Brain and Language

Based on: Chapter 2 of the Fromkin textbook

Main themes

- Knowledge of language

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- Knowledge of language
- Brain structure and functions

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- Lateralization and Contralateralization

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- Language and brain development
- Language evolution

What is knowledge of language?

- Sounds

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- Words

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- Grammar

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- Meaning

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Analyze this ...

- *A red-headed man lives* **near** *my house*

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- *A red-headed man lives* **near** *my house*
- Does the man live outside my house or inside it?

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- *A red-headed man lives* **near** *my house*
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- *I painted my house brown*

Analyze this ...

- *A red-headed man lives* **near** *my house*
- Does the man live outside my house or inside it?
- *I painted my house brown*
- Which surface of my house did I paint: Interior or Exterior?

Effect of Context

Linguistic Context: The obituary of a dentist:

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Neurolinguistics: The study of the biological and neural foundations of language

Structure of the brain

- 100 billion nerve cells (neurons) and billions of fibers connecting them
- Brain surface (cortex) or “gray matter”

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- 100 billion nerve cells (neurons) and billions of fibers connecting them
- Brain surface (cortex) or "gray matter"
- Cortex is decision-maker; Grammar said to be in "gray matter"!
- 2 hemispheres (left and right); 4 lobes (frontal, temporal, parietal, occipital)
- **Corpus callosum** connects the hemispheres

Brain sections

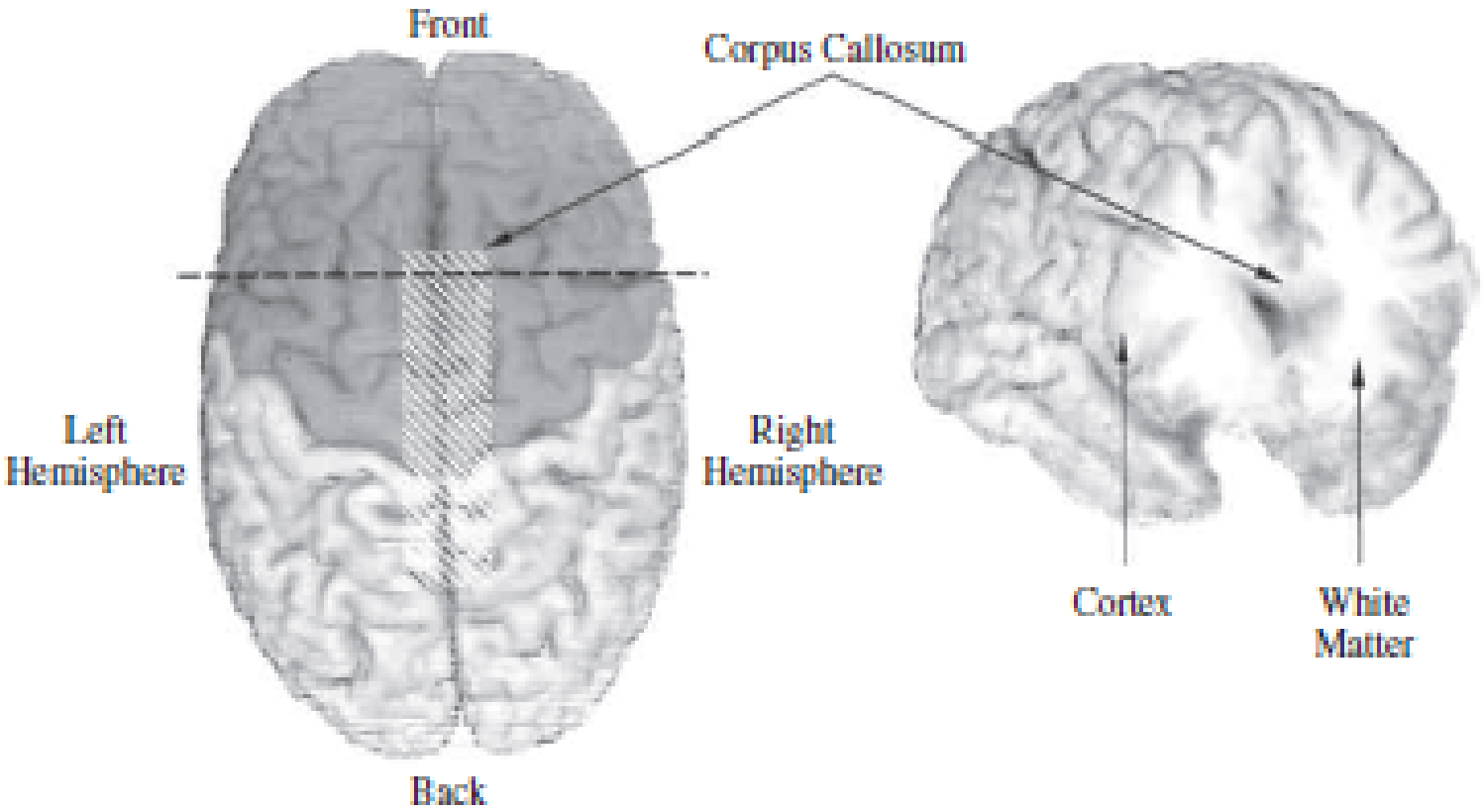

Figure: Left: View from top; Right: View from front

Lateralized brain function

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- This is merely a **tendency** (NOT absolute)

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- True for 95% of right-handers
- 18.8% of left-handers have right dominance for language

Phrenology

Franz Joseph Gall (early 19th century): Theory of localization ("psuedo-scientific"); Examining skull bumps

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Figure: Skull model

Contralateral brain function

- Control: Left hemisphere controls right side of body and vice versa
- Comprehension: Sensations by right side of body received by left hemisphere

Left hemisphere functions

"Hard" aspects of life:

Left hemisphere functions

"Hard" aspects of life:

1. Analytical thought
2. Arithmetic calculations
3. Logic and deductive reasoning
4. Time sequences
5. Lot of language functions

Right hemisphere functions

"Soft" aspects of life (first 3 below):

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2. Creativity (art and music)
3. Relationships

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2. Creativity (art and music)
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4. Pattern matching
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6. Spatial tasks
7. **Right hemisphere also contributes to language**!

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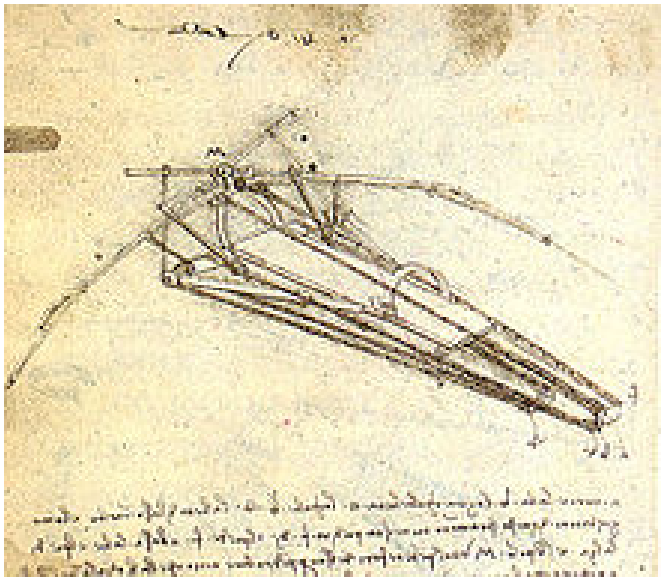

Figure: da Vinci's sketch of a flying device

Evidence for lateralization

1. Brain disorders: Aphasia & Acquired dsylexia
2. Experimental evidence

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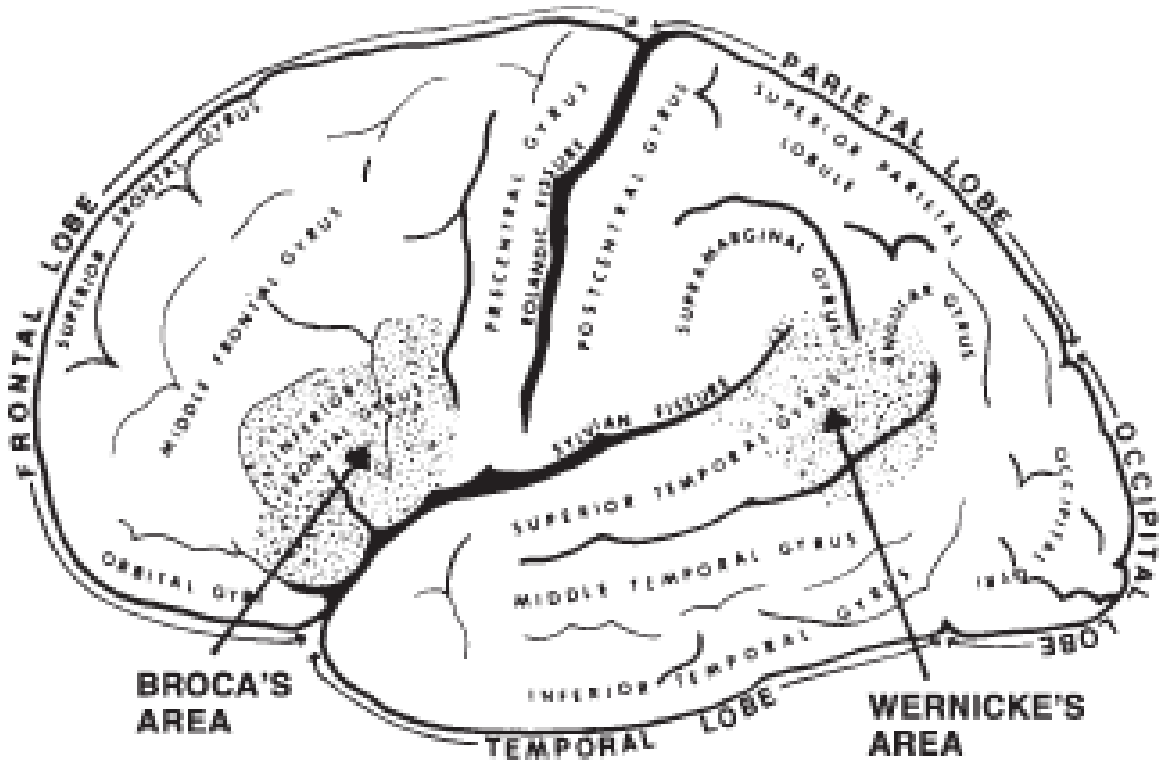
   - Event related potentials (ERP)

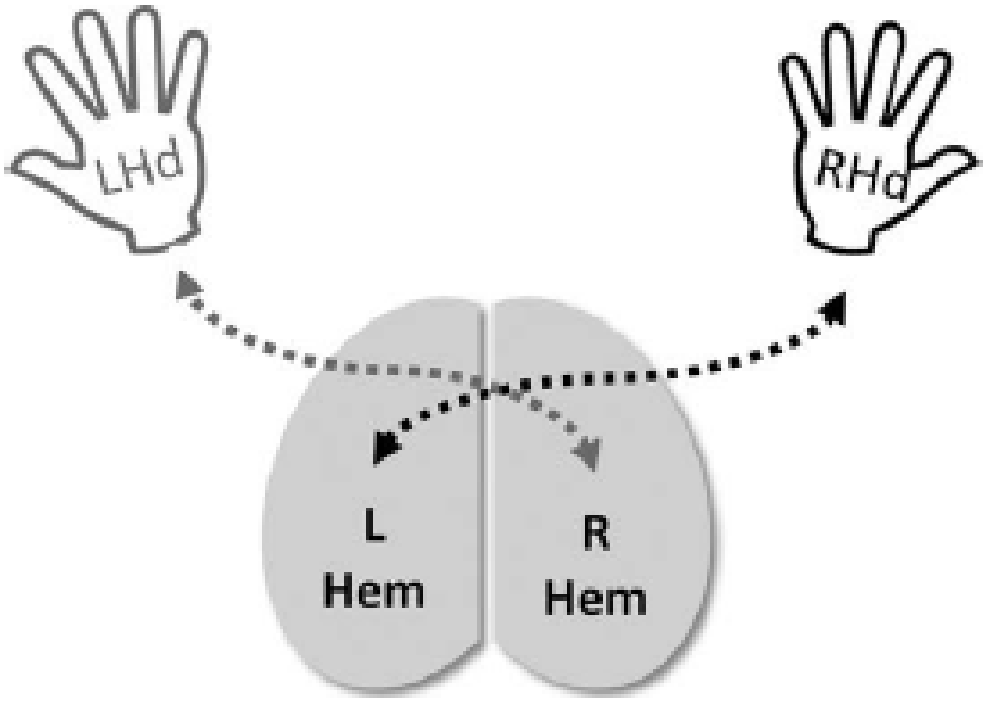
Lateral view of left hemisphere



Evidence for Contralateralization

1. Split-brains
2. Dichotic listening

Contra-Lateral Brain Function



Broca's Aphasia

DOCTOR: *Could you tell me what you have been doing in the hospital?*
PATIENT: *Yes, sure. Me go, er, uh, P.T. none ocot, speech . . . two times . . . read . . . r . . . ripe . . . rike . . . uh write . . . practice . . . get . . . ting . . . better.*

Brain of Broca's Aphasiac

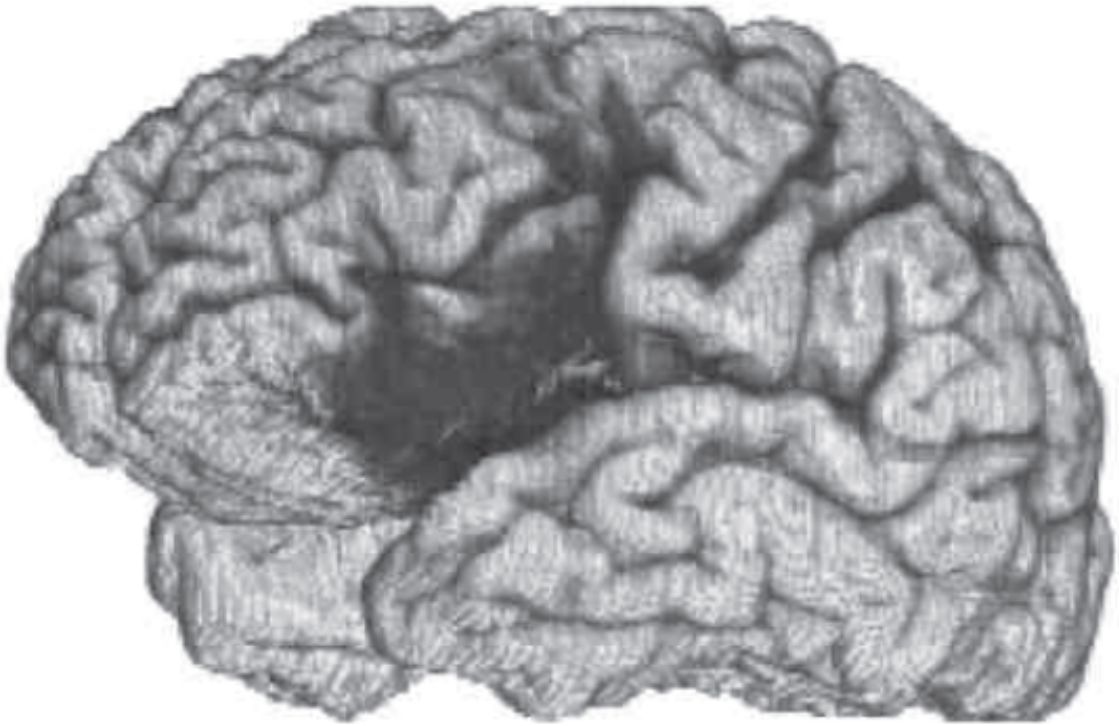


Figure: Damage in left frontal region (dark gray) caused by a stroke.

First noticed by Paul Broca (circa 1860)

1. Injury/lesion to Broca's Area (frontal lobe; left hemisphere)

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7. Ill-formed signs for users of sign language

Function vs. Content words

- **Function/grammatical words**
- **Content/meaning words**

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What are some function words in English?
Are function words processed differently than content words?

Comprehension Difficulties and Broca's Aphasia (Caramazza and Zurif 1976)

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Last example below understood more easily by Broca's aphasiacs. Why?

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3. Problems with auditory comprehension
4. Difficulty naming things (anomia)
5. So produce nonsense words or lexical substitutions
6. Nonsense signs for users of sign language

Brain of Wernicke's Aphasiac

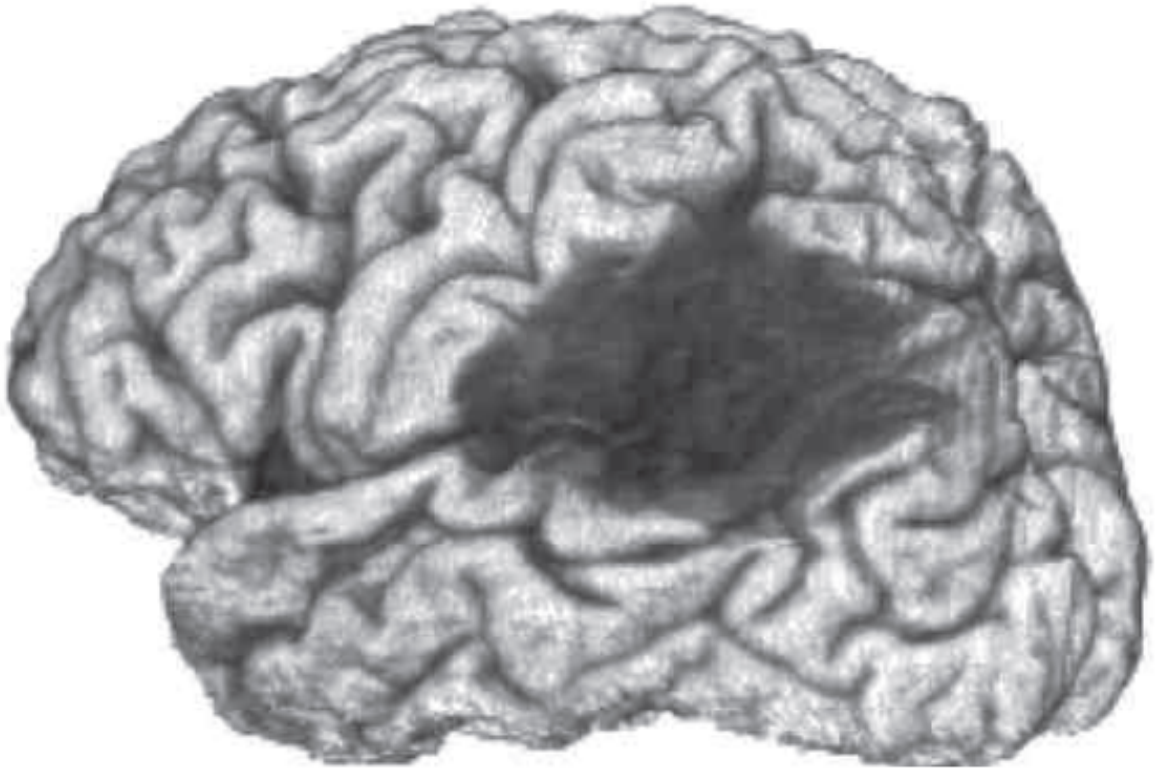

Figure: Area of damage in left posterior temporal and lower parietal region (dark gray) caused by a stroke

Aphasia Studies: Tentative Conclusions

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Agrammatic signs by sign language speakers having injury to Broca's area
Incoherent signs by sign language speakers having injury to Wernicke's area

Aphasia in History

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- Carl Linnaeus published a case study of jargon aphasiac (1745)

Carl Linnaeus

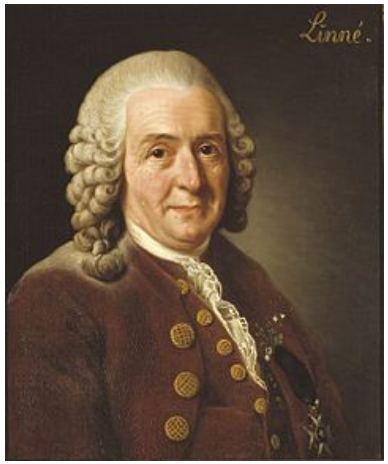

Figure: 1707 to 1778

Dyslexia

What is dyslexia?

Dyslexia

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Figure: Ten variations of the word *Teapot* as written by dyslexics

Acquired dyslexia

Stimulus	Response	Stimulus	Response
witch	witch	which	no!
hour	time	our	no!
eye	eyes	I	no!
hymn	bible	him	no!
wood	wood	would	no!

What type of words induce processing difficulties?

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Function words

Writing systems of some languages

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1. *Kanji*: Symbol=picture of a word (Borrowed Chinese characters)
2. *Kana*: Symbol=syllable
   2 types: Hiragana & Katakana

カプセルホテル

各室がカプセル形の簡易ホテル。終電に乗り遅れたサラリーマンなどが高いタクシー代を払って帰宅するより安く済むことから、手軽に利用している。

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Translation:

> *Capsule Hotel*
>
> *A simple hotel where each room is capsule-shaped. When businessmen miss the last train home, they can stay overnight very cheaply instead of paying a lot of money to go home by taxi.*


4097
4099
4101

What are the deficits caused by damange in different hemispheres?

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- Left hemisphere damaged Japanese patients cannot read *kana* (syllable)

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- Right hemisphere damaged Japanese patients cannot read *kanji* (picture)

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- Left hemisphere damaged Japanese patients cannot read *kana* (syllable)
- Right hemisphere damaged Japanese patients cannot read *kanji* (picture)
- Unimpaired people: Right hemisphere better and faster at reading *kanji*, and vice versa.

Wernicke-Geschwind Model

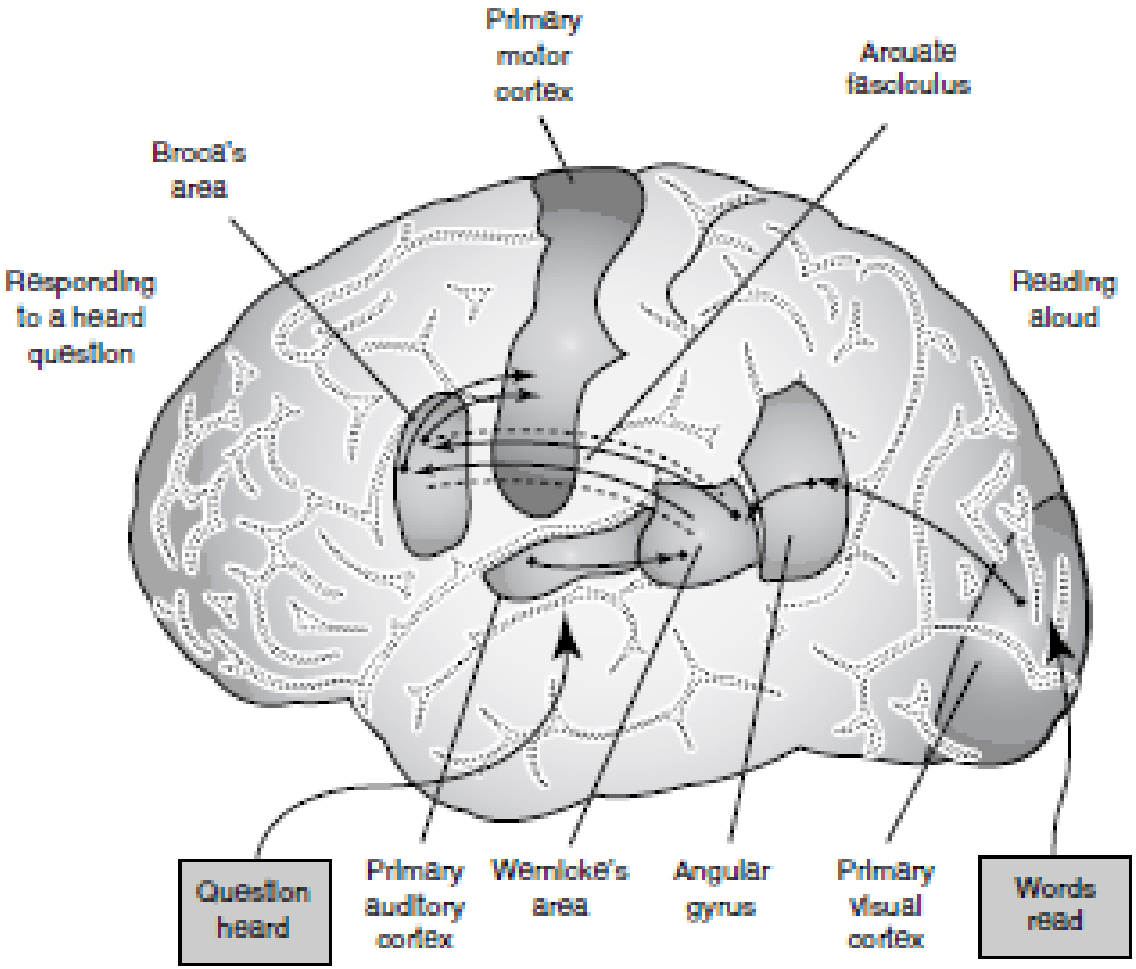

Figure: Brain areas of the left hemisphere that are part of the model of language comprehension and production

Early life: Brain plasticity and lateralization

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- Left hemisphere localization for language
- Right hemisphere's ability for language early in life (but NOT later)

Right hemisphere contributions to language

- Right hemisphere contributes to processing of intonation
- Understanding jokes, puns, metaphors
- Processing of writing (espl for logographic scripts)

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Childhood brain lesions in right hemisphere results in delay in babbling and vocabulary learning

Orientational Metaphors

Adapted from *Metaphors We Live By* by George Lakoff and Mark Johnson (2003):

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2. Physical basis: Drooping posture typically goes along with sadness and depression, erect posture with a positive emotional state.

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   - The amount of artistic activity in this state has gone down in the past year.

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   - He rises early in the morning.He fell asleep.
   - He dropped off to sleep. He's under hypnosis.
   - He sank into a coma.
2. Physical basis: Humans and most other mammals sleep lying down and stand up when they awaken.
3. MORE IS UP; LESS IS DOWN
   - The number of books printed each year keeps going up. His draft number is high. My income rose last year.
   - The amount of artistic activity in this state has gone down in the past year.
   - The number of errors he made is incredibly low.

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4. Physical basis: If you add more of a substance or of physical objects to a container or pile, the level goes up.

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4. Social and physical basis: Status is correlated with (social) power and (physical) power is up.

Split-brain patients

Also evidence for contralateralization

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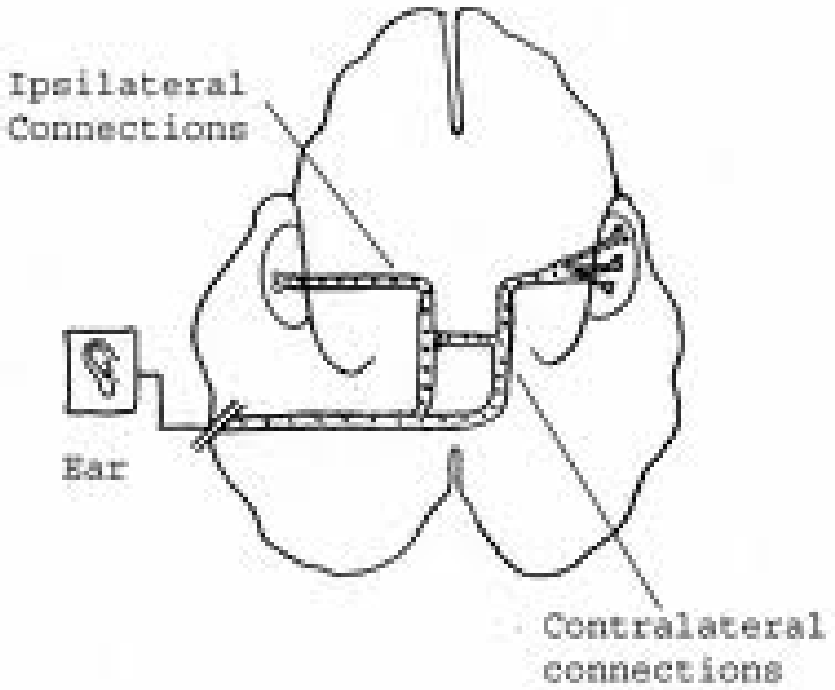
- Person can name and describe pencil

Contra- vs. Ipsi- Lateral Connections



Dichotic listening

Subjects hear two different sounds signals simultaneously

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- No need to cross the corpus callosum in the contralateral case
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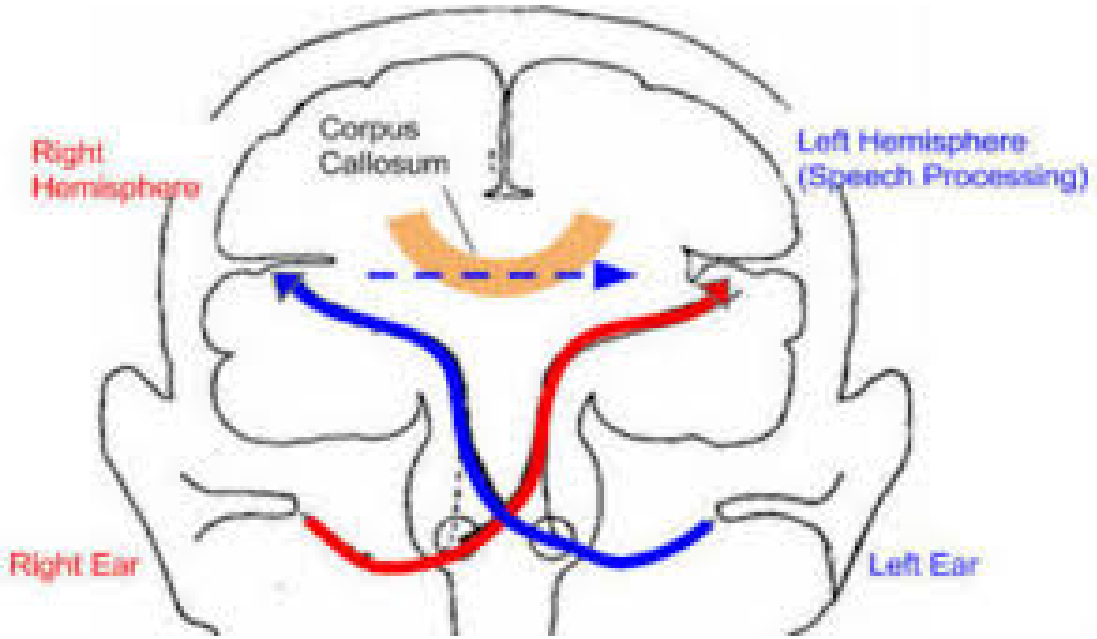
Dichotic Listening



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- Variation in response to:
  **The man admired Don's headache of the landscape*
  The man admired Don's sketch of the landscape
- Sign language is localized in the brain

Autonomy of language

Is language an autonomous module in the brain?

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Sources of evidence:

1. Evidence from impairment
2. Evidence from acquisition

Left Hemisphere of Human Cerebral Cortex (side view)

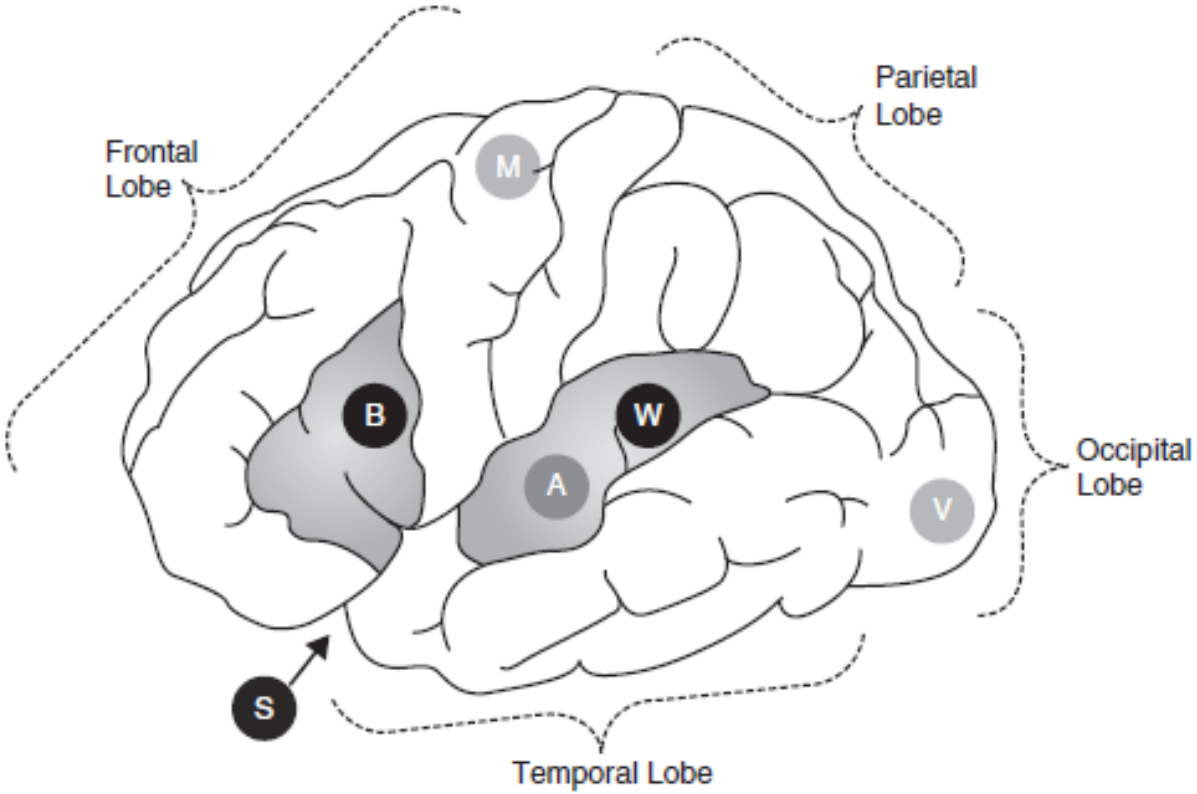

Figure: Broca's Area (**B**); Wernicke's Area (**W**); Motor (**M**); Auditory (**A**); Visual (**V**) areas (approx)

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- Normal intelligence and other cognitive functions

Language vs. Other cognitive abilities

Is linguistic ability independent of other cognitive abilities?

- Idiot savants
- Genetic disorders

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- Cognitive deficiencies like arithmetic and social skills

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- SLI runs in families

Language and brain development

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2. Late exposure alters brain organization for language

Critical age hypothesis

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2. Triggered by experience in a natural "window of oppurtunity"

Critical Period: Window of oppurtunity

Critical period: (between birth and age 12). Evidence:

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Wolf children: Genie and Victor

Both children did not acquire language before age 12. After critical period:

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- NO grammar acquisition after critical period

Genie's Speech

Man motorcycle have.
Genie full stomach.
Genie bad cold live father house.
Want Curtiss play piano.
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- Genie was a powerful non-verbal communicator

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- **Language areas atrophy on inadequate linguistic stimulation**

Bird songs

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- **Moral**: Innate faculty triggered by input within a certain time window

Language Evolution

Language evolution: Evolution of vocal tract and ear
Continuity vs. Discontinuity views

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Continuity vs. Discontinuity views

- Pinker's "Language instinct" view: Darwininan natural selection
- Chomsky-Jay Gould view: Sudden brain size increase gave it complex faculties