Language acquisition, perception and production

Lecture 1 – Language and brain methods

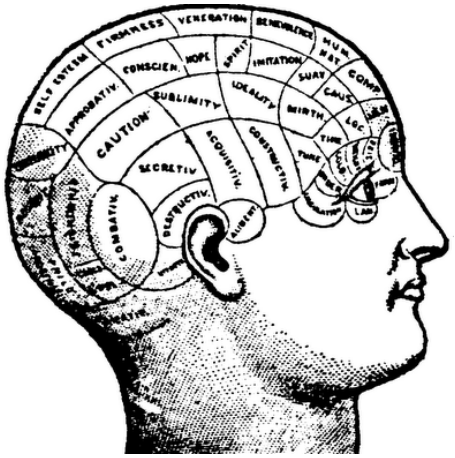
Language and brain

- Neuropsychology
  - Classic model of aphasia
- Hemispheric asymmetries
- Brain imaging

Aphasia

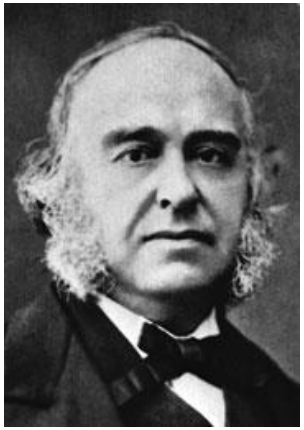
- Gall (Germany, 1758-1828)

- Phrenology
- Brain region to function



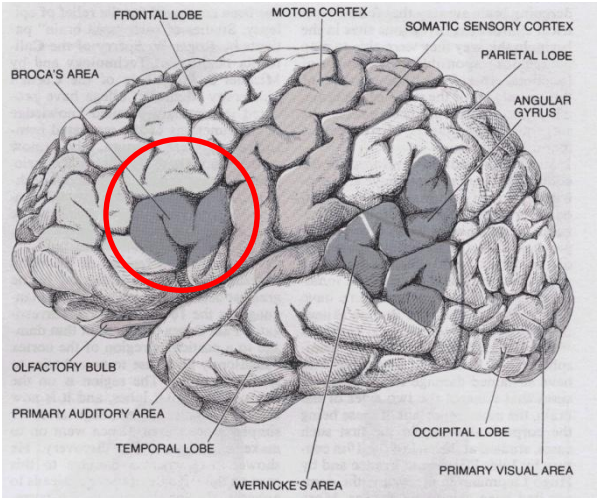
Aphasia

- Paul Broca (France, 1824-1880)
  - Physician
- Patient: Monsieur LeBorgne
  - Loss of speech
  - could only say "tan"
  - Intact comprehension
- Post mortem: damage to frontal lobe



Aphasia

- Broca found 6 more patients
  - Right handed
  - Right hand paralyzed
  - Expressive speech disorder



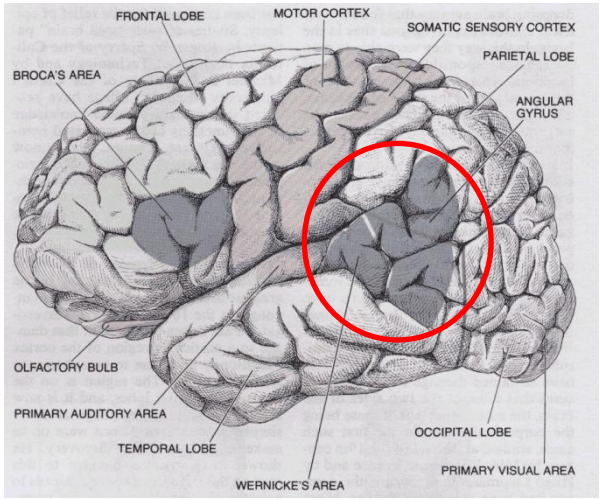
- Damage of *left* frontal lobe
  - This area controls speech production

Aphasia

- Carl Wernicke (Germany, 1848-1905)
  - Physician
- 2 patients
  - Unable to comprehend speech
  - Speak fluently, but nonsense
- Post Mortem: Damage to *left* temporal lobe

Aphasia

- Wernicke
- Post Mortem: Damage to superior temporal gyrus



Aphasia

- Aphasia = refers to a disorder of language apparent in speech, in writing (**agraphia**) or in reading (**alexia**) produced by injury to brain areas specialized for these functions.

- Other cognitive functions largely intact!

Aphasia

- Video of Broca's aphasia

Broca's aphasia

- Broca's aphasia = motor or non-fluent aphasia
  - Laborious speech
  - Good comprehension
  - Anomia = word finding problems
  - Speech contains content words, not function words
  - Difficult inflecting verbs
  - Agrammatism
  - Paraphasias = producing unintended sounds or words (purnpike for turnpike)

Broca's aphasia

- How good is comprehension?
  - "Does a stone float on water?"
  - "The lion is killed by the tiger. Which animal is dead?"

Caramazza & Zurif (1976)

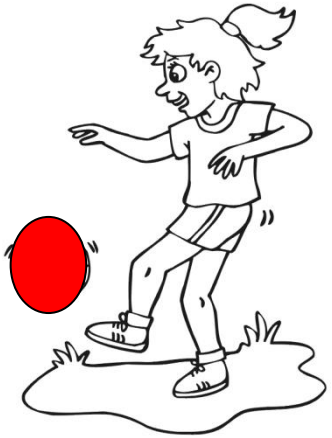
Broca's aphasia

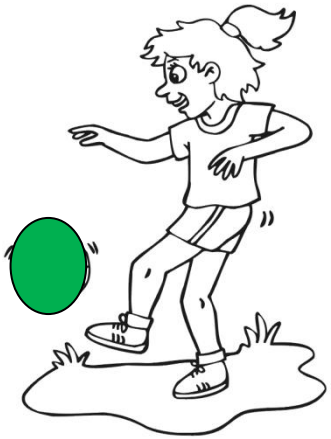
- Sentence comprehension in Broca's
  - Irreversible and reversible sentences
- Irreversible
  - "the ball that the girl is kicking is red"
- Reversible
  - "the cat that the dog is chasing is black"

Broca's aphasia

- Sentence – picture matching
  - Irreversible

"the ball that the girl is kicking is red"

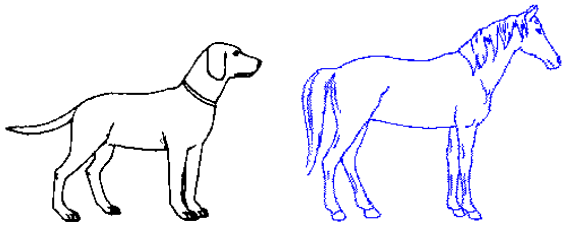


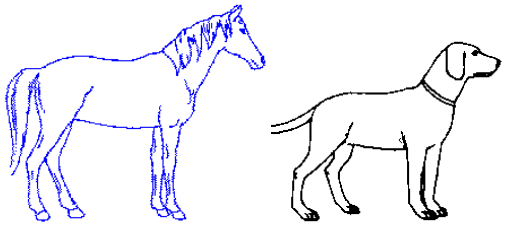


Broca's aphasia

- Sentence – picture matching
  - Reversible

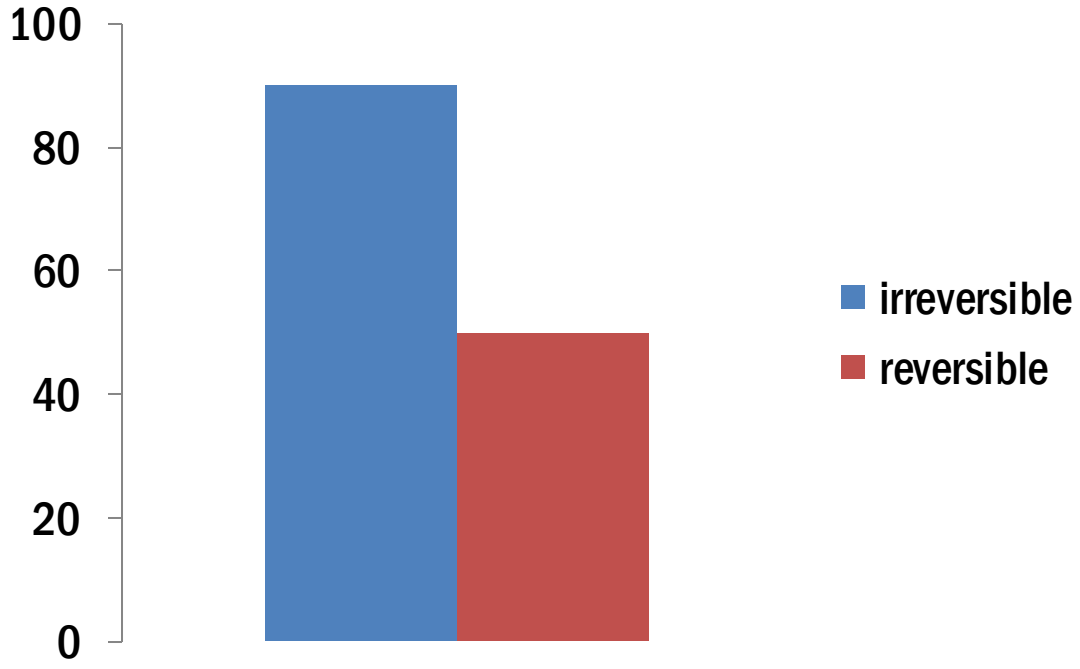
"The horse that the dog is chasing is blue"





Broca's aphasia

- Sentence – picture matching



Broca's aphasia

- Caramazza & Zurif's conclusions:
  - Broca's aphasics have problems with comprehension
  - Function of Broca's area is not just production
  - Broca's area is involved in grammatical processing

Wernicke's aphasia

- Video of Wernicke's aphasia

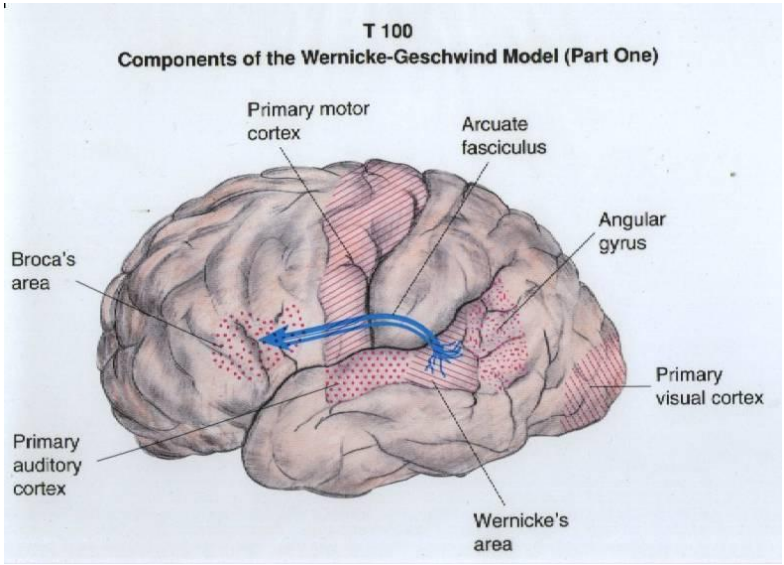
Wernicke's aphasia

- Wernicke's aphasia
  - Fluent speech
  - Poor comprehension (although hard to assess)

- Function of Wernicke's area is that it is involved in relating sounds of words to meaning

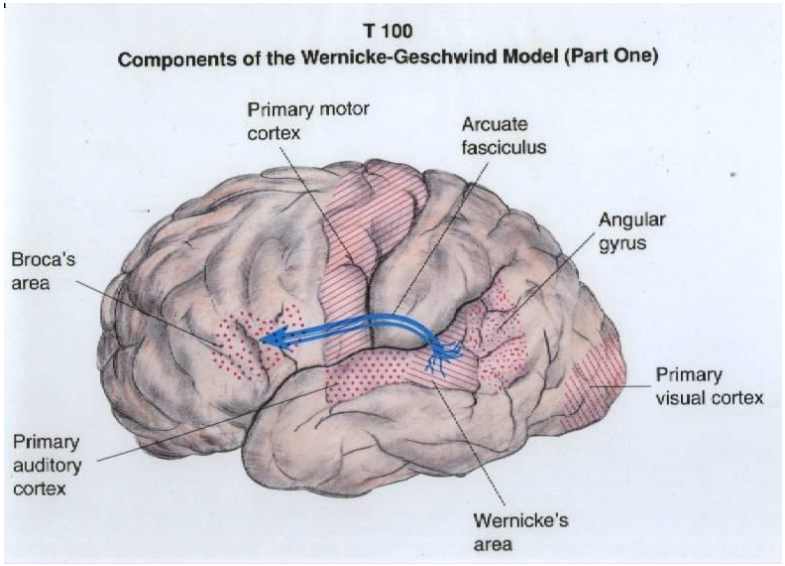
Wernicke-Geschwind Model

- Classic model of language (~1950s)
  - Components:
    1. Wernicke's area
    2. Broca's area
    3. Arcuate Fasciculus
    4. Angular gyrus



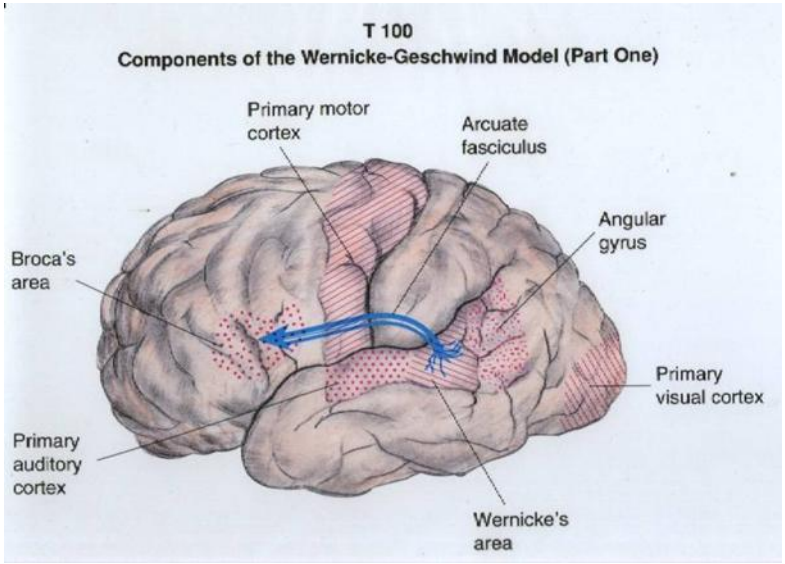
Wernicke-Geschwind model

- Model provides explanation of basic aphasia's
- Model also makes predictions
  - What if damage to Arcuate Fasciculus?



Wernicke-Geschwind model

- Task – repetition of spoken words



– Wernicke's → Arcuate fasciculus → Broca's

Wernicke-Geschwind model

- Conduction aphasia
  - Intact comprehension
  - Intact production

  - Cannot repeat spoken words
  - Read sentences with many errors despite good comprehension

Wernicke-Geschwind model

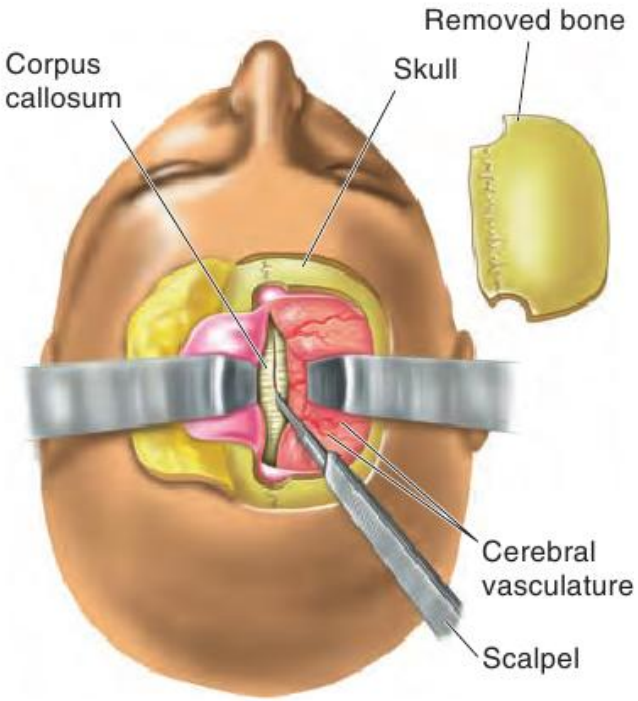
- Some problems with this model
  - Makes some incorrect predictions: repeating written words should not be possible if damage to arcuate fasciculus
    - Visual areas directly project to Broca's
  - Aphasia can also result from damage to other areas than those listed in model
    - Subcortical damage (thalamus, caudate nucleus)
  - There is often recovery after stroke, meaning that other areas can take over function. There is nothing special about each area.
  - The dissociations are never so clear cut as proposed by model. Pure production deficit does not exist

Hemispheric asymmetries

- Which side of the brain controls language?
  - Neuropsychology (Broca / Wernicke) = Left side
  - Language is left lateralized:
    - 96% of right handers
    - 70% of left handers
  - Wada test

Hemispheric asymmetries

- Split-brain studies
  - Cut corpus callosum (200 million axons)
  - No noticable effects in animal studies



Hemispheric asymmetries

- Split-brain studies of Gazzaniga
  - Make sure that only one side of brain "sees" stimuli

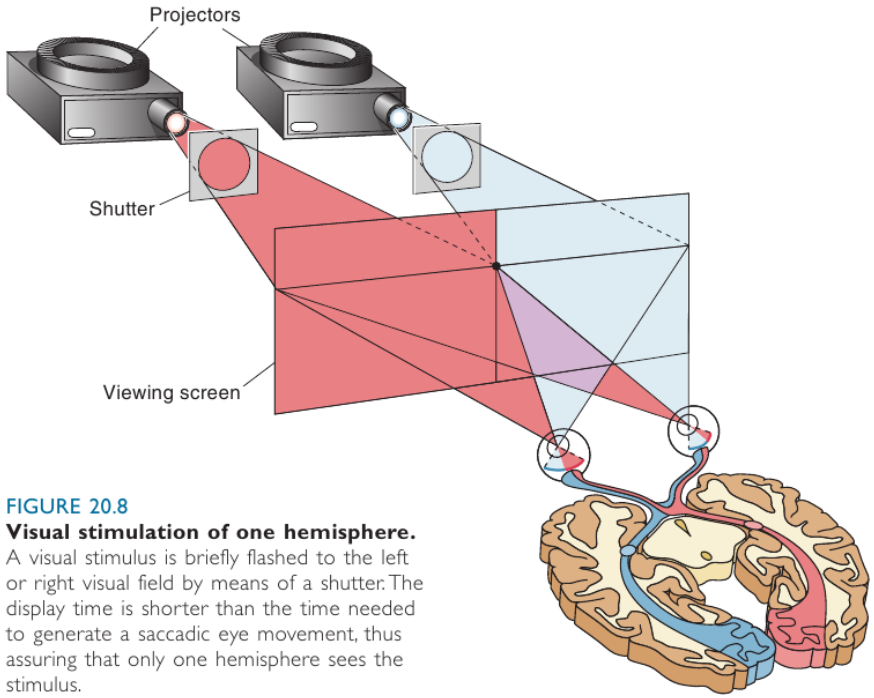
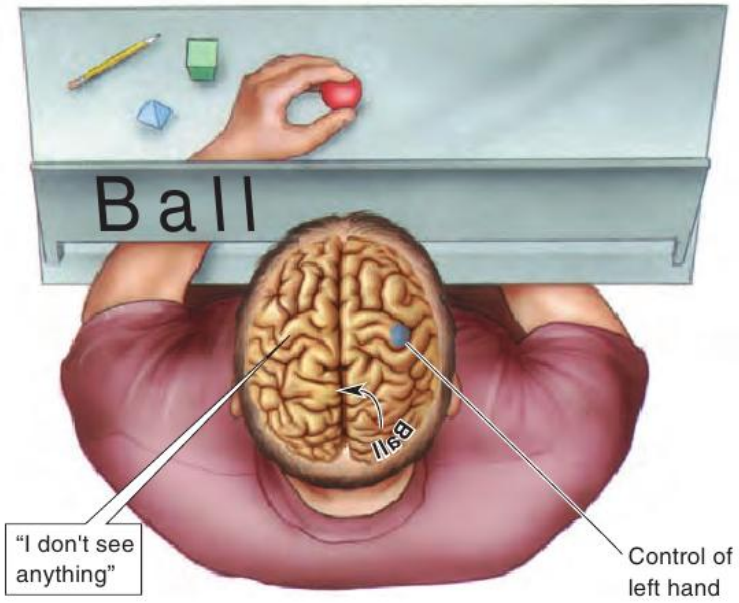


FIGURE 20.8
Visual stimulation of one hemisphere.
A visual stimulus is briefly flashed to the left or right visual field by means of a shutter. The display time is shorter than the time needed to generate a saccadic eye movement, thus assuring that only one hemisphere sees the stimulus.

Hemispheric asymmetries

- Present words or images or objects to left or right side of brain



Hemispheric asymmetries

- Right hemisphere has no language control at all?
  - Show word to right hemisphere (e.g., BALL)
  - Subjects says he sees nothing
  - But, left hand can choose correct object from others!

- Right hemisphere can process short words

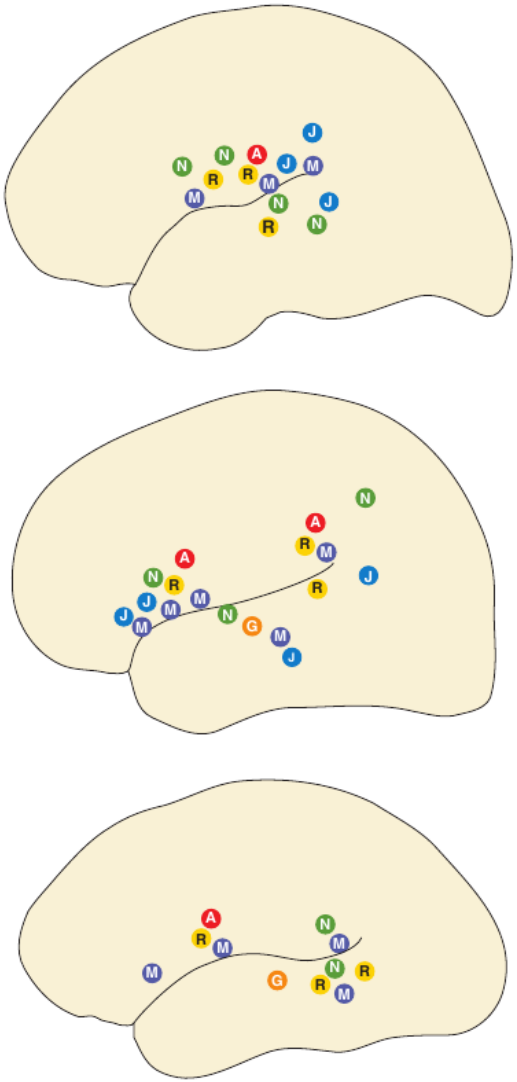
Hemispheric asymmetries

- left hemisphere is more important for language than right hemisphere

- Left hemisphere is language dominant

Brain stimulation

- Wilder Penfield & George Ojemann
  - Found similar areas as in aphasia
  - Also found other areas
  - Found small displacement of electrode had large impact



Brain imaging

- Reveals language processing in intact brain
  - PET / fMRI
    - Infer activity from blood flow

- Have shown that language processing in brain is more complex than Wernicke-Geschwind model

Brain imaging

- Lehericy et al. (2000)
- First WADA to determine dominance then fMRI

A. Word generation from category (e.g., animals)
B. Silently repeat a sentence
C. Passively listen to a story

Brain imaging

- For patient with left hemisphere dominance:

  A. Word generation from category
  B. Silently repeat a sentence
  C. Passively listen to a story

- Strong bilateral activity!

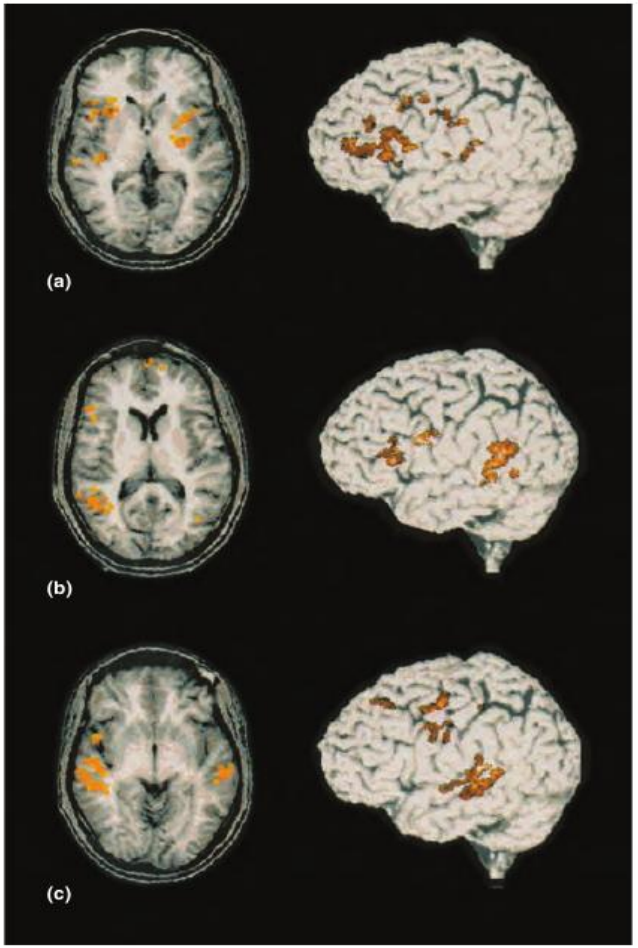


FIGURE 20.14
Bilateral brain activation from fMRI. Based on a Wada procedure, this subject had a strongly dominant left hemisphere for language. Images from fMRI show significant bilateral activation of language areas on **(a)** a word generation task, **(b)** silent sentence repetition, and **(c)** passive listening. (Source: Adapted from Lehericy et al., 2000, Fig. 1.)

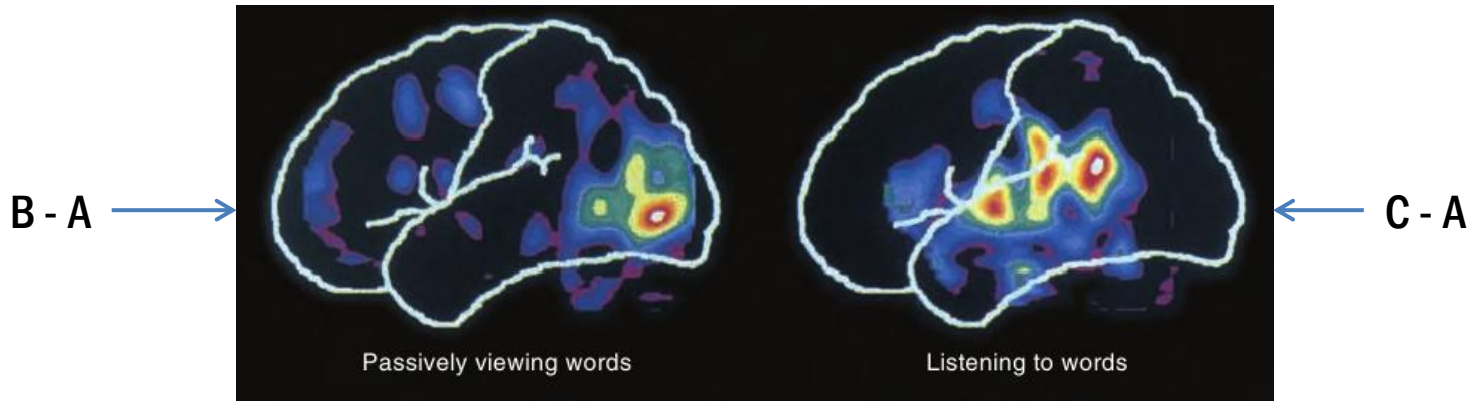
Brain imaging

- Posner & Raichle (1994)
  - Comprehension of speech
  - PET study, measure blood flow while:
  A. Subject at rest
  B. Listen to words being read
  C. Watch written words

- B – A
- C – A

Brain imaging

- Posner & Raichle (1994)



- These areas not activated by visual or auditory stimuli that were not language!

Brain imaging

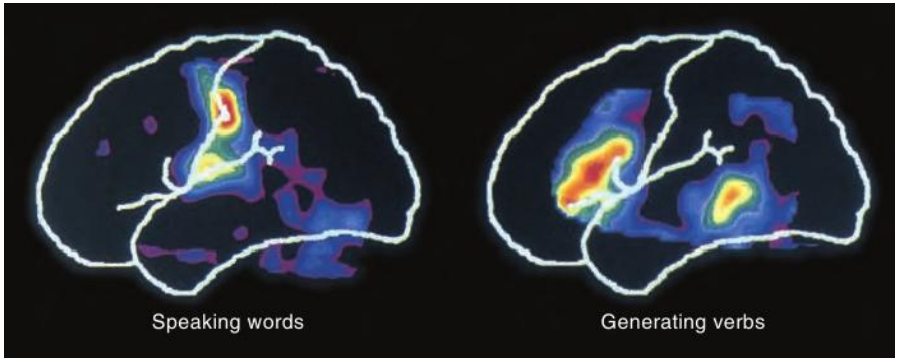
- Posner & Raichle (1994)
  - Production of language

A. Do production
B. Comprehension component

- A – B

Brain imaging

- Posner & Raichle (1994)
  - Production from written words
  - Verb generation (e.g., cake → "eat")



Brain imaging

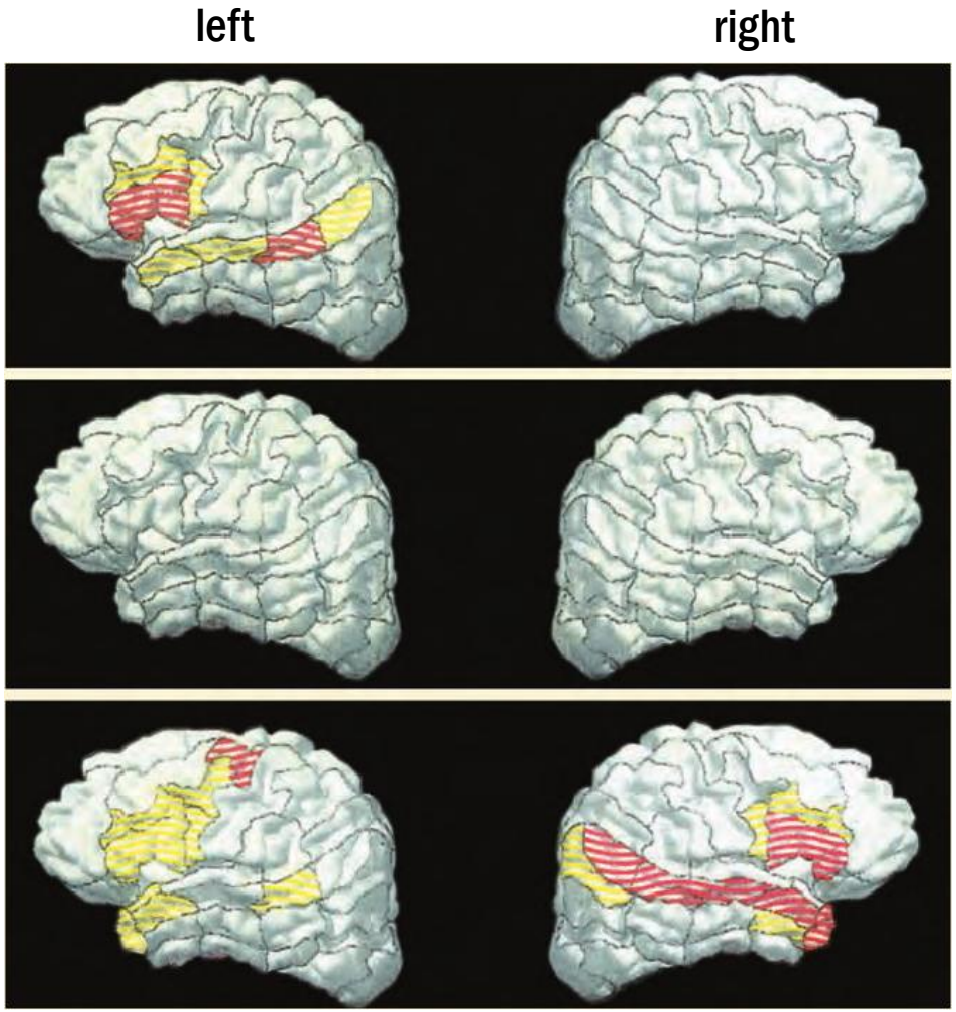
- Language network considerably more complex
  - Involving other areas than Broca / Wernicke
- Bilateral activation

Plasticity

- Plasticity = Cerebral functions are not fixed

- Brain of deaf persons seeing sign language
  - What happens to language areas (Neville et al., 1998)

Plasticity



Normal English speaker reading sentences

Normal English speaker seeing sign language

Normal deaf person seeing sign language

Summary

- Classical model of aphasia
- Hemispheric asymmetry
- Brain imaging studies