Psychology of Language

18 Language & brain

Fall 2023
Tues/Thur 5:00-6:15pm

Emma Wing
Drop-in hours:
Wednesdays 3-4pm
& by appointment
Webex link

Road map

- Unit 3: Language, Brain, & Diversity
    - Language & mind (RadioLab)
    - Language & brain
    - Acquired Aphasia
    - Reading
    - Acquired dyslexia
    - (Break)
    - Diversity & multilingualism
    - Language, culture, & thought
    - Big picture discussion

Preview of Unit 3 content

- Comments on RadioLab?
  - Are language and thought separate?
  - Does the language you speak affect the way that you think?
- How are speech comprehension and reading comprehension similar or different?
- What is the difference between a language and a dialect?
- How different are the languages of the world? Do they differ in complexity?
- What is the definition of “bilingual” or “multilingual”?
  - What is the difference between a person’s L1 and L2?
- Does speaking more than one language change how you think?
- Is it better/worse to learn/speak more than one language?
  - In other words, is learning two languages at once when you are young bad for you?
- What is the connection between language and culture?

Road map

- Unit 3: Language, Brain, & Diversity

  18 Language & brain

Learning objectives

- Give 1+ reasons to look at the brain when studying language
- Describe brain lateralization of language
- Describe what split brain patients can teach us about language in the brain
- Describe the dual stream model of speech processing
- Say what EEG, ERP, the N400, and P600 are

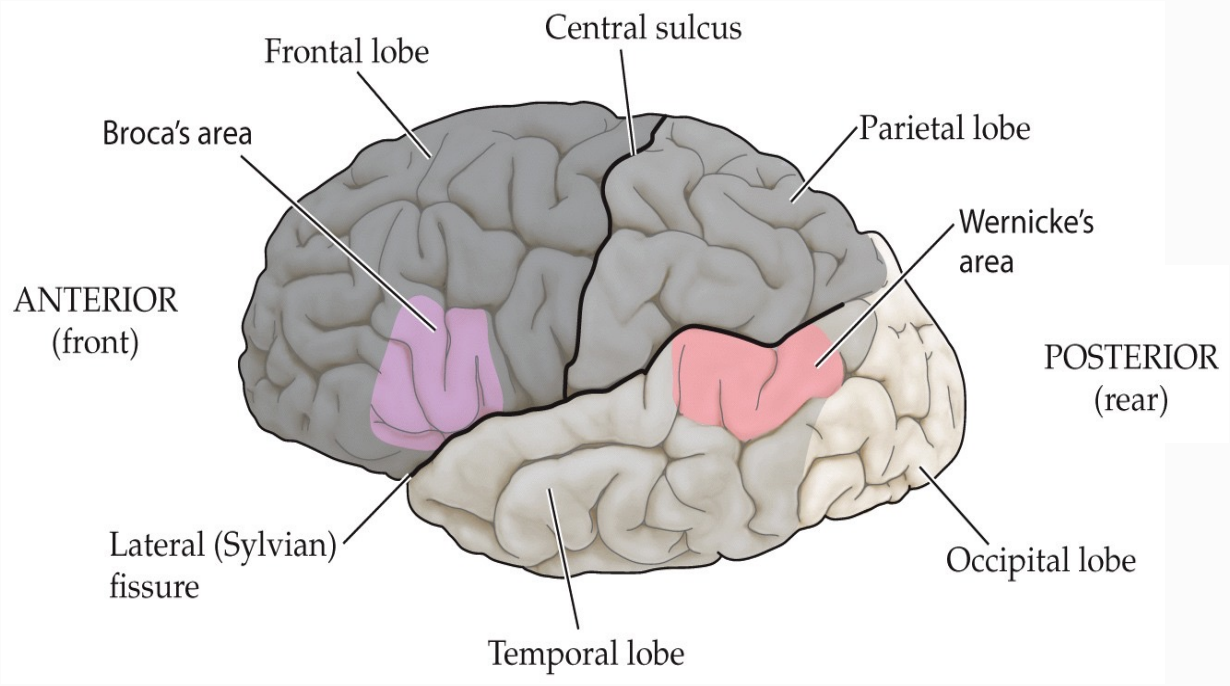
Why brains?

- Studying healthy brains helps us:
  - Learn about organization (cognitive or neural) of the language system
  - Learn about structure-function relationships in brain
  - Healthy brains help us discover areas are involved in language (damaged brains help us discover areas necessary for language)

Background on the brain

Left lateralization

- Language functions are typically left lateralized, or supported primarily by the left side of the brain (both for speaking and signed languages)
  - How do we figure this out?
    - Studying disorders and and taking measurements of neural activity

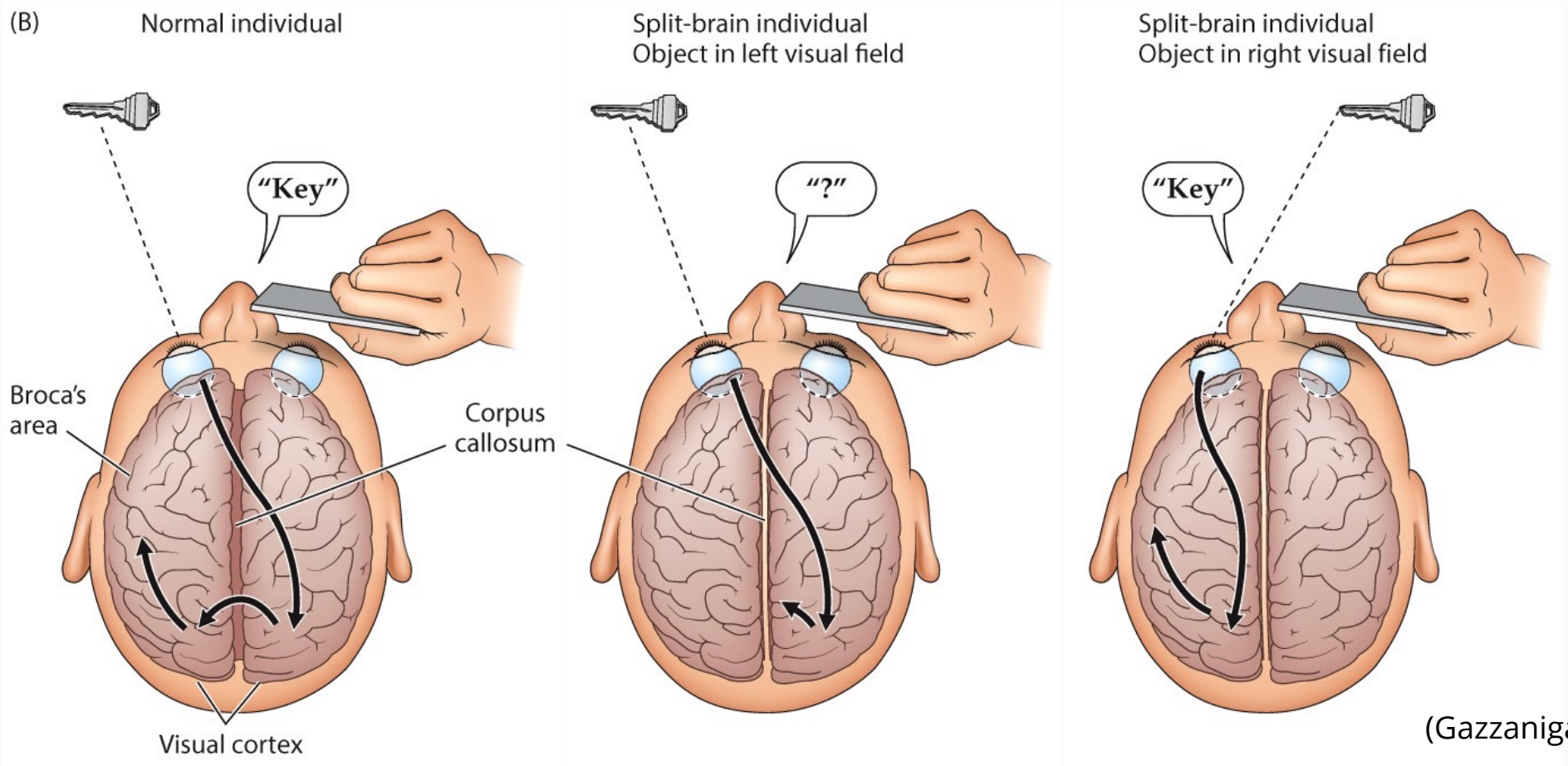


Left lateralization

- Video: Severed corpus callosum

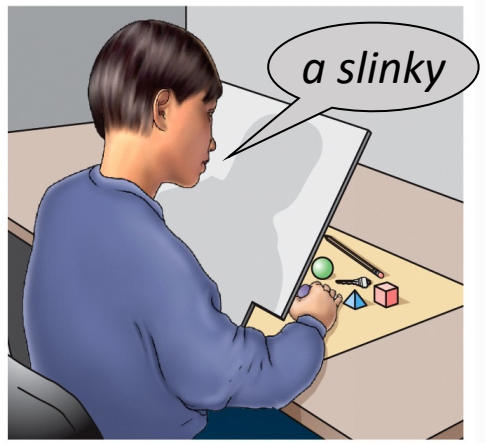
Left lateralization

- Split-brain individuals provide more evidence of lateralization



(Gazzaniga & Sperry, 1967)

Left lateralization



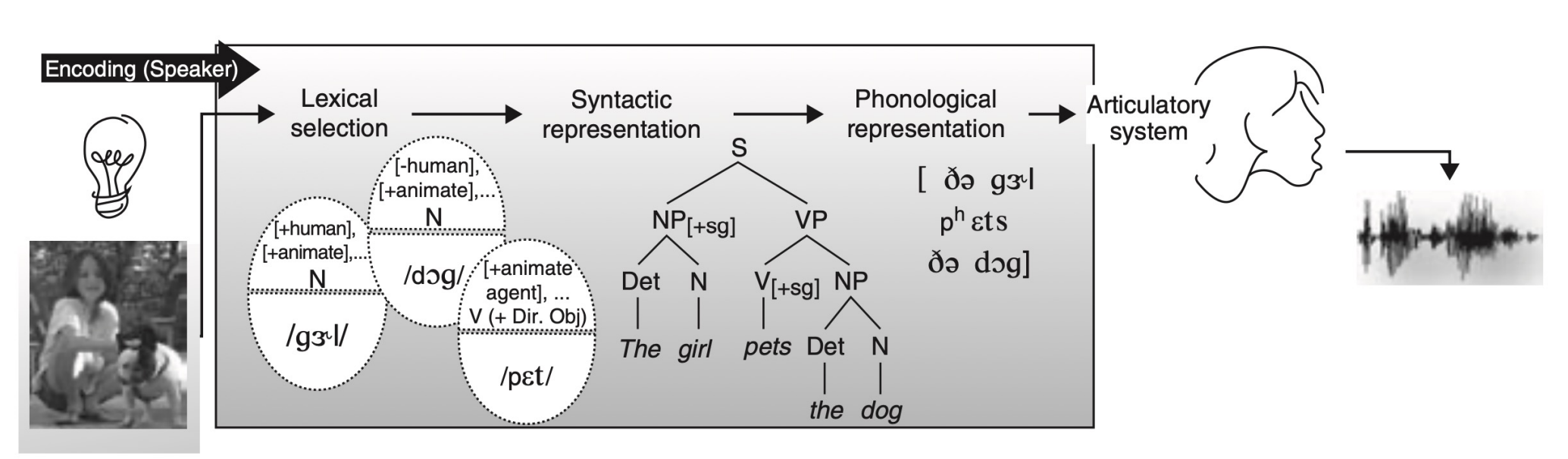
They can name an object they handle with their right hand (left hemisphere)…

… But can't name an object they handle with their left hand (right hemisphere) …

… when they say "I don't know", they can later select handled object from picture array:

Left lateralization

- Considering the language **production** behavior of split-brain individuals, what connection is likely damaged?



Left lateralization

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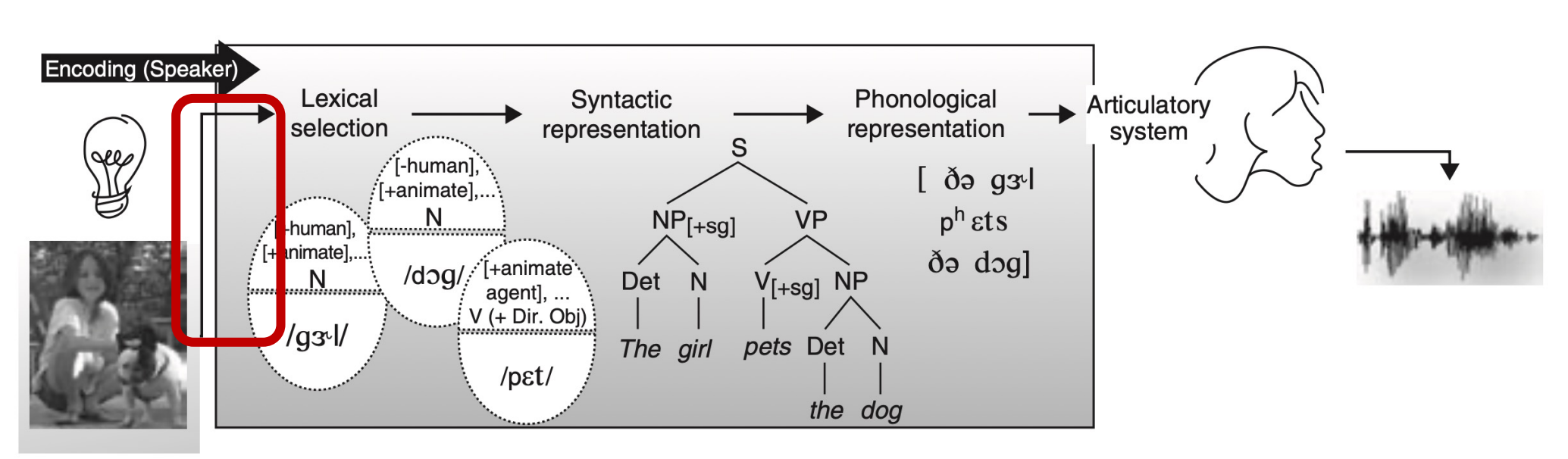

Tools to study language in the brain

- Currently, most researchers study language in the brain by measuring neural activity with functional neuroimaging (especially fMRI)
  - fMRI measures oxygen level in blood (more active neurons require more blood)

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finger

foot tongue

(A)	(B)	(C)
kick	type	lick
step	throw	speak
walk	write	bite
tiptoe	grasp	smile
jump	poke	chew

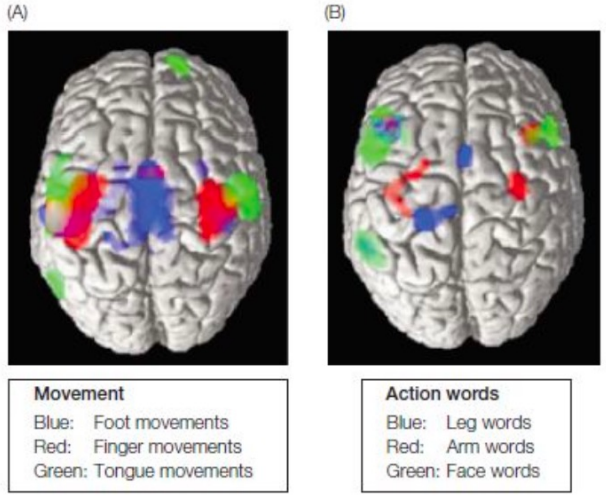


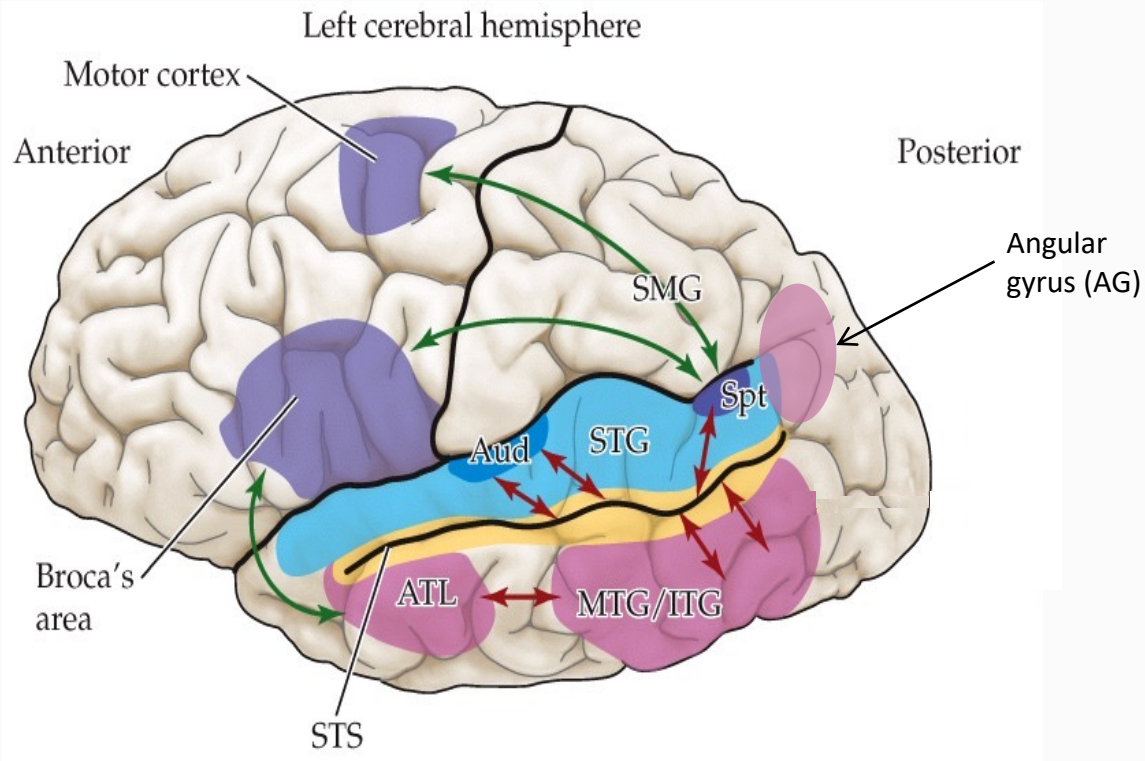
Figure 3.11 Results from a study of action words. (A) Activation of brain areas following instructions to move particular parts of the body. (B) Activation of brain areas during silent reading of action words involving three parts of the body. In a comparison (baseline) condition, subjects saw meaningless rows of hatch marks, averaging the same length as the action words. (From Hauk et al., 2004, *Neuron* 41, 301.)

Burton et al. (2002)

Dual-stream model of speech processing

- **Dorsal stream (green arrows):** Supports speech <u>production</u> by translating sounds/phonological representations (blue) into motor sequences for speech (purple)

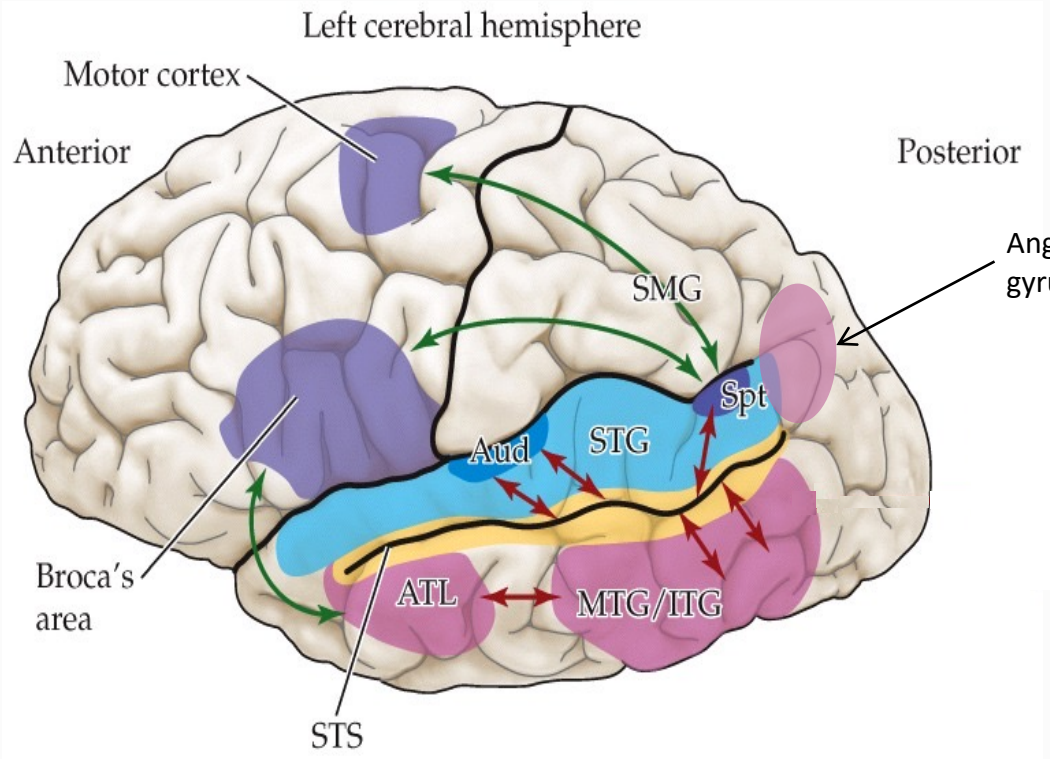
- **Ventral stream (red arrows):** Supports speech <u>comprehension</u> by mapping sounds/phonological representations (blue) onto to meaning (pink)
  - Meaning is widely distributed across cortex, but this model focuses on anterior temporal lobe (ATL) & middle temporal gyrus (MTG) – two areas where aspects of meaning are processed.
    - Angular gyrus (AG) is another important area for meaning



Hickok & Poeppel (2000)

Dual-stream model of speech processing

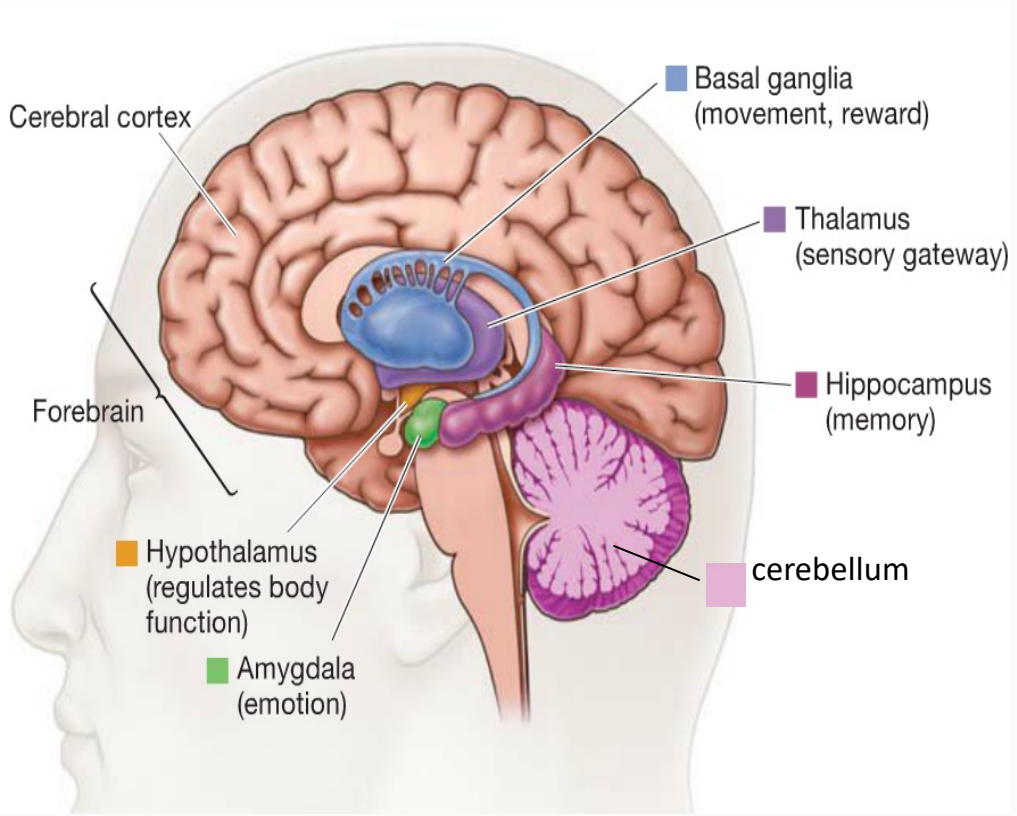
- Processing meaning
  - anterior temporal lobe (ATL)
    - accessing and integrating semantic knowledge across modalities, like visual, tactile, auditory (within a syntactic structure)
    - middle temporal gyrus (MTG)
      - Involved in mapping sound and written words to meaning



Hickok & Poeppel (2000)

Language in the brain

- Other brain areas to be aware of
  - Motor sequencing and syntax supported by basal ganglia, thalamus, cerebellum
  - Depending on task/stimuli, sound/meaning retrieval supported by inferior frontal gyrus, hippocampus & amygdala



Tools to study language in the brain

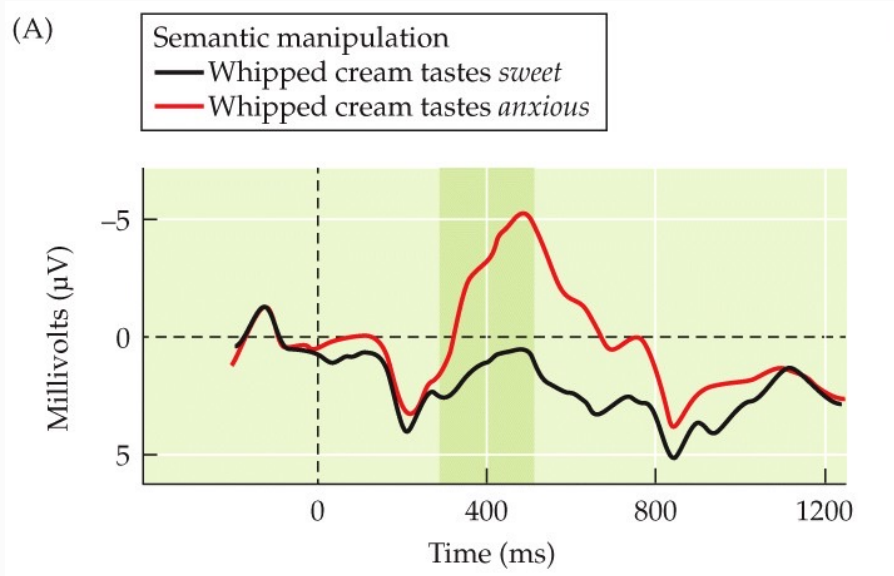
Electroencephalography (EEG)

Figure 3.23 A research participant with EEG electrodes placed over the scalp. (Photograph © Burger/Phanie/Science Source.)

Tools to study language in the brain

Electroencephalography (EEG)

- Major language-related "event related potentials" (ERPs) – negative is plotted UP
  - Two major ones:
    a) N400: typically related to a semantic anomaly
       1. John buttered his bread with socks.



What?	When?	Why?	Example(s)	Triggering stimulus[a]
Negative-going activity	Peaks at about 400 ms after stimulus onset	Occurs when the content of a word is unexpected	Reading words that are nonsensical in a sentence	*The winter was harsh this* ***allowance***. (Expected: *The winter was harsh this* ***year***.)
			Reading rare or unusual words in a sentence	*He painted the bike* ***vermillion***. (Expected: *He painted the bike* ***red***.)

Tools to study language in the brain

Electroencephalography (EEG)

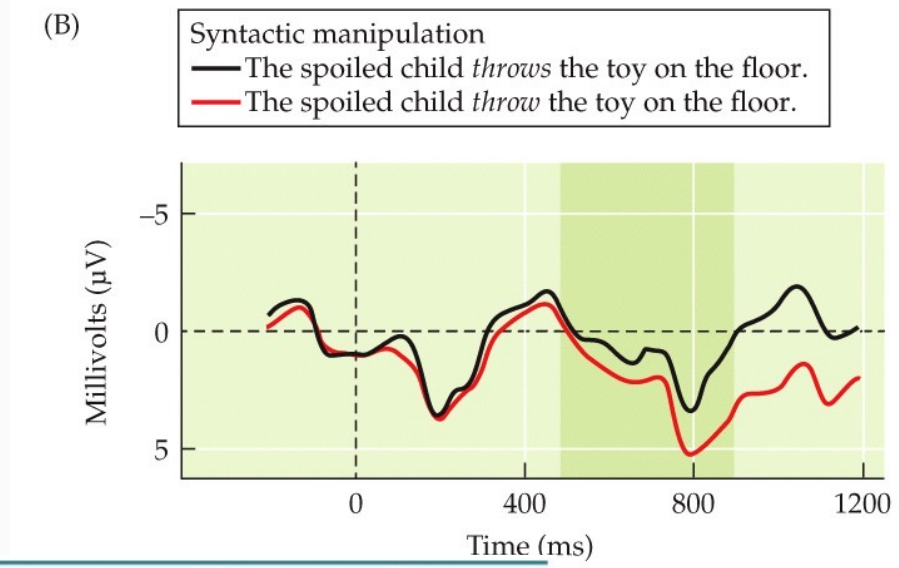
- Major language-related “event related potentials” (ERPs) – negative is plotted UP
  - Two major ones:
    a) N400: typically related to a semantic anomaly
       1. John buttered his bread with socks.

Involved in accessing a word’s contents from stored memory and integrating it with preceding information.

Tools to study language in the brain

Electroencephalography (EEG)

- Major language-related "event related potentials" (ERPs) – positive is plotted DOWN
  - Two major ones:
    b) P600: typically related to a syntactic violation
       1. The spoiled child throw the toys on the floor.



What?	When?	Why?	Example(s)	Triggering stimulus[a]
Positive-going activity	Peaks at about 600 ms after stimulus onset	Occurs in processing (and possibly trying to repair) an unexpected syntactic structure	Reading or hearing sentences with a syntactic violation	*The boats **is** at the dock.* (Expected: *The boats **are** at the dock.*)
			Reading sentences that contain an unusual or unexpected structure	*The broker persuaded **to sell** the stock was tall.* (Expected: *The broker persuaded **his client** to sell the stock.*)
			Reading sentences in which the participants involved in an event are in the wrong order	*The hearty meal was **devouring** the kids.* (Expected: *The kids were **devouring** the hearty meal.*)

Tools to study language in the brain

Electroencephalography (EEG)

- Major language-related “event related potentials” (ERPs) – positive is plotted DOWN
  - Two major ones:
    b) P600: typically related to a syntactic violation
       1. The spoiled child throw the toys on the floor.

Found in the combination of syntactic units.

Are syntax and semantics two different processes?

Electroencephalography (EEG)

- N400 isn't just nonsensical, but unpredictable
  - Example: He painted the bike *vermillion*.
- P600 isn't just a problem with syntactic structure
  - Example: structures that are less common (straining working memory)