Department of Linguistics and Translation
香港城市大學
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Language and its Applications LT5903

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Lecture 9: Neurolinguistics

Lecture plan

- Language acquisition review
- Psycholinguistics v.s Neurolinguistics
- Broca’s and Wernicke’s Aphasia
- Brain anatomy and language regions
- Research tools and studies
- Short break (15 mins)
- Group discussion on HW9

Language Acquisition review

theories

the innateness hypothesis: critical period hypothesis

imitation theory

reinforcement theory

active construction of a grammar theory

- rule-based v.s. connectionist model for the acquisition of English past tense

social interaction theory: child-directed speech

research methods

experiment:

- high-amplitude sucking: newborns
- head-turn preference: 5-18 months
- preferential looking: 5-18 months

corpus:

- CHILDES

Psycholinguistics

psycholinguistics: the study of the language processing steps that are required for speaking and understanding words and sentences, learning first and later languages, and also of language processing in disorders of speech, language, and reading.

research methods: behavioral measures

self-paced reading, eye-tracking, lexical decision, naming task, priming task, etc.

Neurolinguistics

neurolinguistics: the study of how language is represented in the brain: that is, how and where our brains store our knowledge of the language (or languages) that we speak, understand, read, and write, what happens in our brains as we acquire that knowledge, and what happens as we use it in our everyday lives.

research methods: neuroimaging tools
EEG, MEG, ECoG, fMRI, etc

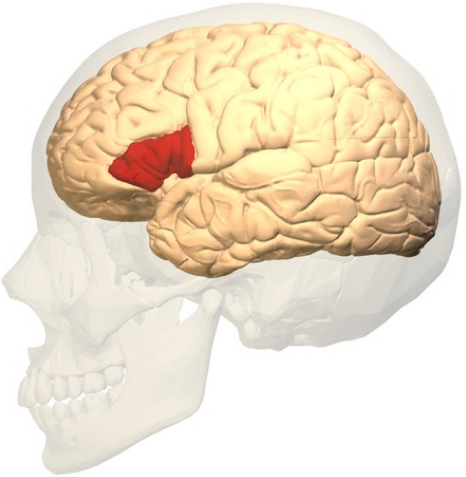
Broca’s aphasia

aphasia: patients lose their ability to produce or understand language due to stroke or brain injury.

Pierre Paul Broca reported impairments in two patients in 1861.

They had lost the ability to **speak fluently** after injury to the **posterior inferior frontal gyrus** of the brain
→ **Broca's area**
→ **Broca's aphasia** (expressive aphasia)

1824-1880



Broca's aphasia

a **Spontaneously speaking**

b **Repeating**

c **Listening for comprehension**

Wernicke’s aphasia

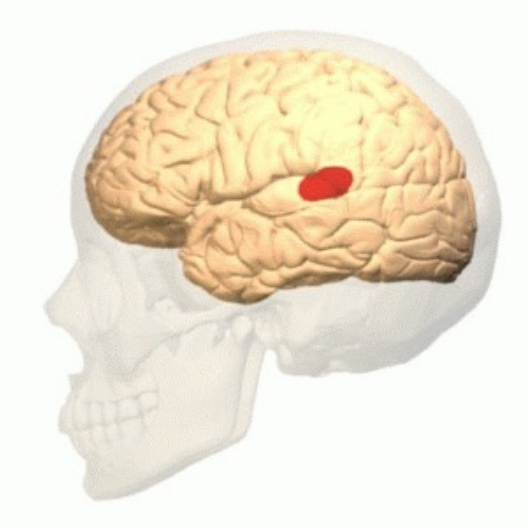
Carl Wernicke reported patients with fluent but disordered speech in 1874.

They have trouble understanding others’ speech and tend to produce semantically incoherent speech after injury to the **posterior superior temporal gyrus** of the brain

→ **Wernicke's area**

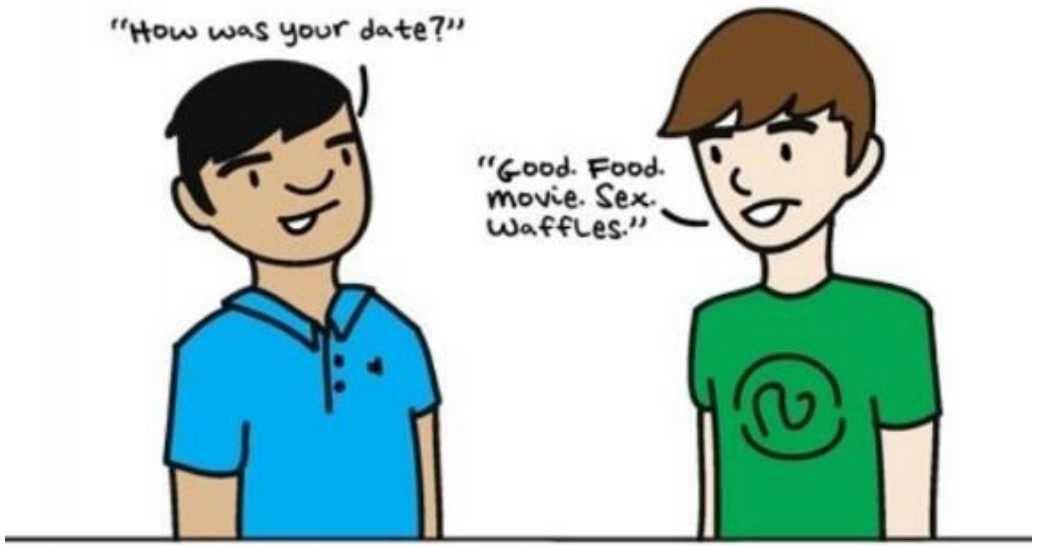
→ **Wernicke's aphasia** (receptive aphasia)

1848-1905

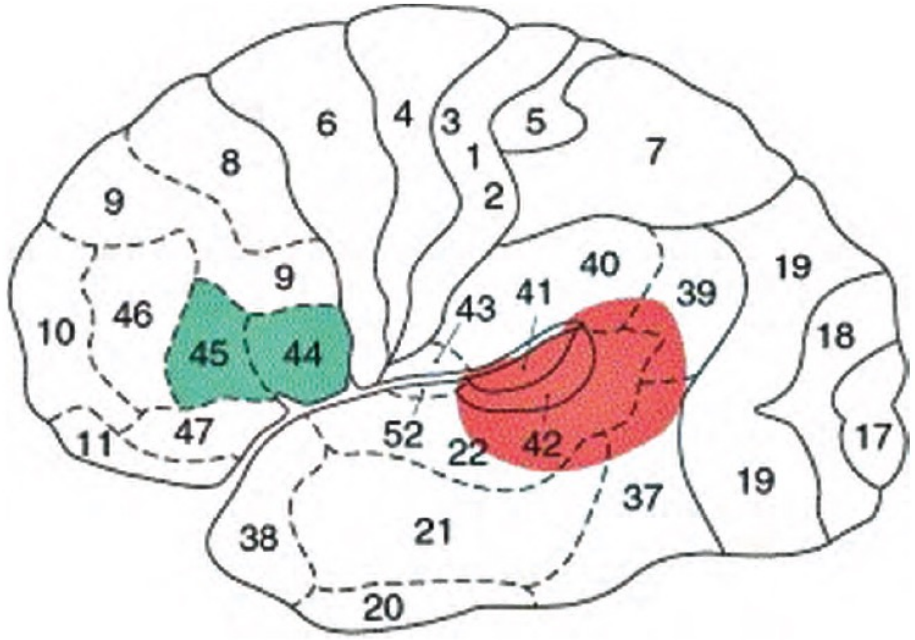


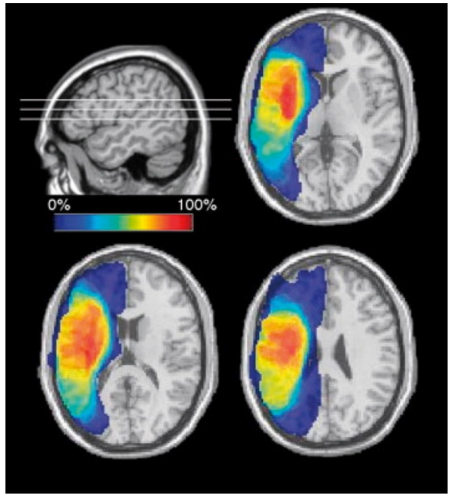
Wernicke’s aphasia

TactusTherapy

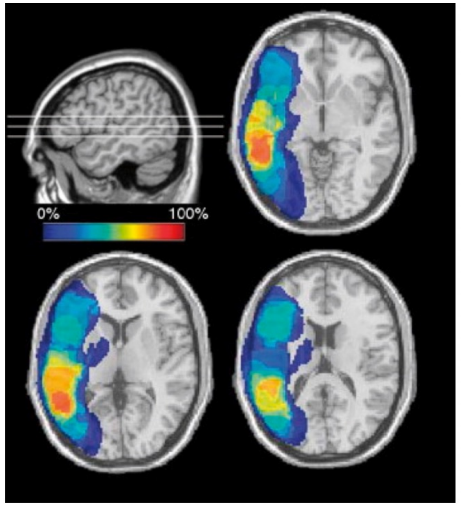


Traditional language regions





Broca's: insula

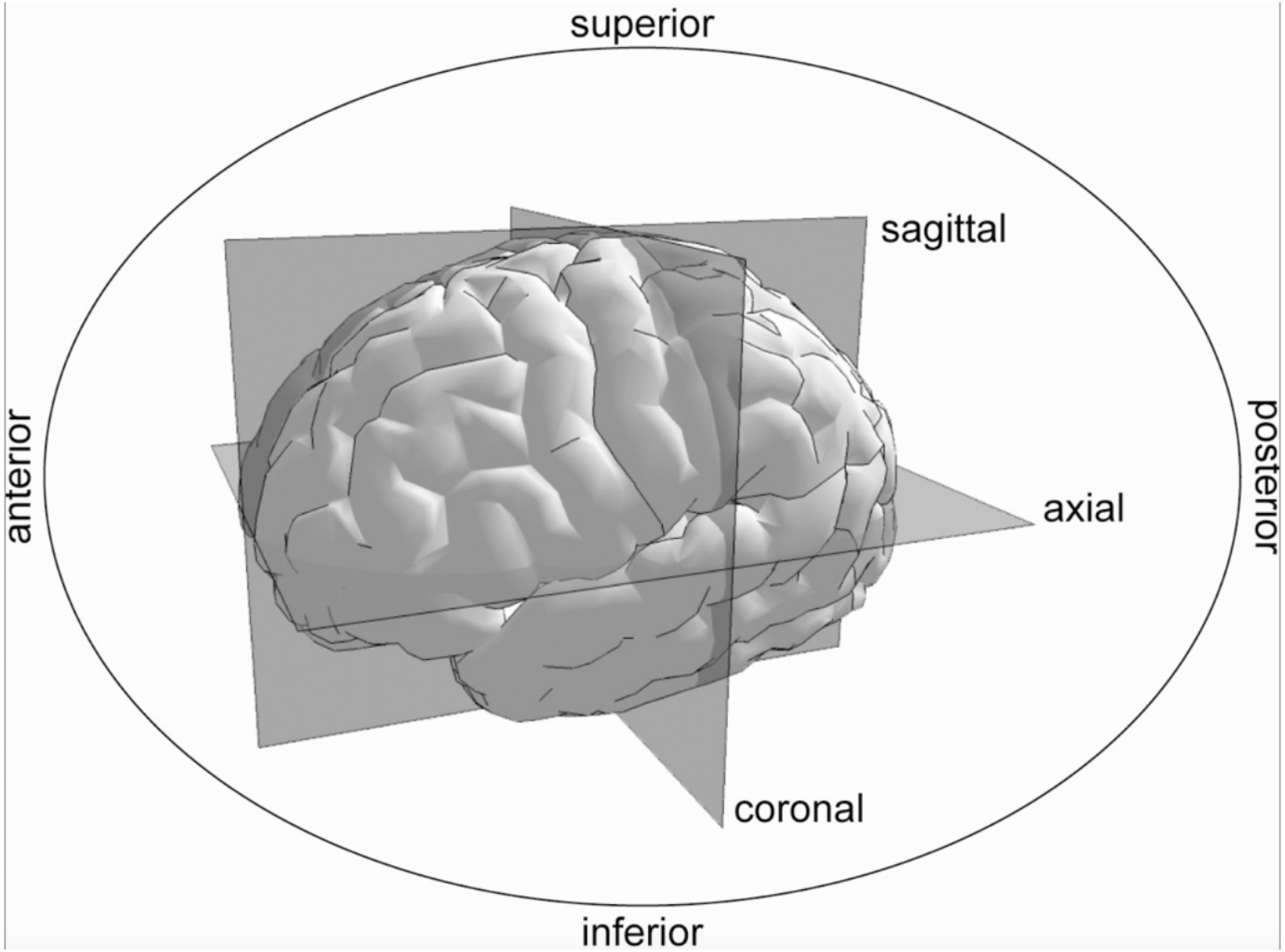


Wernicke's: MTG

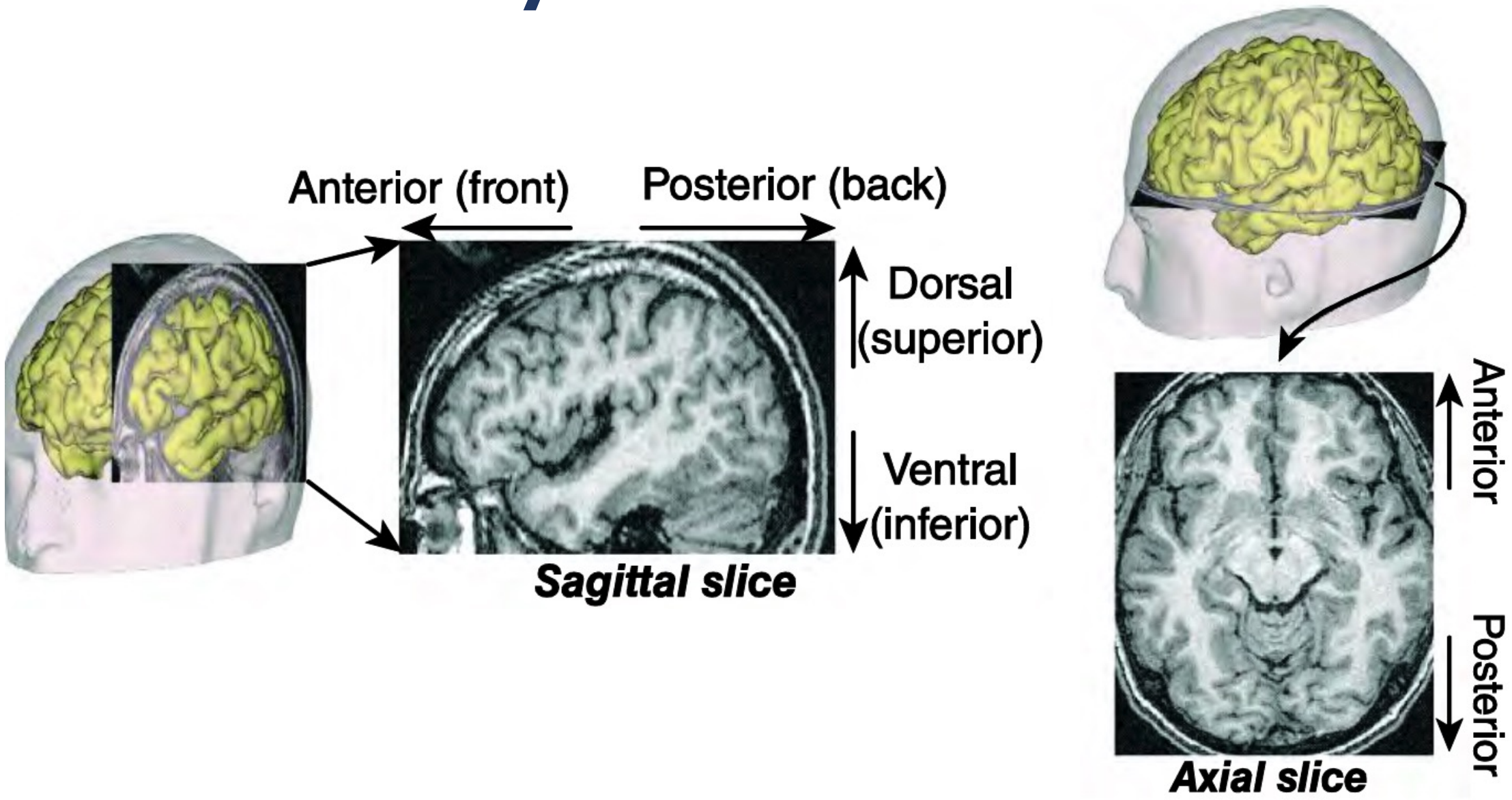
Broca's area (speech production) = posterior two-thirds of the inferior frontal gyrus (BAs 44 and 45).

Wernicke's area (speech perception) = posterior third of the superior temporal gyrus
but also some extension into adjacent temporal and parietal regions. BA22, 37,39,40,41,42,.....

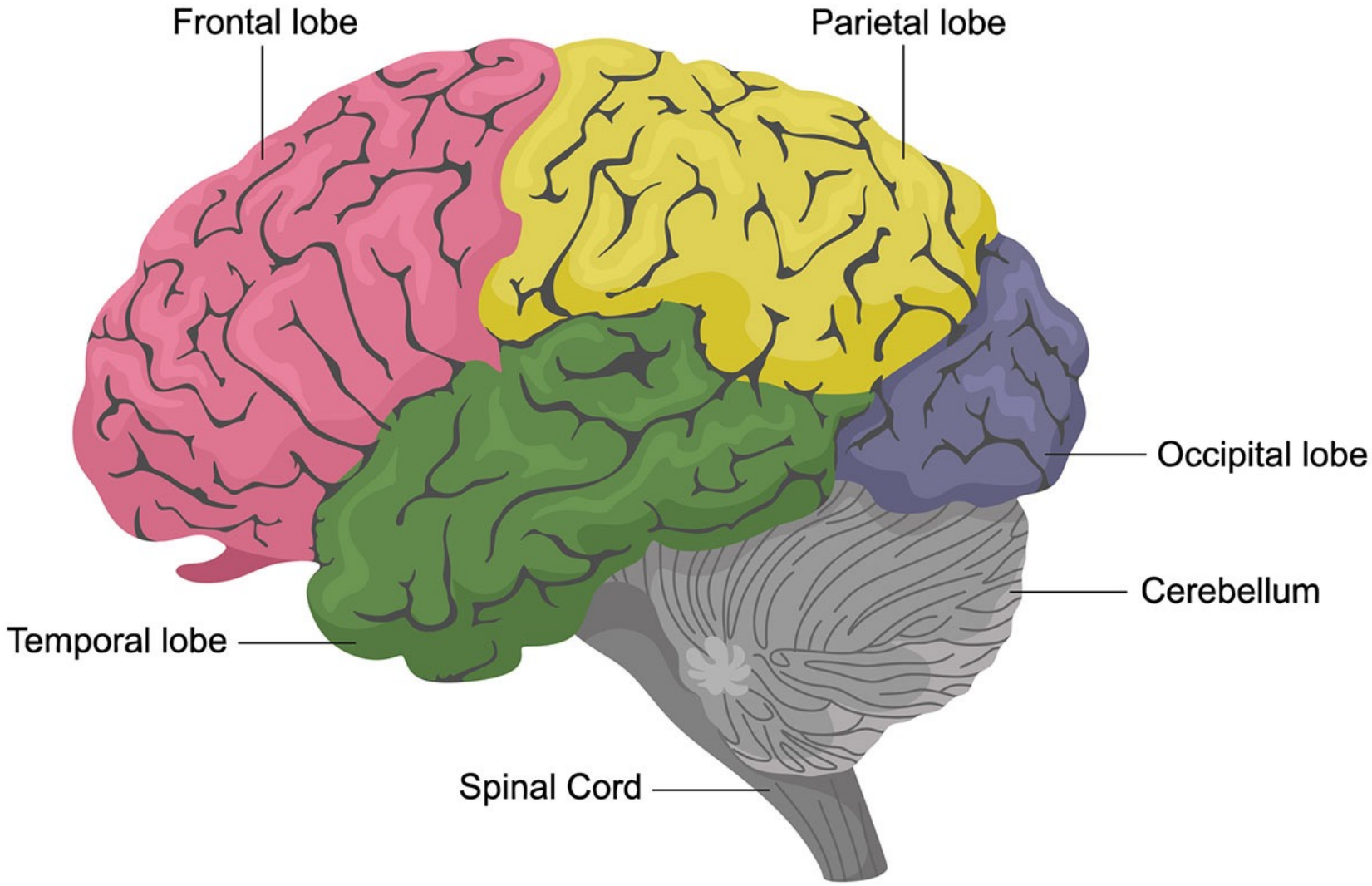
Brain anatomy: sections



Brain anatomy: slices

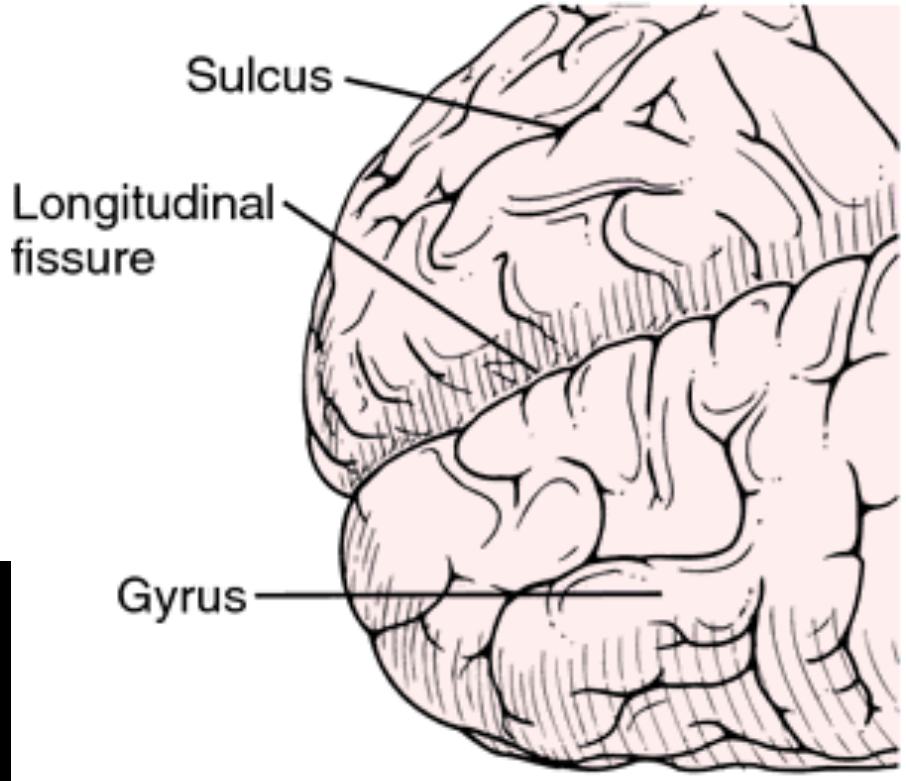


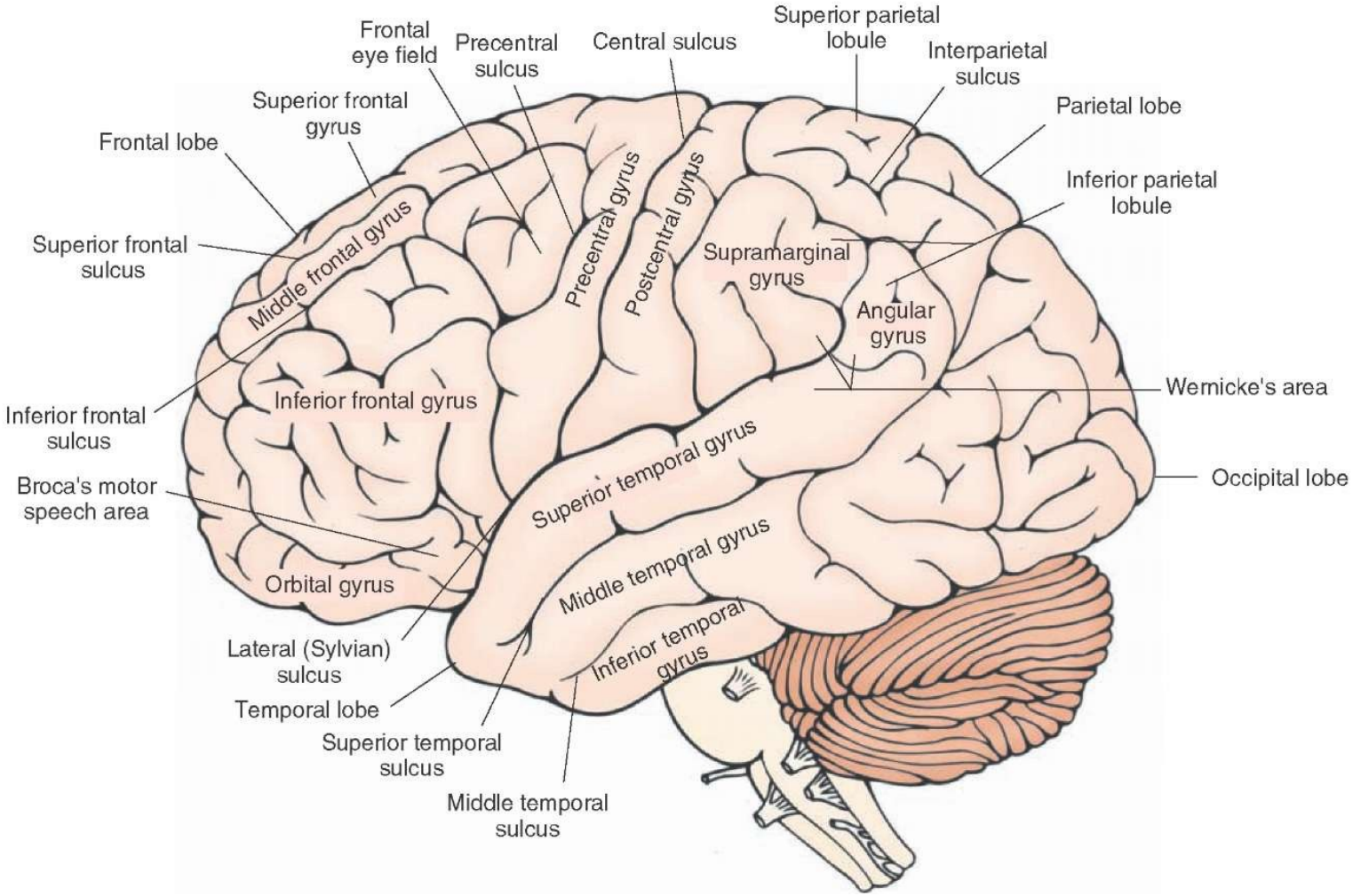
Brain anatomy: lobes



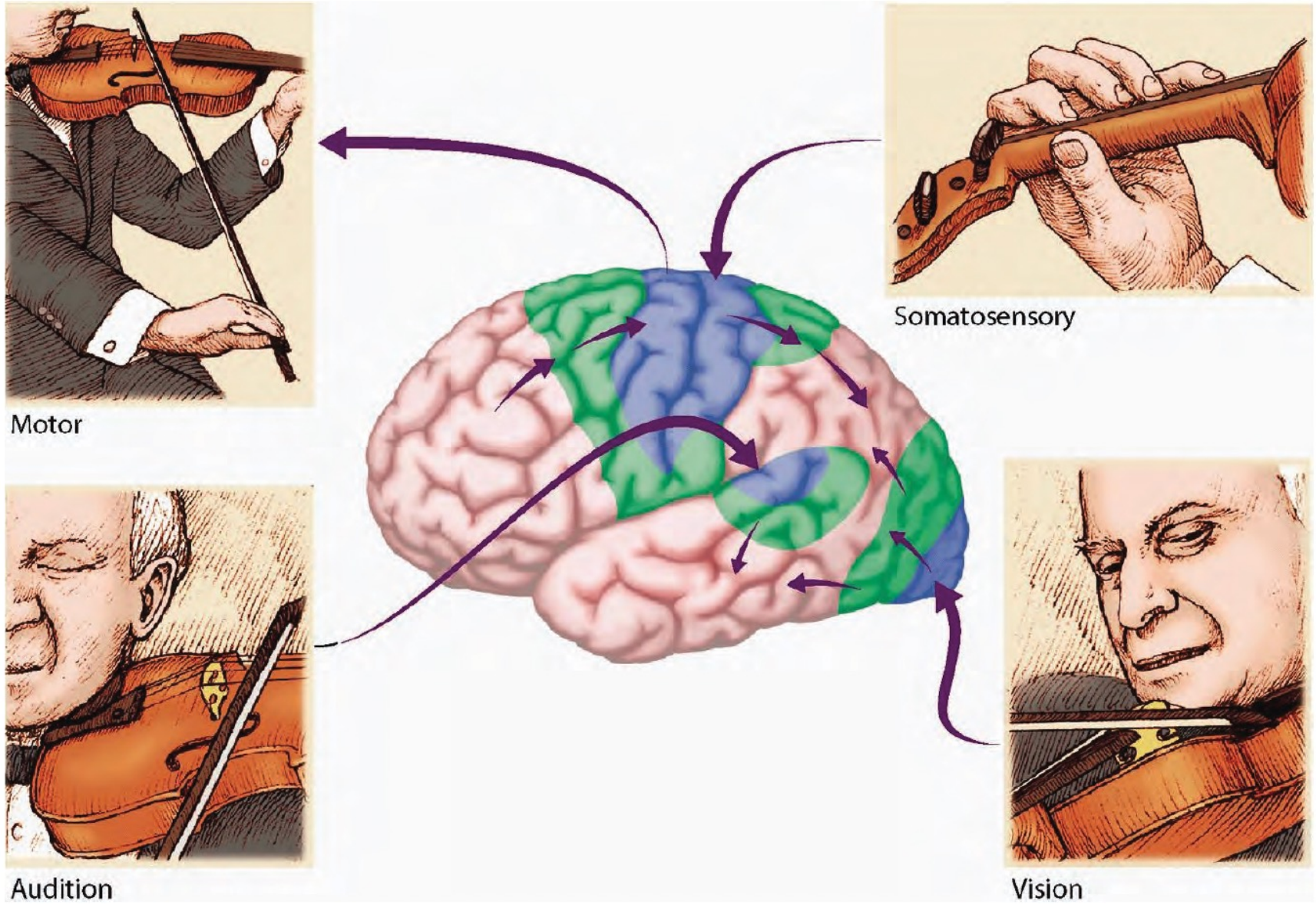
Brain anatomy: gyrus and sulcus

gyri (singular: gyrus):
the folds or bumps in the brain
sulci (singular: sulcus):
the indentations or grooves



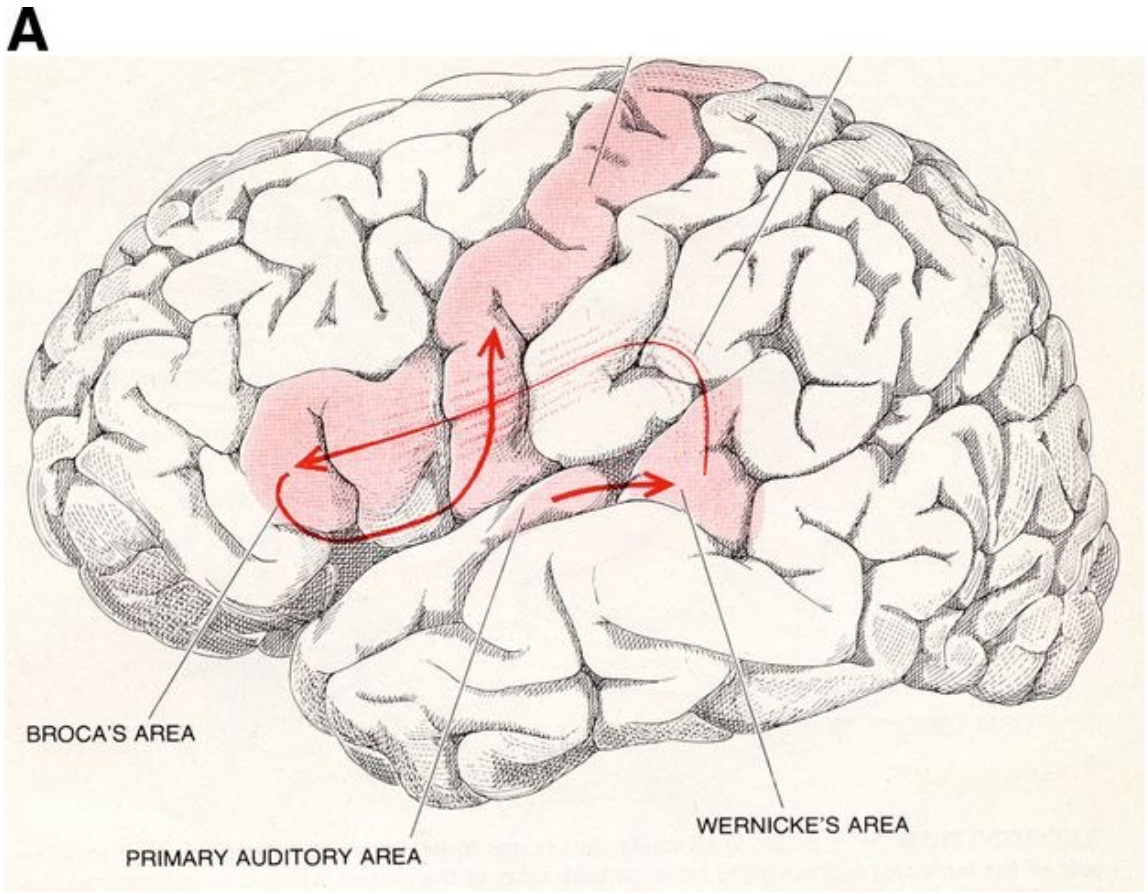


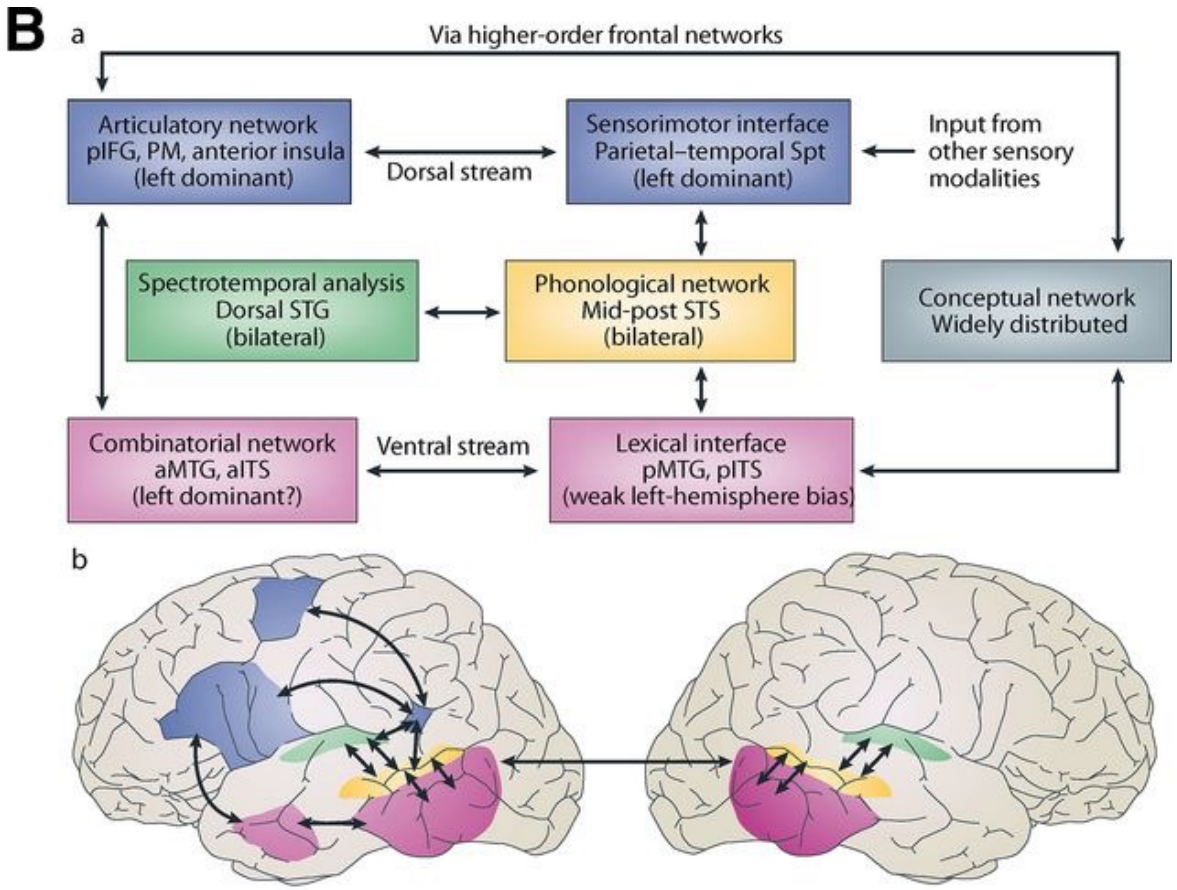
Brain anatomy: functions



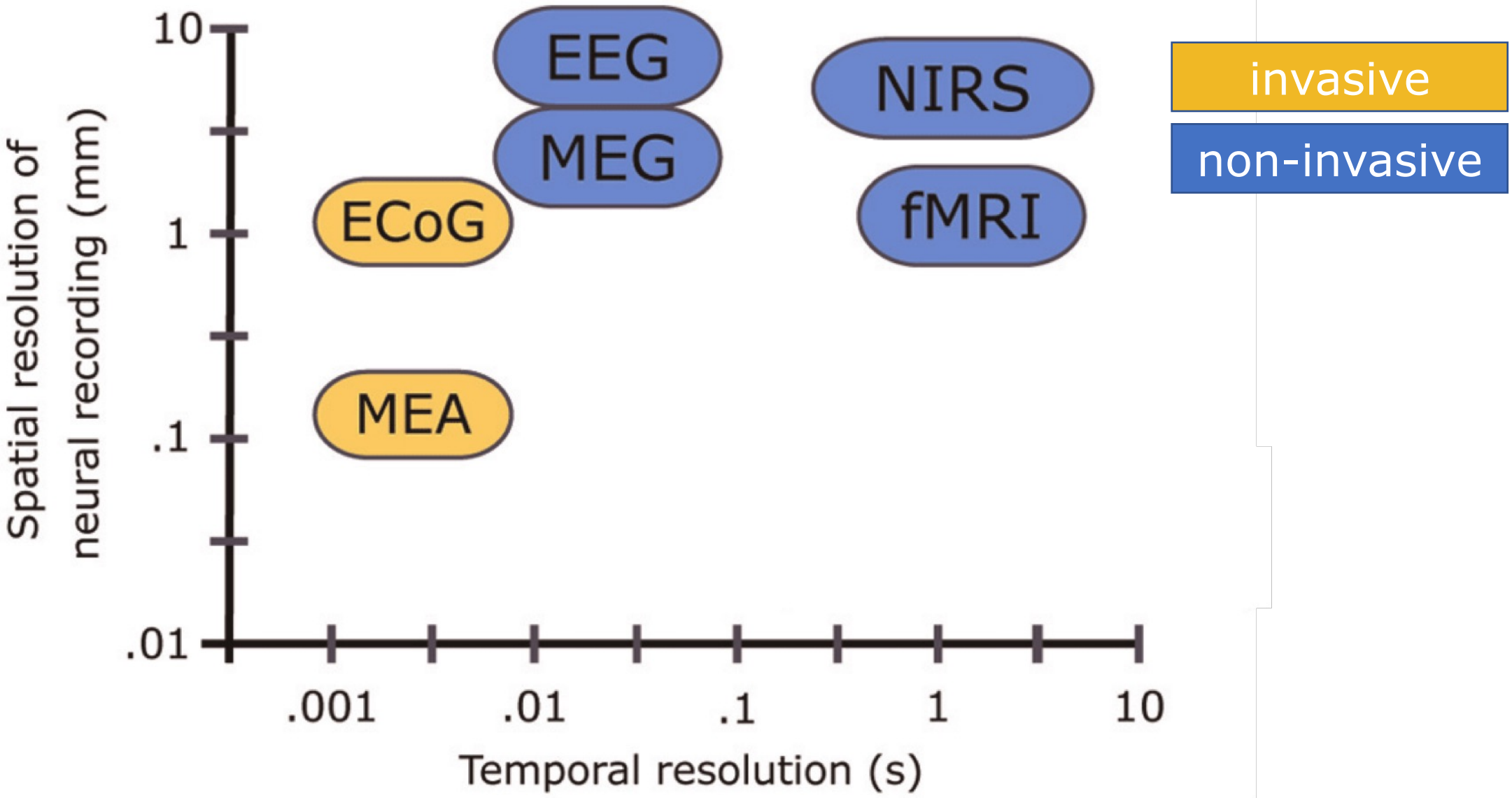
Language regions

Hickok and Poeppel (2007)



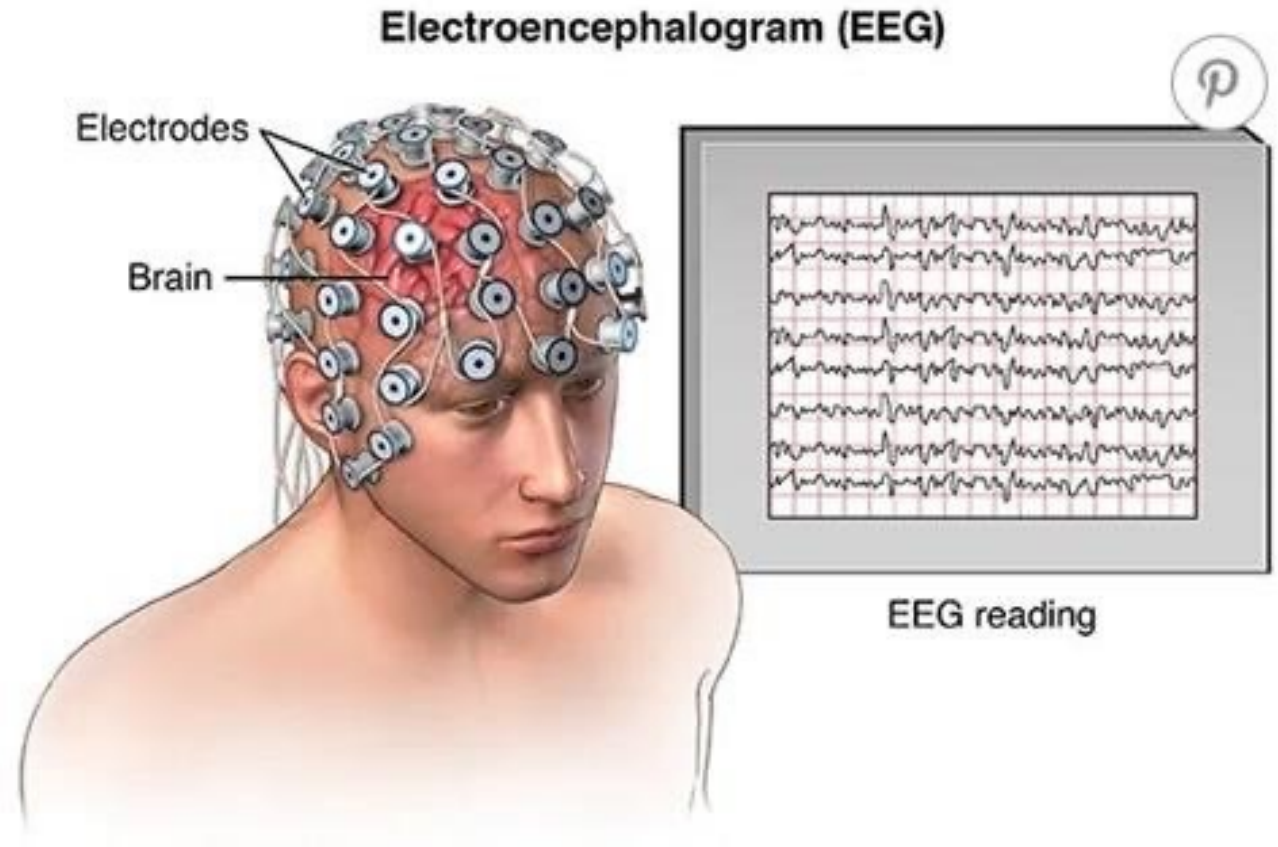


Research methods



Electroencephalogram (EEG)

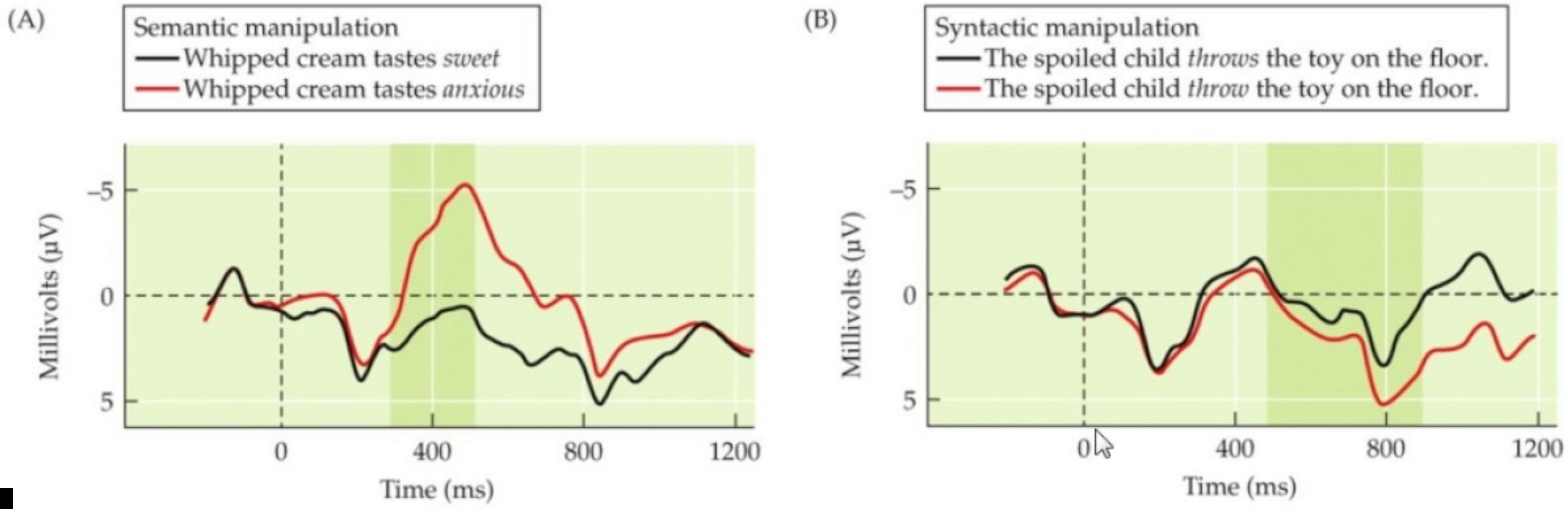
EEG: measures electrical activity in the brain using small, metal discs (electrodes) attached to the scalp.



direct measure
non-invasive
temporal resolution:
high (~1 ms)
spatial resolution:
low (signals distorted by sculp)

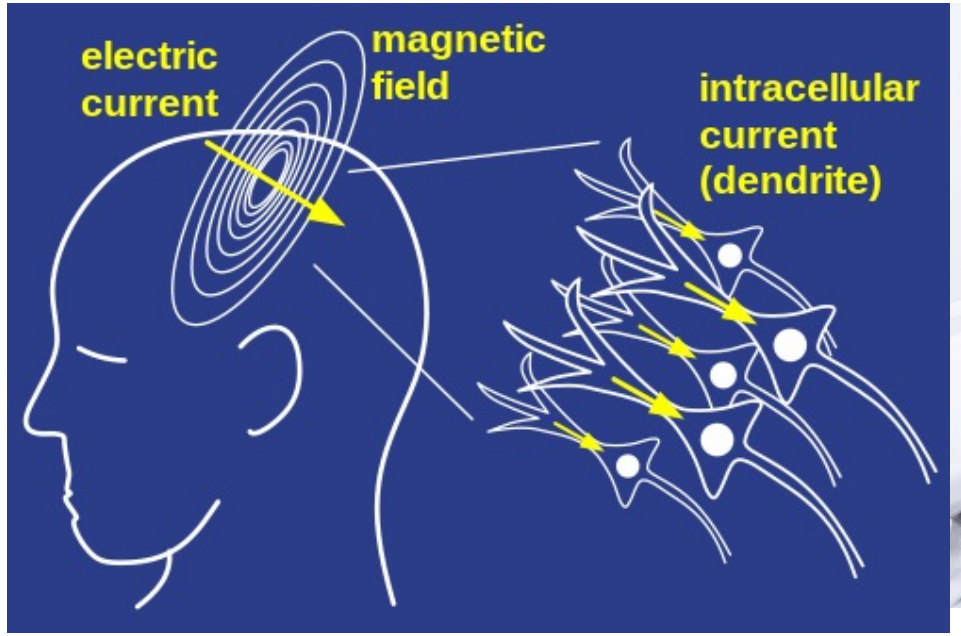
EEG: N400 and P600

Kutas and Hillyard (1980)



Magnetoencephalography (MEG)

MEG: measures magnetic fields produced by electrical currents occurring naturally in the brain, using very sensitive magnetometers.

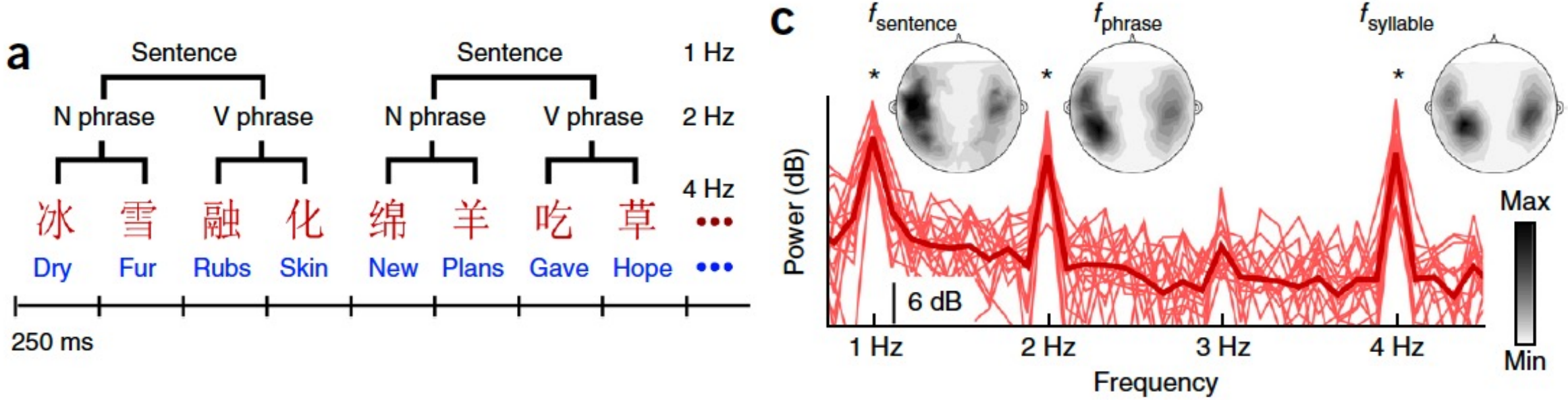


direct measure
non-invasive
temporal resolution: high (~1 ms)
spatial resolution: middle

MEG: Tracking hierarchical structures

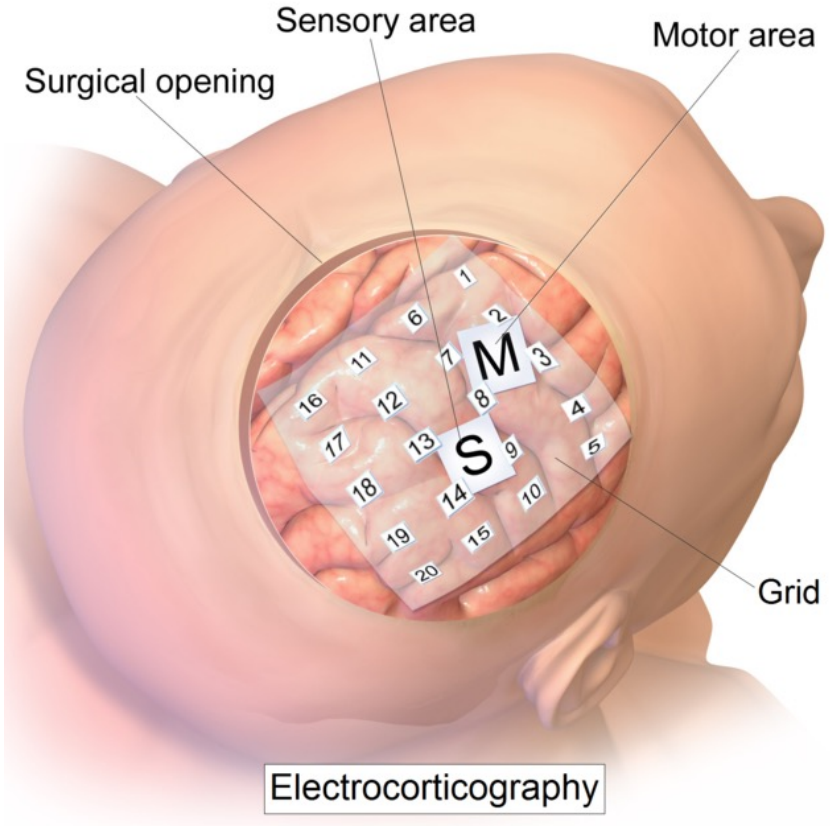
Ding et al., (2015)

Participants listened to 4-syllable Chinese sentences, each syllable is 250 ms long.



Electrocorticography (ECoG)

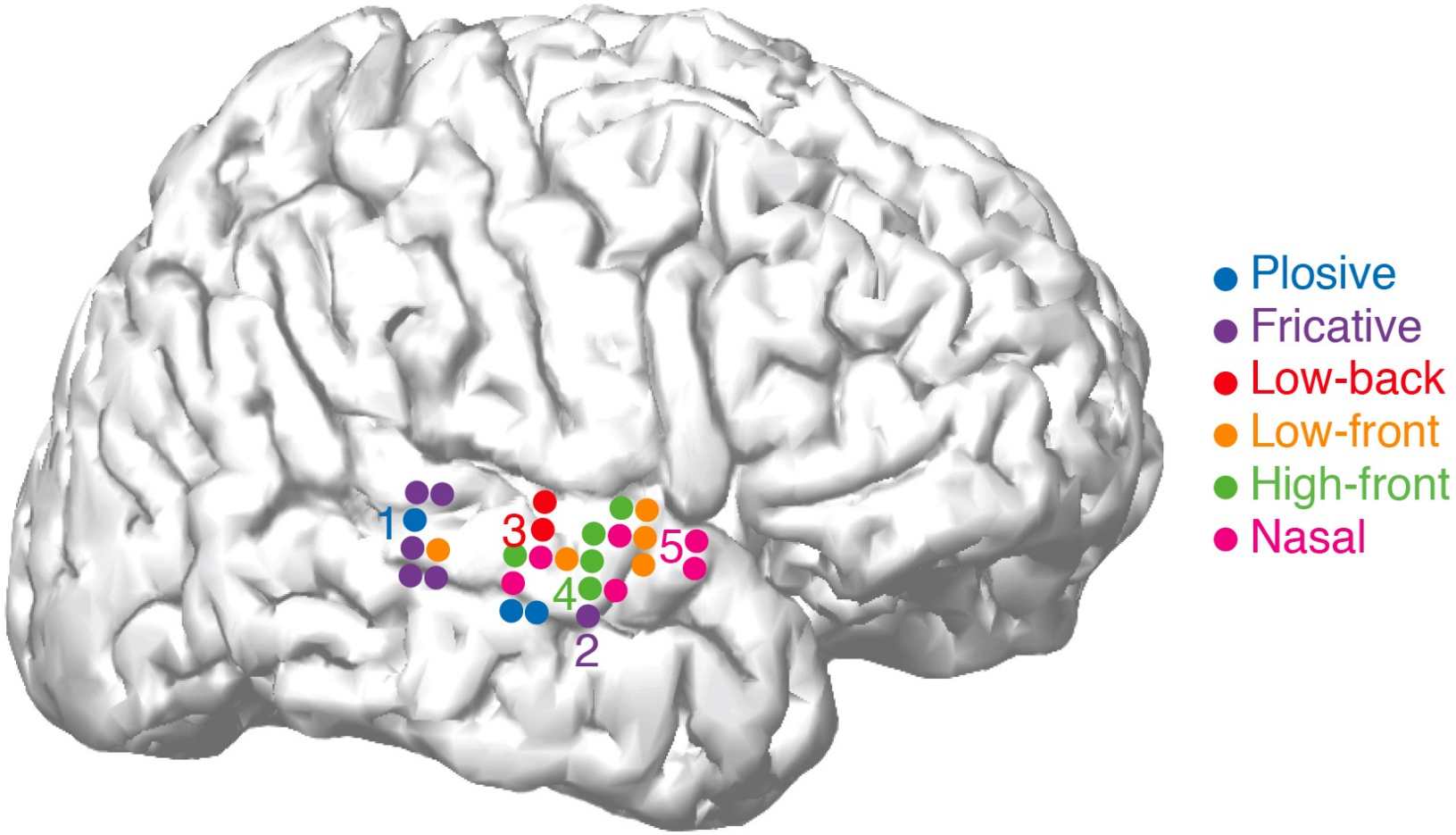
ECoG, intracranial electroencephalography (**iEEG**): measures electrical activity from the cerebral cortex using electrodes placed directly on the exposed surface of the brain.



direct measure
invasive
temporal resolution:
high (~1 ms)
spatial resolution:
high

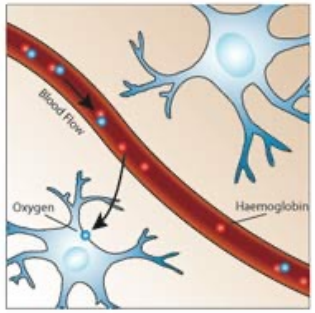
ECoG: Tonotopy

Mesgarani et al (2014)

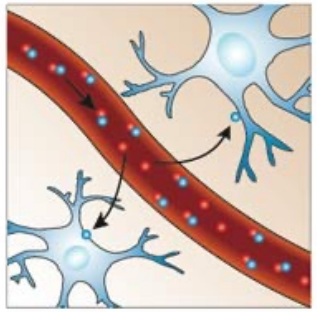


functional Magnetic Resonance Imaging (fMRI)

fMRI: measures brain activity by detecting changes associated with blood flow. Neural activities consumes oxygen, which is bound to hemoglobin.
→ blood flow increases → MRI signal is higher for oxygenated blood



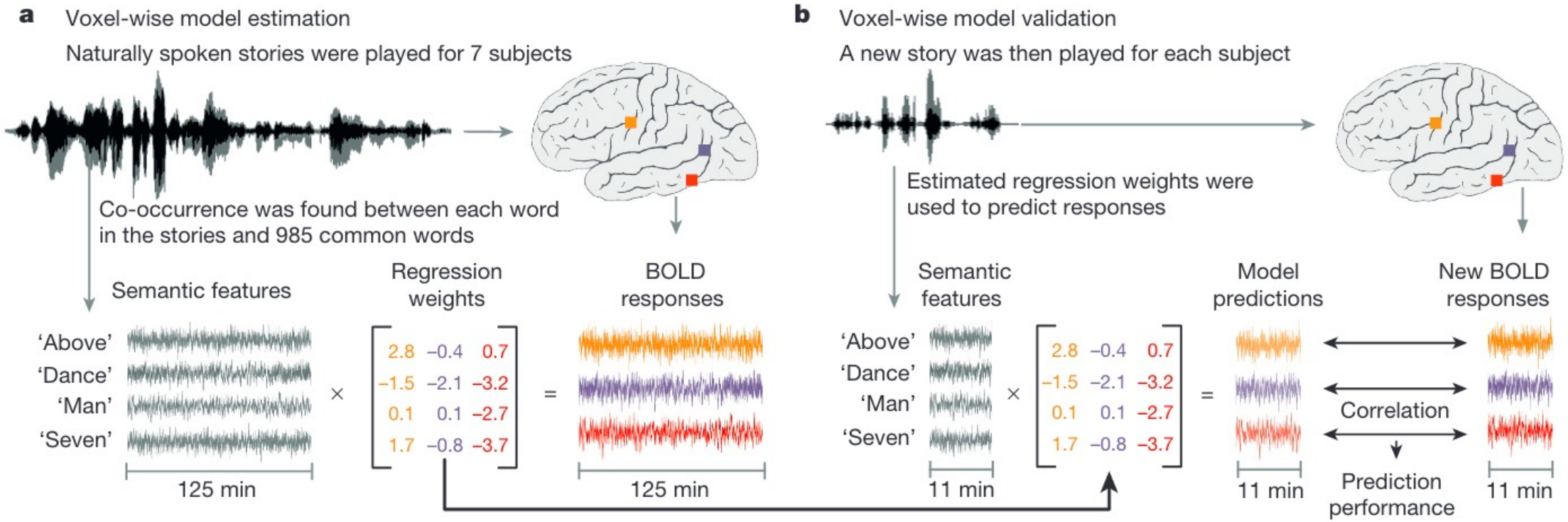
Resting


Activated

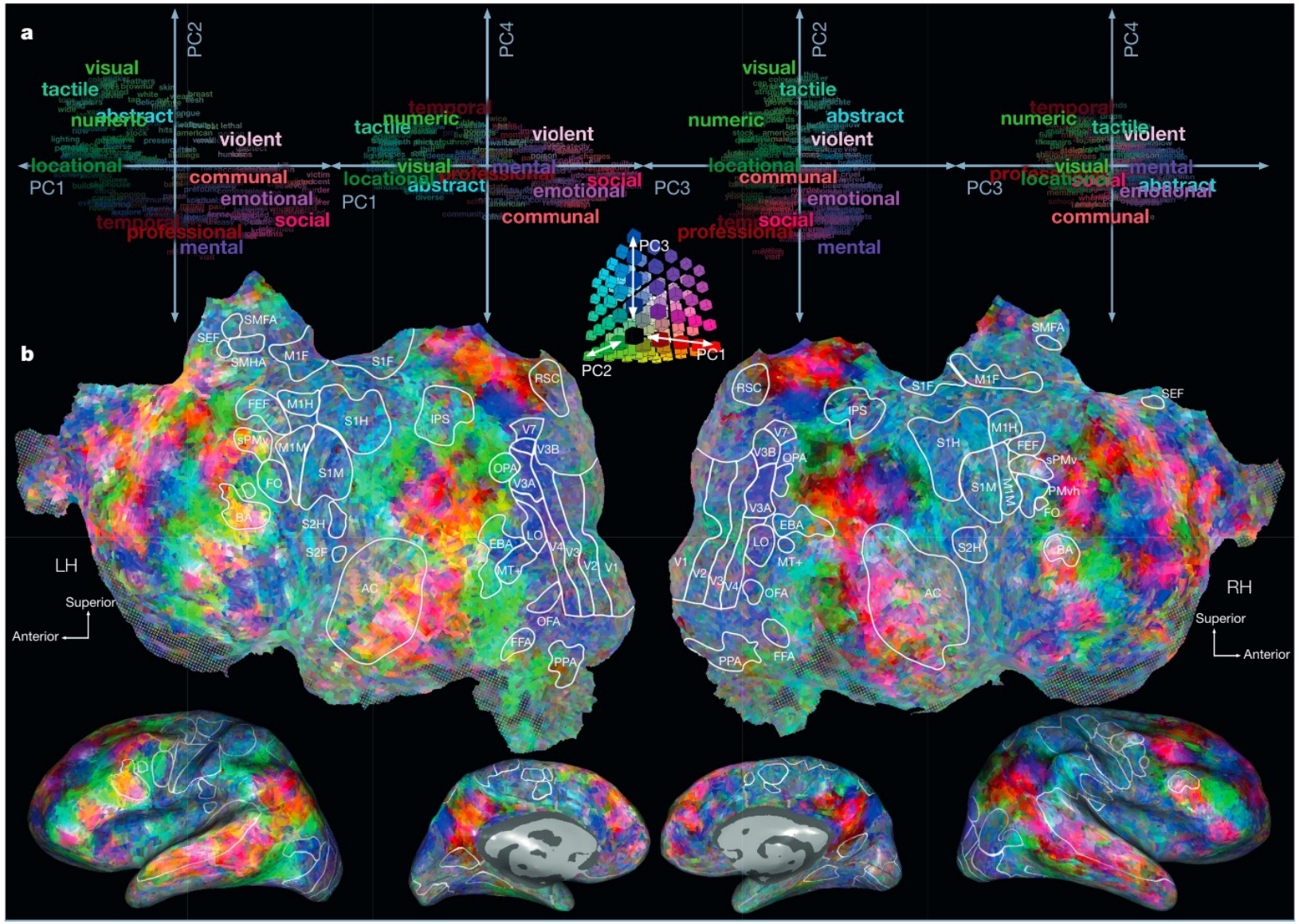
indirect measure
non-invasive
temporal resolution: low (~1 s; blood flow takes time)
spatial resolution: high

fMRI: semantic representation

Huth et al (2016)



fMRI: semantic representation



To do

Do HW9

Read:
This lecture: **File** Ch9; Hickok and Poeppel, 2007
Textbook: Kemmerer 2015 *Cognitive Neuroscience of Language*

Next lecture: **File** Ch16
Textbooks:
Jurafsky and Martin, *Speech and Language Processing*
https://web.stanford.edu/~jurafsky/slp3/
Bird et al. *Natural Language Processing with Python*
https://www.nltk.org/book/