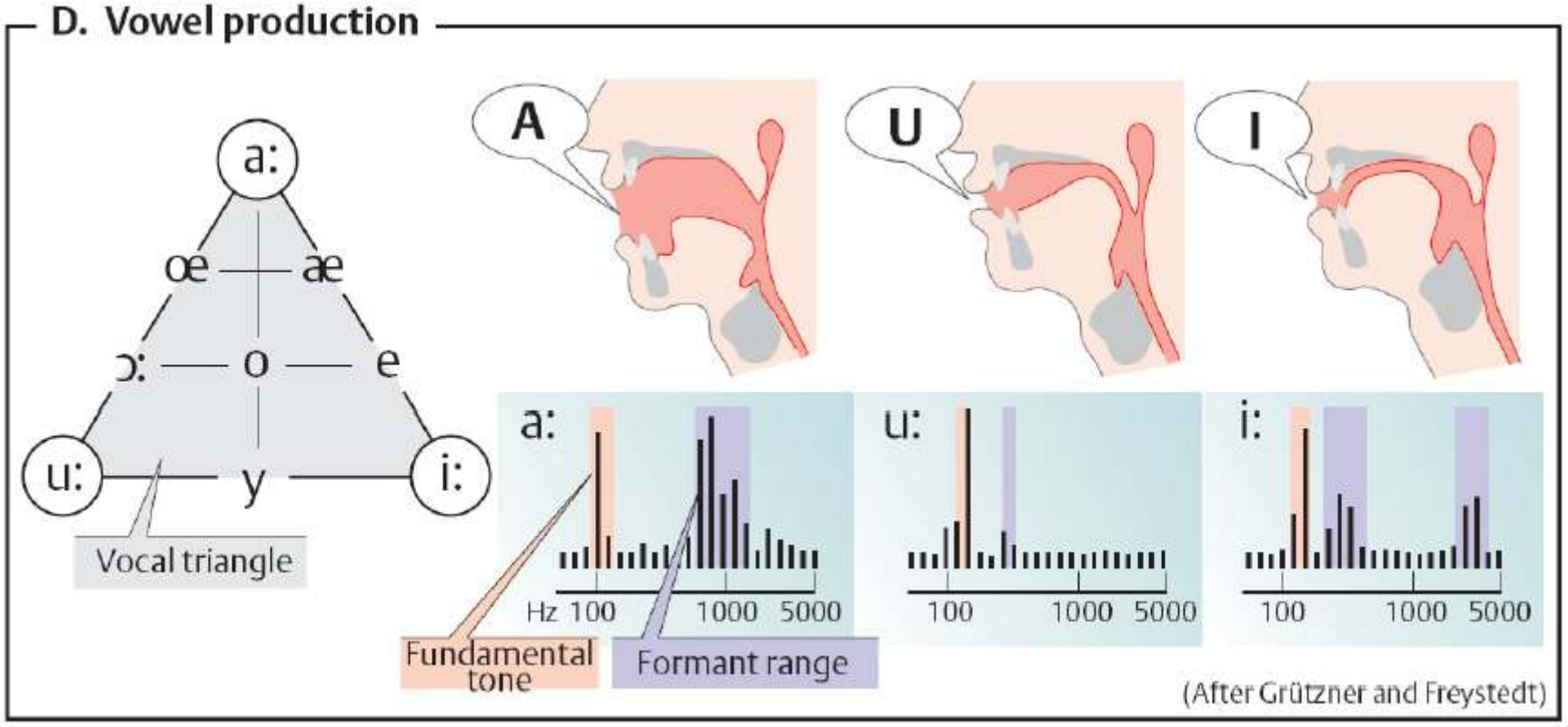


Speech Processing in Cerebral Cortex



Vocal range and singing range + modalities...

Formants of Vowels in Different Languages



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Stages of Speech and Language Acquisition

6 mo **Beginning of distinct babbling.**

1 y **Beginning of language understanding, one word utterances.**

1.5 y **Dictionary of 30 to 50 words.**

2 y **Dictionary of 50 to several hundred words. Two word (telegraphic/ short message) speaker.**

2.5 y **Three or more word sentences. Many grammatical errors and idiosyncratic expressions. Good understanding of language.**

3 y **Dictionary of 1000 words.**

4 y **Dictionary of 2000 words. Speech competence close to adults.**

[Kandel, Schwartz, Jessel, Principles of Neural Science, 1991]

EN: babble, CZ: žvatlat, SK: džavotať, GE: plappern,

LAT: balbuties, et cetera…

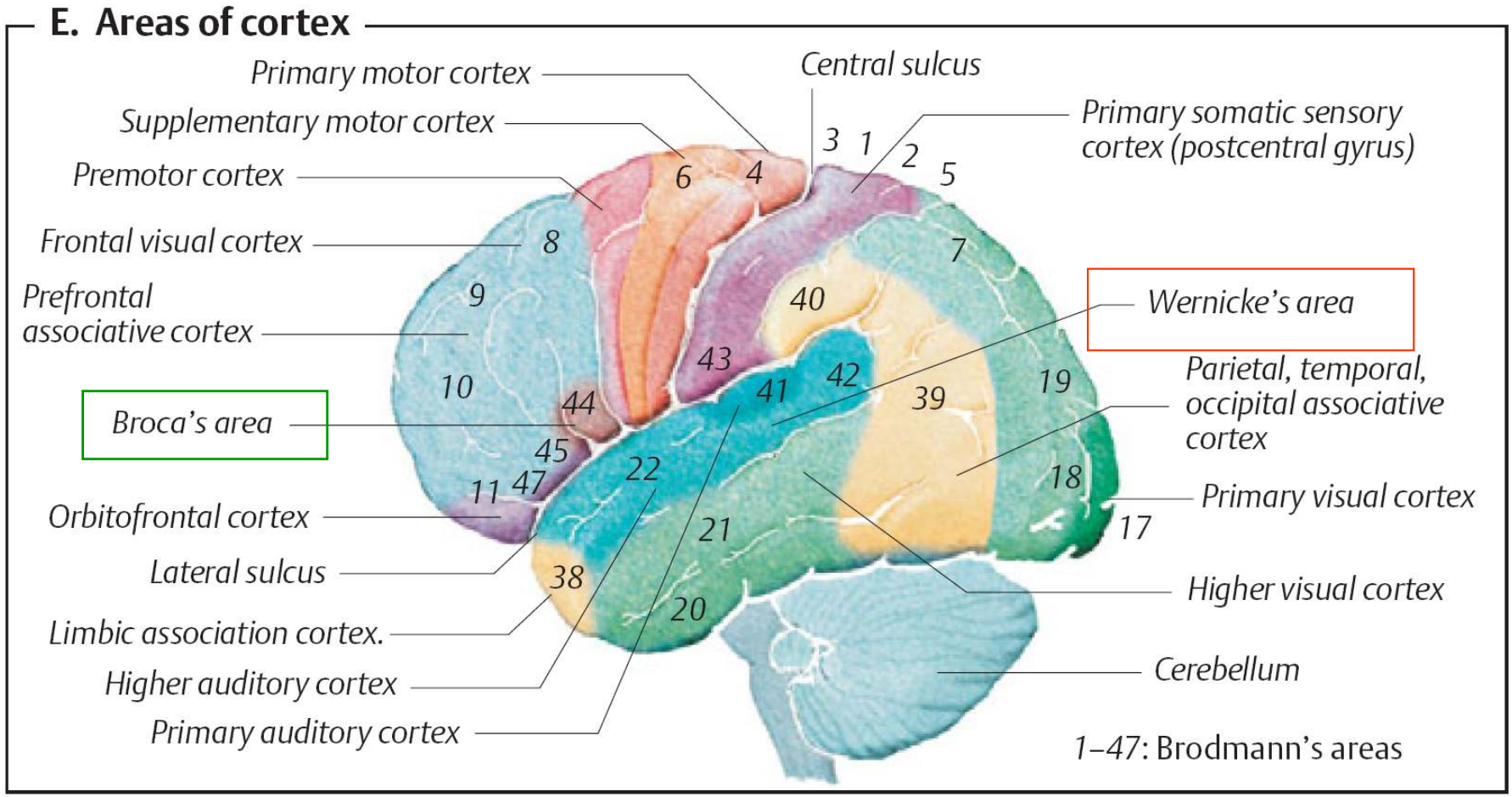
Comments On Speech Centres

(1) On rare cases of ‘split brain’ patients, it has been demonstrated that lateralization of is a purposeful physiological feature

(2) Sensory speech center deficit (= aphasia) is more devastating than motor aphasia. This is because one does not have a way how to communicate with a patient affected by sensory aphasia.

(3) There are critical developmental periods in native (and foreign) language and speech acquisition.

Two Main Speech Centers Within the Brodmann's Areas



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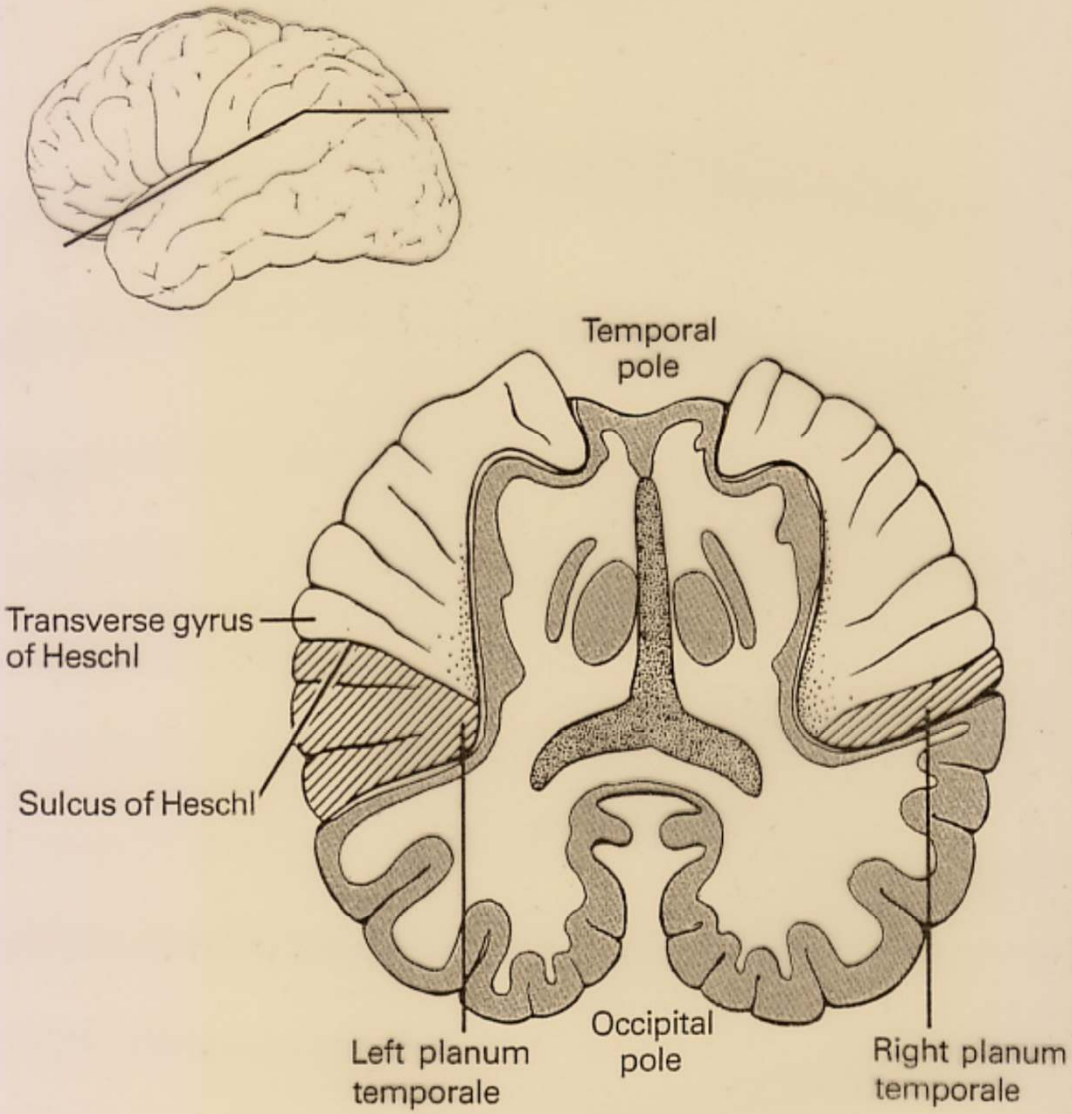


FIGURE 53–8
The planum temporale is larger in the left hemisphere than in the right in the majority of human brains (horizontal section in the plane of the Sylvian fissure). (Adapted from Geschwind and Levitsky, 1968.)

TABLE 53–2. Linguistic Dominance and Handedness

Handedness	Dominant hemisphere (%)		
	Left	Right	Both
Left or mixed handed	70	15	15
Right handed	96	4	0

(Data from Rasmussen and Milner, 1977.)

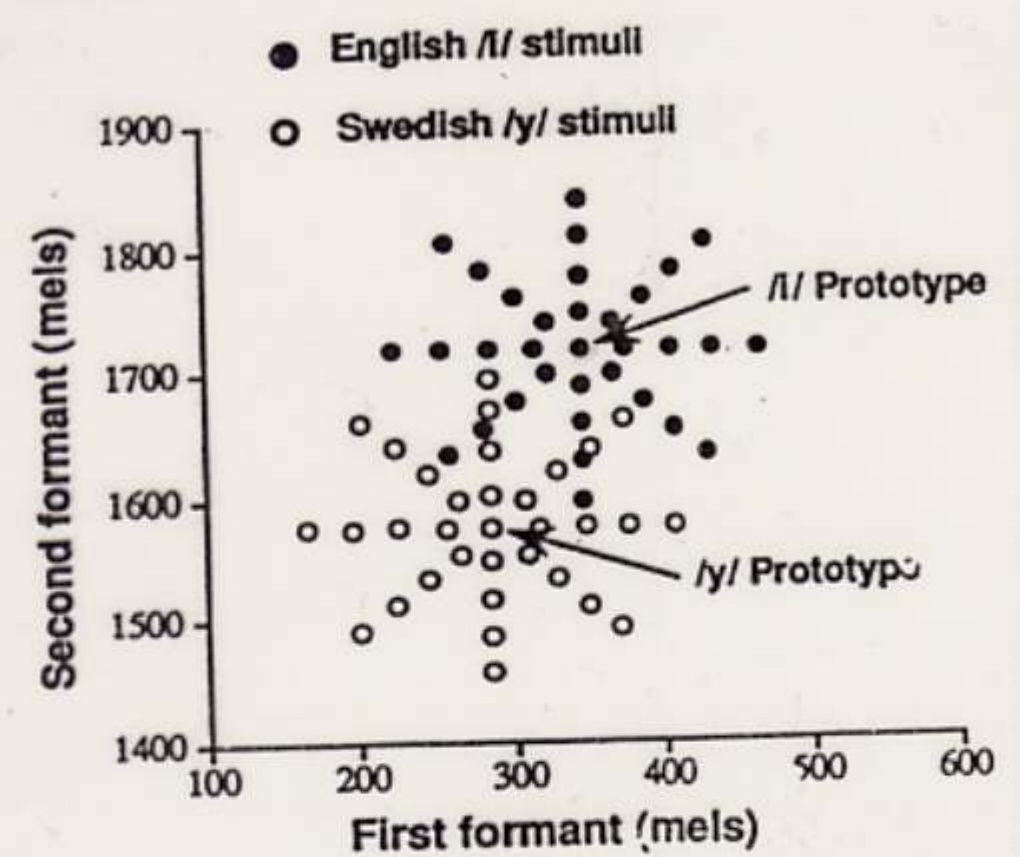


Fig. 1. Six-month-old infants from America and Sweden were tested with two sets of vowel stimuli, American English /i/ and Swedish /y/. Each set included an exceptionally good instance of the vowel (the prototype) and 32 variants that formed four rings (eight stimuli each) around the prototype (*8*).

Prototypes of vowels and synthetic vowels in formant space

[P. Kuhl et al, 1992]

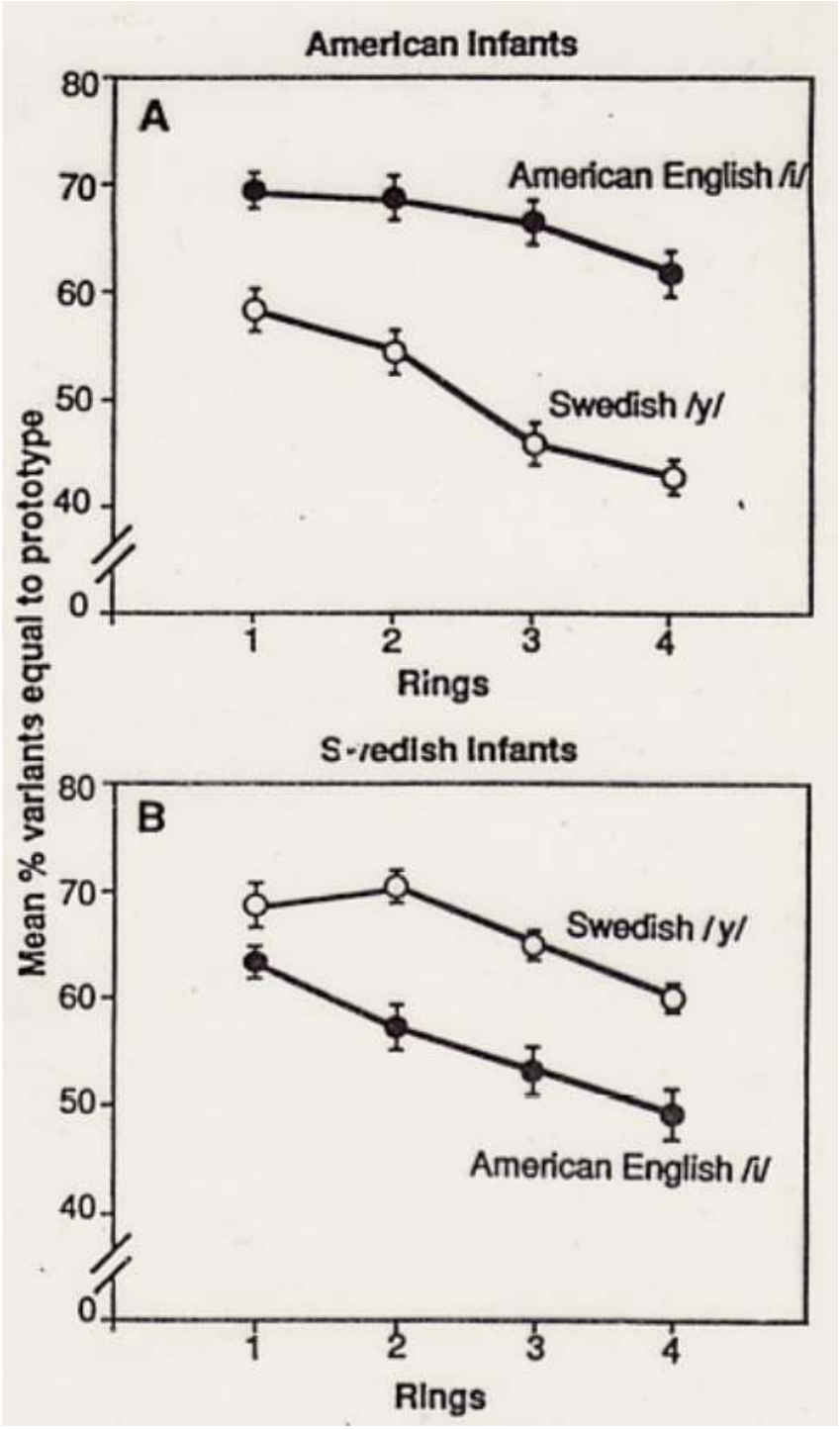
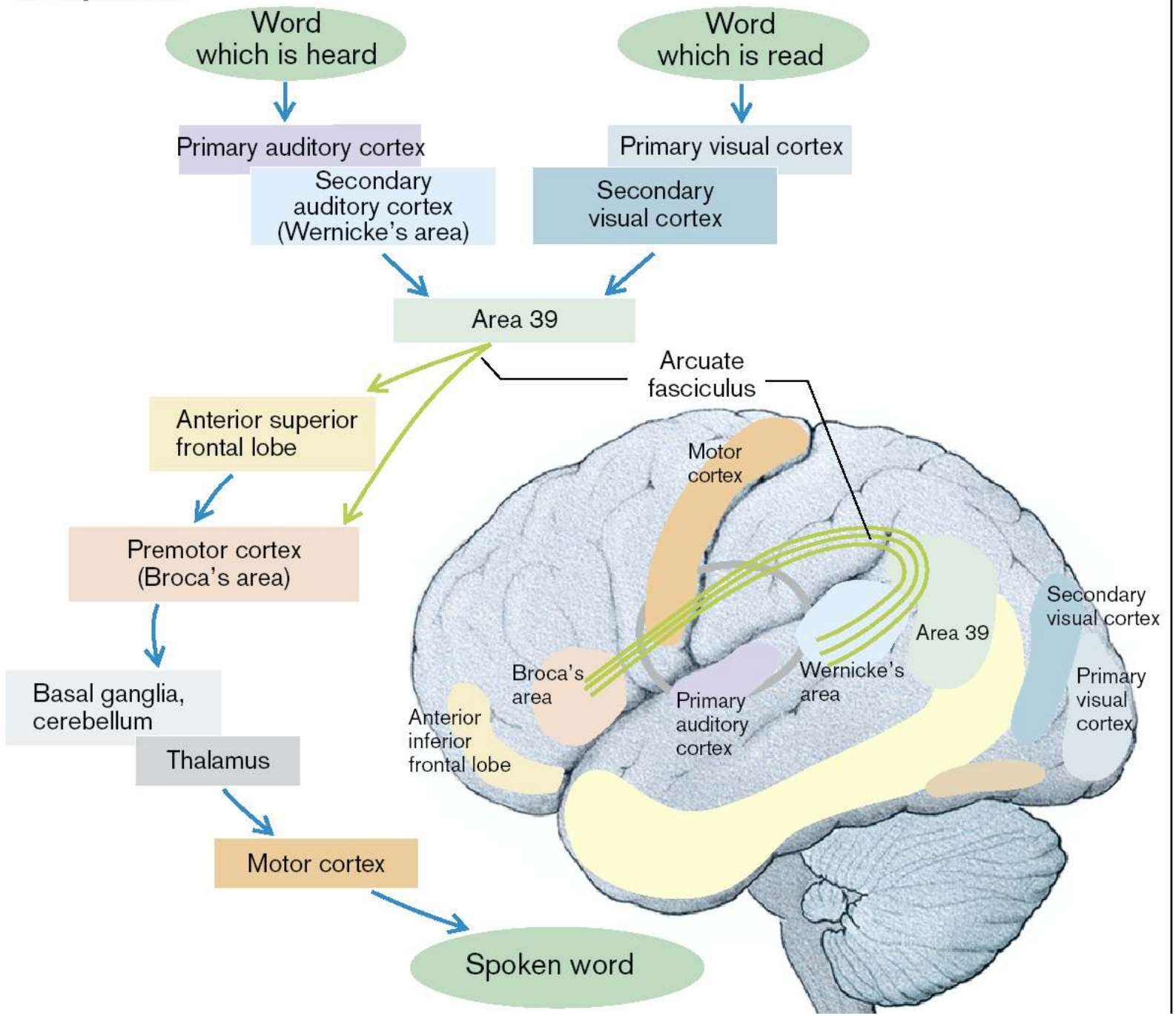


Fig. 2. Results showing an effect of language experience on young infants' perception of speech. Two groups of 6-month-old infants, (**A**) American and (**B**) Swedish, were tested with two different vowel prototypes, American English /i/ and Swedish /y/. The mean percentage of trials in which infants equated variants on each of the four rings to the prototype is plotted. Infants from both countries produced a stronger magnet effect (equated variants to the prototype more often) for the native-language vowel prototype when compared to the foreign-language vowel prototype. (Error bars = standard error.)

Psycho-physical responses of 6 month old infants to vowels of native and foreign language

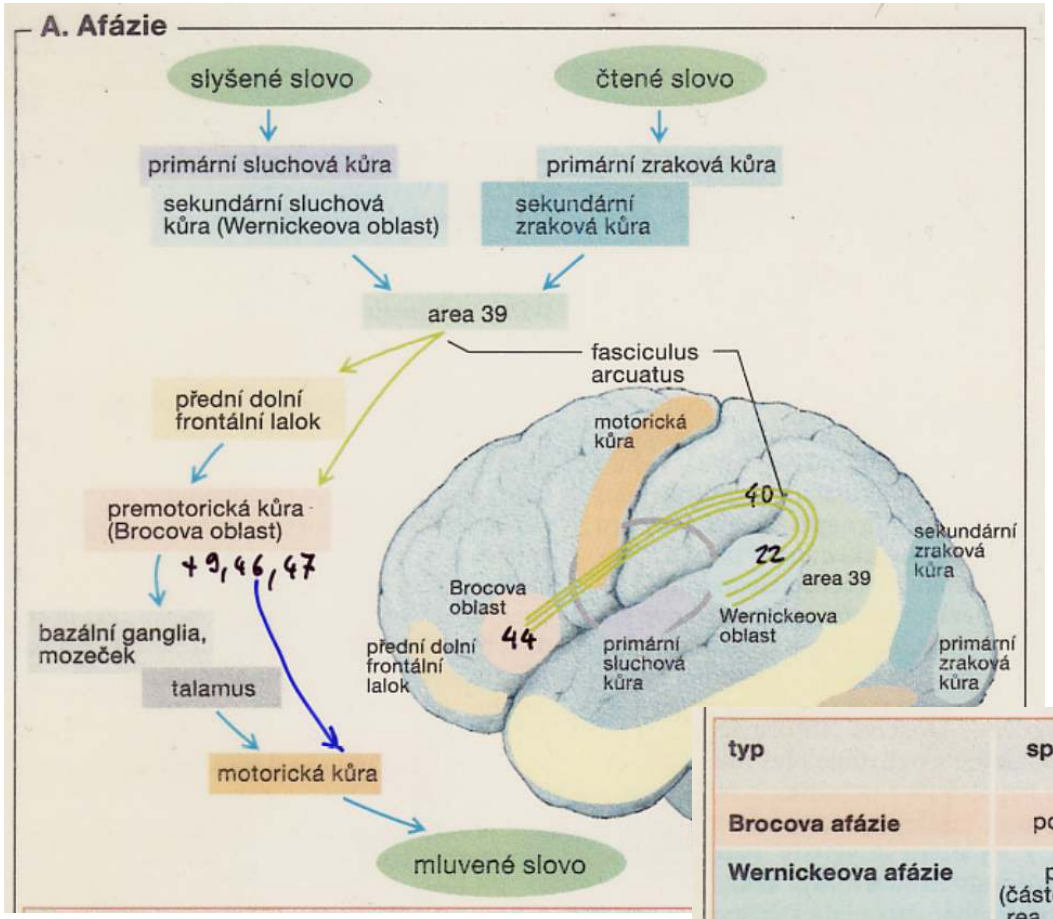
[P. Kuhl et al, 1992]

- A. Aphasias


Word which is heard
Word which is read
Primary auditory cortex
Primary visual cortex
Secondary auditory cortex (Wernicke's area)
Secondary visual cortex
Area 39
Arcuate fasciculus
Anterior superior frontal lobe
Premotor cortex (Broca's area)
Basal ganglia, cerebellum
Thalamus
Motor cortex
Spoken word
Motor cortex
Broca's area
Anterior inferior frontal lobe
Primary auditory cortex
Wernicke's area
Area 39
Secondary visual cortex
Primary visual cortex

Type	Spontaneous speech	Repetition of words	Language comprehension	Finding words
Broca's aphasia	abnormal	abnormal	normal	impaired
Wernicke's aphasia	fluent (at times logorrhea, paraphasia, neologisms)	abnormal	impaired	impaired
Conduction aphasia	fluent, but paraphasic	markedly impaired	normal	abnormal, paraphasic
Global aphasia	abnormal	abnormal	abnormal	abnormal
Anomic aphasia	fluent	normal, but anomic	normal	impaired
Achromatic aphasia	fluent	normal, but anomic	normal	impaired
Motor transcortical aphasia	abnormal	normal	normal	abnormal
Sensory transcortical aphasia	fluent	fluent	abnormal	abnormal
Subcortical aphasia	fluent	normal	abnormal (transient)	abnormal (transient)

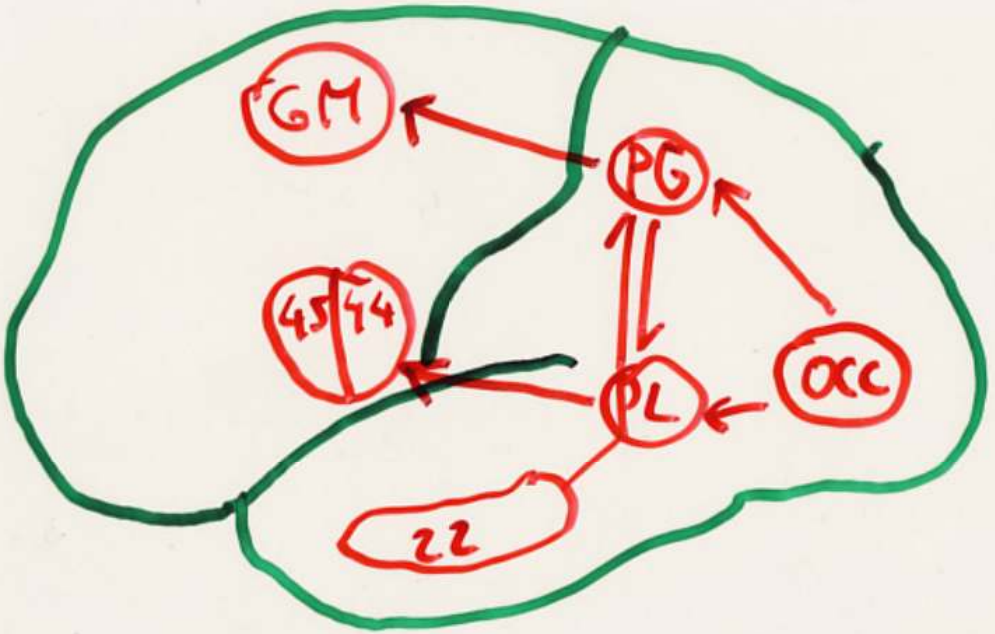
Řečové, (fatické) poruchy (=afázie)



typ	spontánní řeč	opakovaná řeč	rozumění řeči	hledání slov
Brocova afázie	porušená	porušená	normální	omezené
Wernickeova afázie	plynulá (částečně logorea, parafázie, neologismy)	porušená	omezené	omezené
svodná afázie	plynulá, ale parafázická	silně omezená	normální	porušené, parafázické
globální afázie	porušená	porušená	porušené	porušené
anomická afázie	plynulá	normální, ale anomická	normální	omezené
achromatická afázie	plynulá	normální, ale anomická	normální	omezené
motorická transkortikální afázie	porušená	normální	normální	porušené
senzorická transkortikální afázie	plynulá	plynulá	porušené	porušené
subkortikální afázie	plynulá	normální	porušené (přechodně)	porušené (přechodně)

APHASIAS (acc. Hrbek, Tichý)

BARTEO, 1985



LEFT OUTER HEMISPHERE

PG - parietal graphesthetic center
PL - parietal logesthetic center
OCC - occipital assoc. center 22 - Wernicke's c. - (logesthetic c.)
GM - graphomotoric center 44, 45 - Broca's c. - (logomotoric c.)

Summary FAV 4

- Thalamus is a gateway through which sensory stimulation gains attention and processing. We can be woken up by strong auditory or visual stimuli.
- Neocortical brain areas have common features (six layers) and distinctions (sensory versus motor, and others).
- Sensory areas are typically divided into 'primary' and 'secondary', but the functional features of processing order between these remain unclear.
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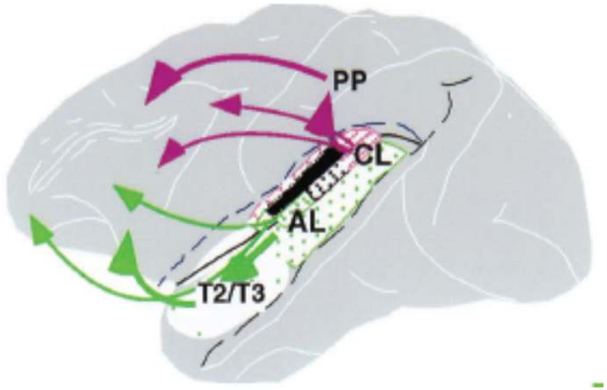

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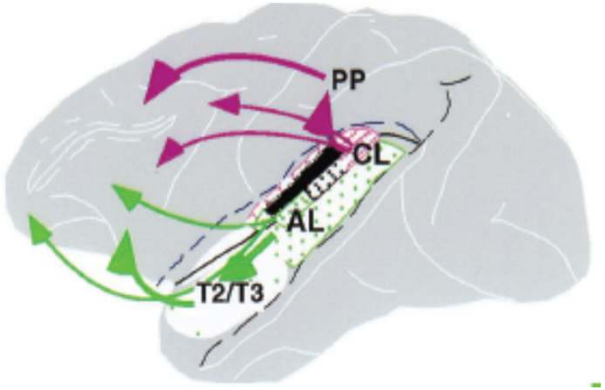

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END

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