Language and Aphasia

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What is language?

- The use of words to communicate meaning
  - Small units of language (words) can be combined to form larger units (phrases, sentences, paragraphs) to communicate meaning
    - Small units of language can be combined into larger units to create *novel* utterances
      - You are not restricted to merely saying things other people have said before, but rather can also say new things
      - “Colorless green ideas sleep furiously.”
      - “There is evidence of injury to the disco ligament.”

- All cognitively intact humans who grow up exposed to language will learn language
  - As far as we know, only humans use language (as defined above)

Do dogs use language?

Dinosaur Comics
3/23/16

- Language can be spoken, signed, or written
- Fundamental representation of language in the brain is spoken language
  - Written language is cobbled together from other brain functions
  - Mass literacy very new phenomenon—past 100 years
  - Except where otherwise specified, we will focus on spoken language in this talk
    - Sign language essentially equivalent to spoken language, not written language

- Speech ≠ Language
  - Speech: elementary motor function of tongue, lips, vocal cords, mouth
  - Language: cognitive function consisting of using words to communicate meaning
- Scuba divers can't speak because under water, but can still use language by writing on a slate
- A parrot can speak but is not combining words to create novel meanings (i.e., not using language)

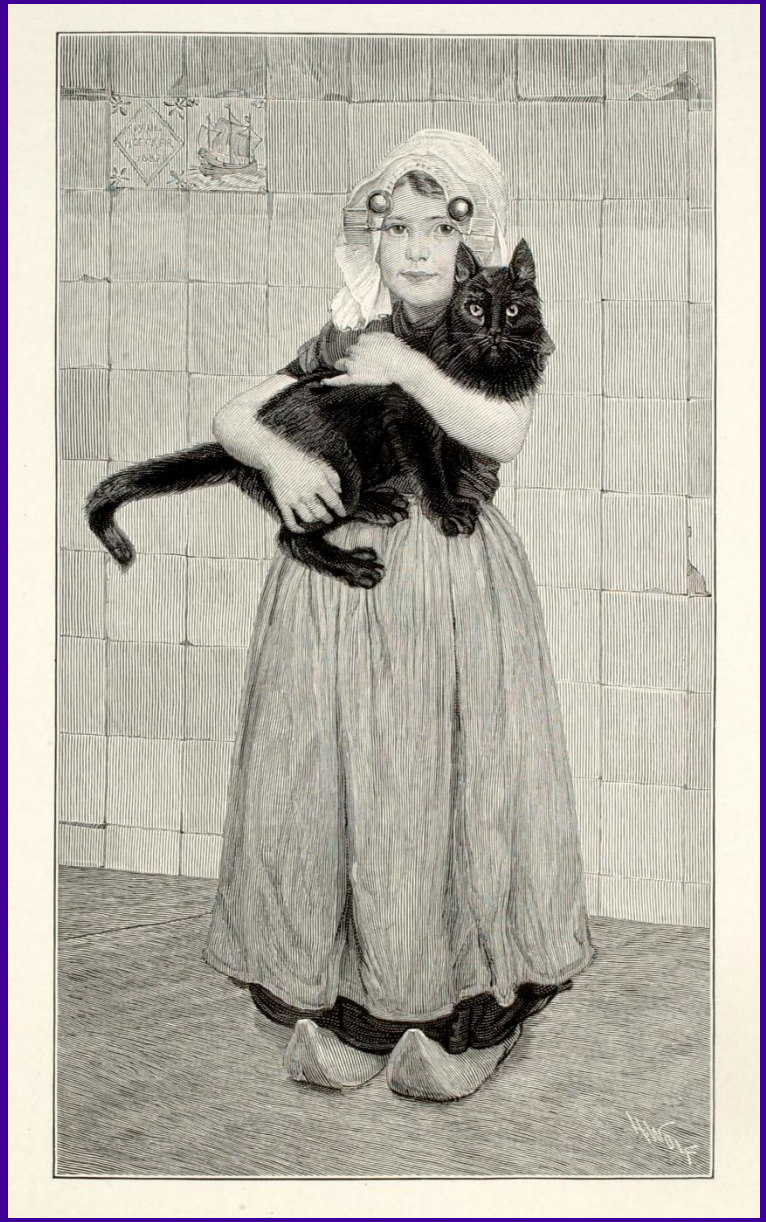
Various ways of classifying the different aspects of language

- Choose the most helpful classification based on the task at hand
  - Describing elements of normal language, vs classifying aphasias

  Elements of language often referred to in Linguistics:
  - Phonology: word sounds (phonemes)
  - Semantics: word meanings (morphemes)
  - Syntax: sentence/phrase structure
    - (closely related to grammar, but not identical)
  - Pragmatics: social functions of language

What is a word?

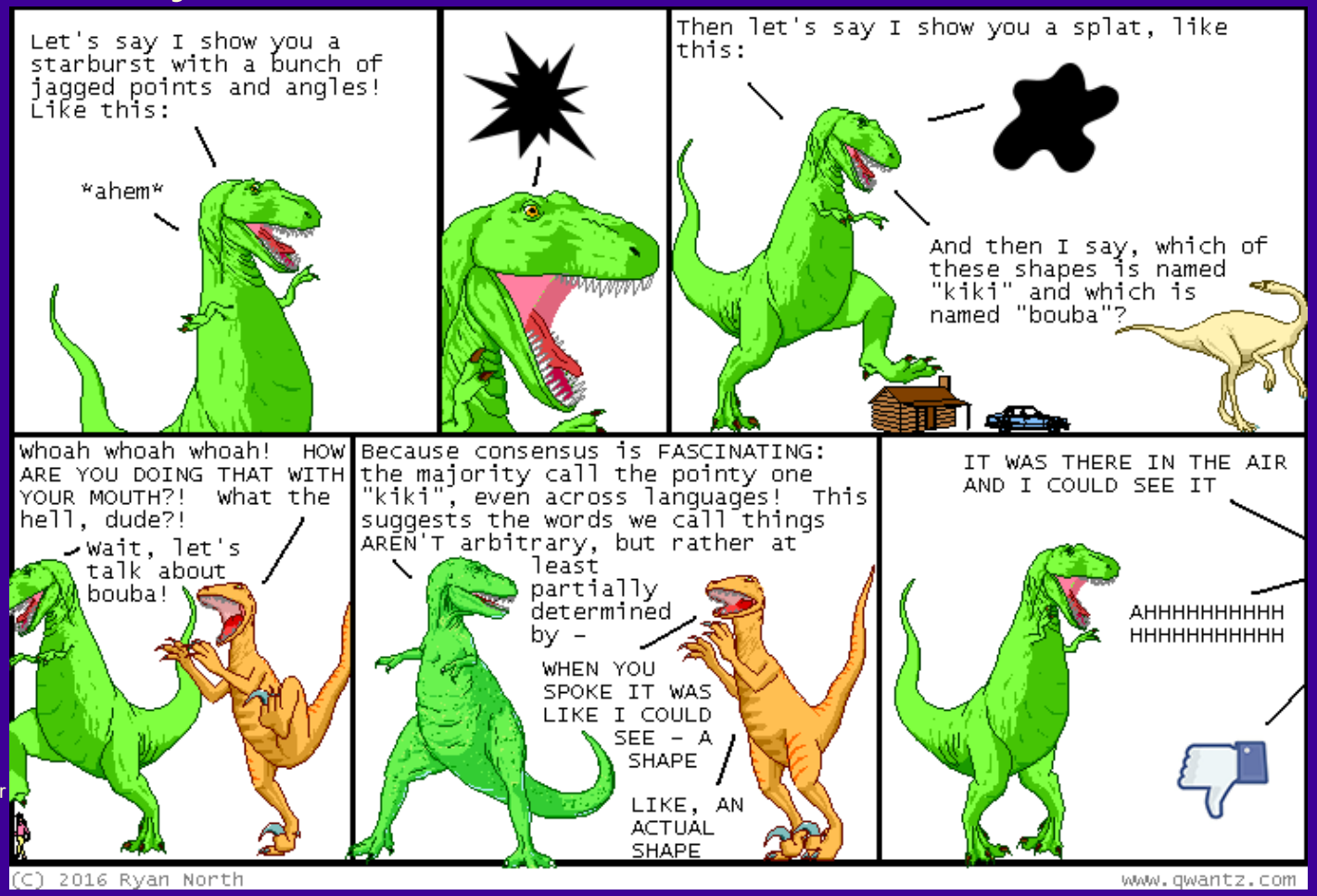
- Words are made up of two parts: phonemes and morphemes
- Phonemes: the various sounds in a particular language
  - Different languages can have different phonemes:
  - “rr” is phoneme in Spanish but not English
  - “r” and “l” are distinct phonemes in English but not in many other languages
  - The word "cat"
    - Phonemes: /k/, /æ/, /t/



- Morphemes: the smallest meaningful units of language
  - "cat" = 1 morpheme: "cat" (small furry animal that meows)
  - "cats" = 2 morphemes: "cat" (small furry animal that meows) + "s" (plural marker)
  - "unpredictable" = 3 morphemes = “un” (not) + “predict” (estimate whether something will happen in the future) + “able” (possible to do)

In general, which phonemes (sounds) correspond to which morphemes (meanings) is random

- Exceptions: onomatopoeia
  - Gurgle, splash, clang
- Maybe some others?



Dinosaur Comics 4/6/16

- But, on the whole, there is no obvious way to tell which sounds (phonemes) go with which meanings (morphemes)
- So, if you want to talk about a cat, how does your brain know which sounds to produce?
- If you hear someone say the sounds /dɒg/, how do you know what that person means?

- To match sounds with meanings, the “sound-maker” and “sound-hearer” in your brain need to communicate with the “dictionary”
  - Different parts of your brain perform these different functions, and have to communicate with each other for you to use language

Syntax

- The way in which individual words combine to form phrases and sentences
- Word order
  - English generally uses Subject-Verb-Object order
    - “I read the book”
    - But some exceptions:
      - Yoda: “Much to learn, you still have”
  - Spanish often uses SVO, but occasionally Subject-Object-Verb
    - “Yo leí el libro” = “I read the book”
    - “Yo lo leí” = “I it read”
  - Other languages use different orders; in languages that use morphemes to designate subject/object, the order often doesn’t matter (free order)
    - Declensions in Latin

Other aspects of syntax

- What part of a sentence refers to what
- Easier to understand why syntax is important when people use ambiguous syntax
  - News article about a school that burned down:
    - “An electrical fire in September 2017 gutted the school now called Tampa Heights Elementary, and was built by volunteers in 2006”.
  - Newspaper headline:
    - “Shark attacks puzzle experts”
  - Oxford comma controversy:
    - “This book is dedicated to my parents, Ayn Rand and God”
- Some jokes rely on syntactical ambiguity:
  - Customer: “Hi, I’d like to try on that dress in the window”
  - Store salesperson: “I’m sorry, but you’ll have to use the fitting room just like everybody else”

Pragmatics

- Social communicative aspects of language
- Generally, when communicating with others, we expect everyone to be:
  - Informative
  - Truthful
  - Relevant
  - Clear
  - (aka Grice's maxims)
- People can accidentally not follow these principles (because they're bad at communicating) or deliberately not follow these principles (deception, humor, sarcasm, poetry) but in general we rely on them when communicating with others.

- Informative
  - Give the right amount of information to be useful: not too little, not too much
    - “Excuse me, do you have the time?” “May I use your restroom?”
      - “Yes” is not the appropriate answer: might be true, but is not adequately informative
    - If you meet a tourist and ask them “where do you live?”
      - “Iowa” is an informative answer
      - “In Iowa City, near Sycamore Mall” is too much information, as people in FL probably don’t know that local landmark
- Truthful
  - Don’t tell lies or say things for which you have no evidence or rational basis to believe
    - “I have a pet unicorn and I ride her around town every day”
    - “I have a special pill made from grass clippings that cures all diseases”

- Relevant
  - You ask me to give a lecture on aphasia, but I show up and give a lecture on Anna Freud's ego defense mechanisms instead
    - Might be informative, truthful, and clear—but it's not relevant
  - A joke that depends on violating the maxim of relevance:
    - "When I die, I want to go peacefully in my sleep, like my grandfather—not screaming in terror like the passengers in his car"

- Clear
  - You gave tPA to a patient with an acute stroke and you need to explain to their family what's going on
    - "Your dad presented with a R hemiparesis and Broca aphasia, and was found to be in a-fib. It looks like a cardioembolic stroke to the L MCA territory. He arrived in the window, so we gave him tPA."

    vs
    - "Your dad had a blood clot in his brain. The parts of his brain that control his movement and his talking weren't getting any blood or oxygen, so that's why he wasn't able to talk to you or move his right side. We think the stroke was probably caused by his irregular heart beat. Luckily you got him to the hospital really fast, so we gave him a clot-busting medicine to hopefully get the blood flowing to all parts of his brain again".

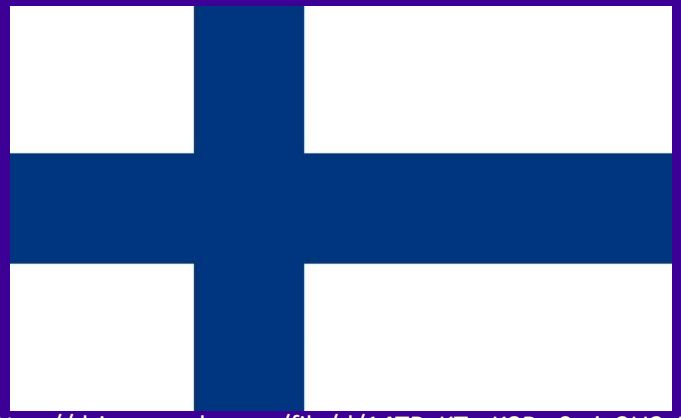
4 elements of language useful for understanding and classifying aphasias*

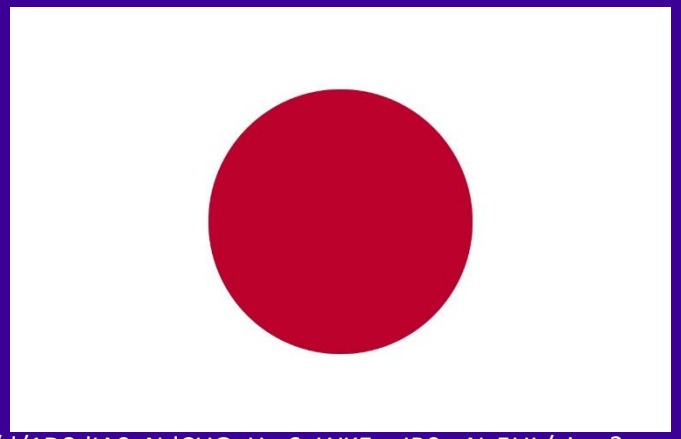
- Fluency
- Comprehension
- Repetition
- Naming

*These are not the only elements of language, but we won't address the others here

- Fluency:
  - Appropriate number of words coming out of the person's mouth at an appropriate rate of speed
  - How many words do you have to produce in a row (ie, without pausing) to count as fluent?
    - 7
    - Some aphasiologists say 5-6
    - Or 100 words/min
  - Need to look at overall picture, not just one utterance in isolation
  - Different from the concept of “fluency” in a foreign language

- To be fluent, does what you say have to make any sense?
  - No!
  - There is nothing in the definition of fluency that says the words have to make sense or be real words!
- Can you judge the fluency of someone speaking in a language you do not speak?
  - Yes!
  - Won't know content of what they are saying, but can tell if fluent or not





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Comprehension:

- Can the person understand what is being said to them?
  - Technically, comprehension has nothing to do with what the person says, only whether the person understands what others are saying to them
    - When you assess comprehension, should only look at whether person understands what you say
      - Usually, you assess comprehension by seeing whether the patient can follow verbal commands or answer very simple questions

- If the patient has intact comprehension, will you be able to easily understand everything the patient says?
  - No! You can have *comprehension* without *comprehensibility*
    - Comprehension: can the patient understand what you say?
    - Comprehensibility: can you understand what the patient says?
- Essentially all patients with aphasia have some problems with comprehensibility (ie, they use the wrong word, omit words, make up nonexistent words, etc)
  - If you can 100% understand everything your patient says, with no difficulties at all, that patient DOES NOT have aphasia

- Is the reverse true? If a patient can't comprehend what you say, will you be able to comprehend what the patient says?
- IE, can you have *comprehensibility* without *comprehension*?
  - No
  - Impaired comprehension means that "storehouse of auditory word forms" has been damaged—which means that what the person says won't be real words used correctly

- In healthy individuals: if you don't understand a particular language, also won't be able to speak that language—because you lack a working "storehouse of auditory word forms" for that language
  - Do you understand these Kenyan TV announcers, speaking Swahili?
  - If you try to talk to them in Swahili, will they understand you?

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- However, syntactic complexity also plays a role in comprehension
  - Easier to comprehend single words than sentences
  - Easier to comprehend 1-step commands than multistep commands
  - Easier to comprehend grammatically simple commands than syntax complex commands
    - “Touch the ball before you touch the book” = easier
    - “Before you touch the ball, touch the book” = harder
  - Easier to comprehend syntactically simple questions than syntactically complex questions
    - “Do wolves attack deer?” = easier
    - “Are wolves attacked by deer?” = harder

Repetition:

- Ability to reproduce the same string of sounds that you hear
  - Repetition to command or echolalic repetition both count
- Do you need to understand what was said in order to repeat it?
  - No!
  - Possible to repeat without comprehending

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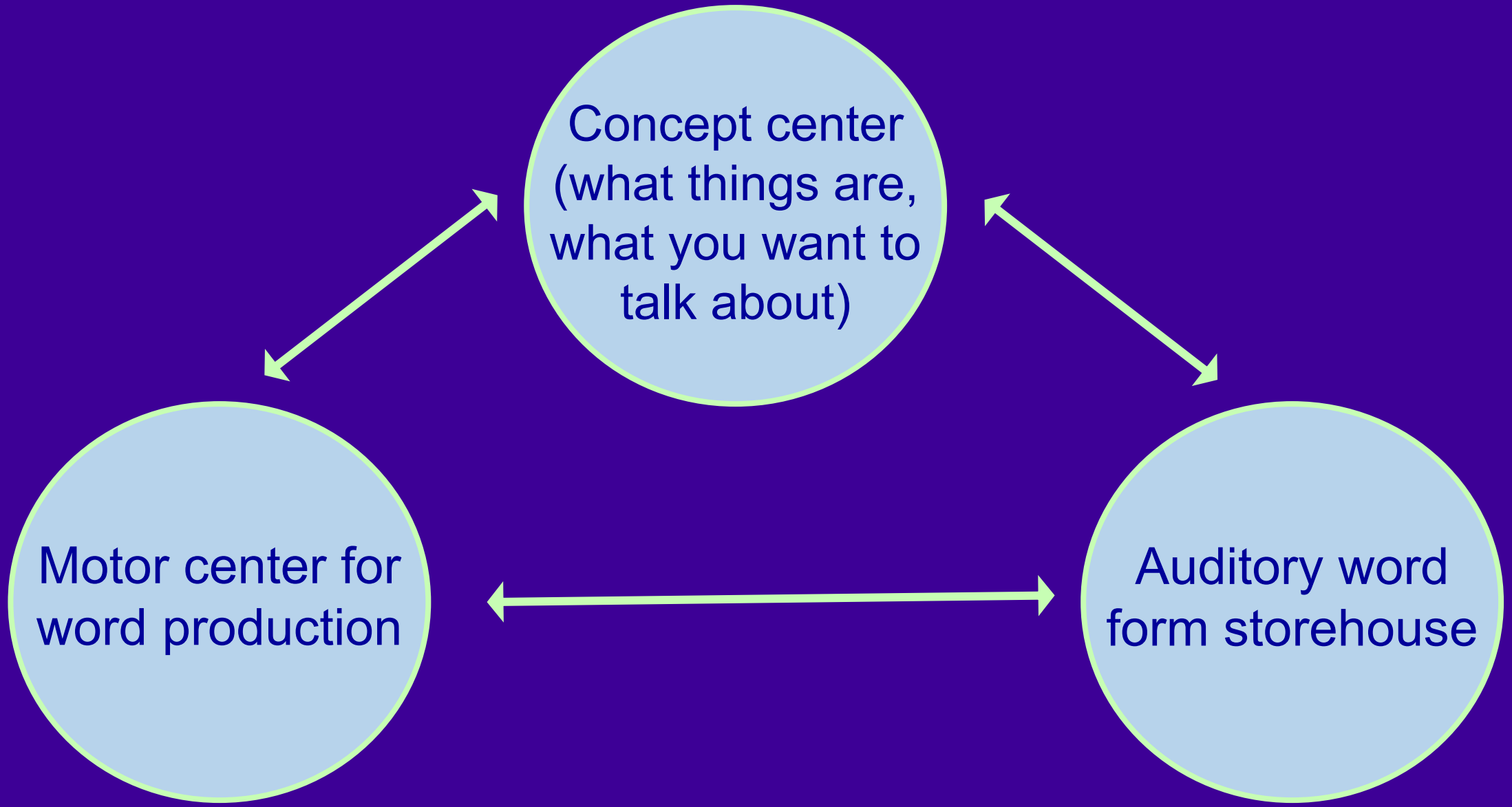
Naming:

- Ability to identify the appropriate word and then verbally produce the appropriate word
  - Involves both naming to confrontation and word-finding in spontaneous conversation
- All patients with aphasia have word-finding difficulty
  - Common words usually easier for patients with aphasia to produce than rare words

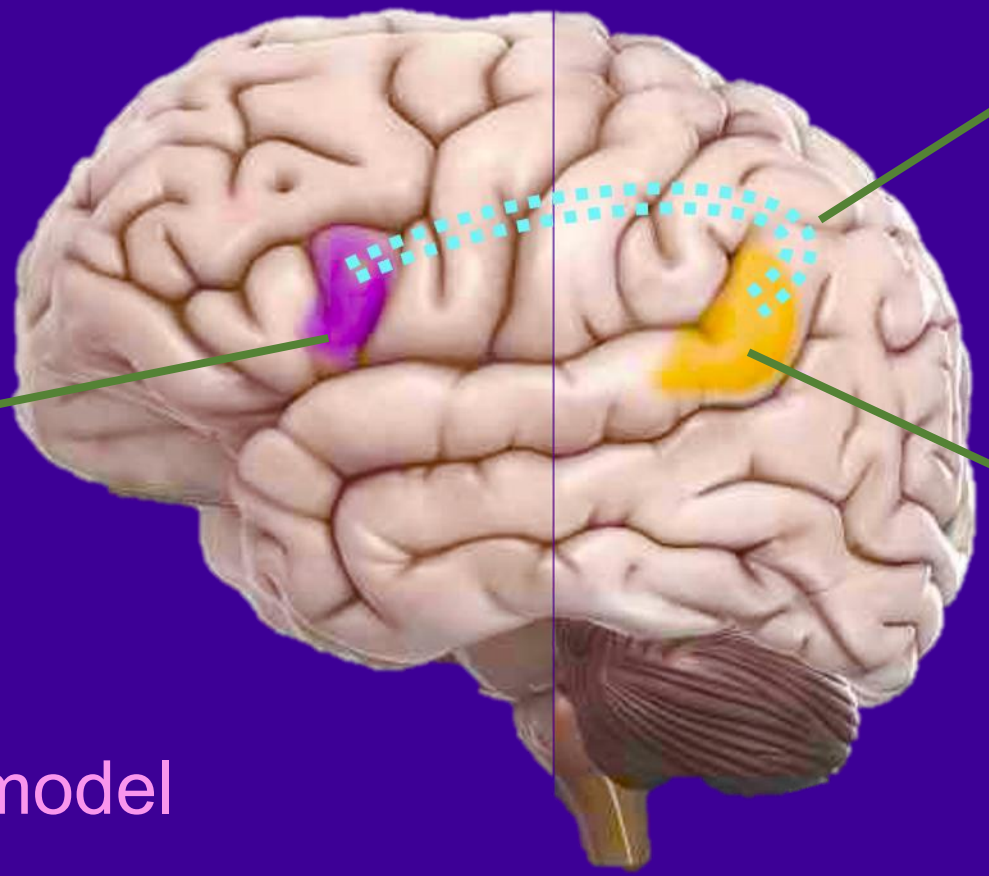
Types of naming / word-finding errors:

- Neologism
  - Random made-up word, unrelated to target word
  - “Bibu” instead of “fork”
- Paraphasias
  - Phonemic paraphasias:
    - Wrong sound
    - “Tork” instead of “fork”
  - Semantic paraphasias:
    - Wrong but related concept
    - “Spoon” instead of “fork”
- Circumlocution
  - “That thing, you stab the food, for eating” instead of “fork”

- What does your brain need to use (propositional) language?



- In about 95% of right-handed people and 75% of left-handed people, which side of the brain is involved in (propositional) language?
  - Left
- Which lobe(s)?
  - Frontotemporal



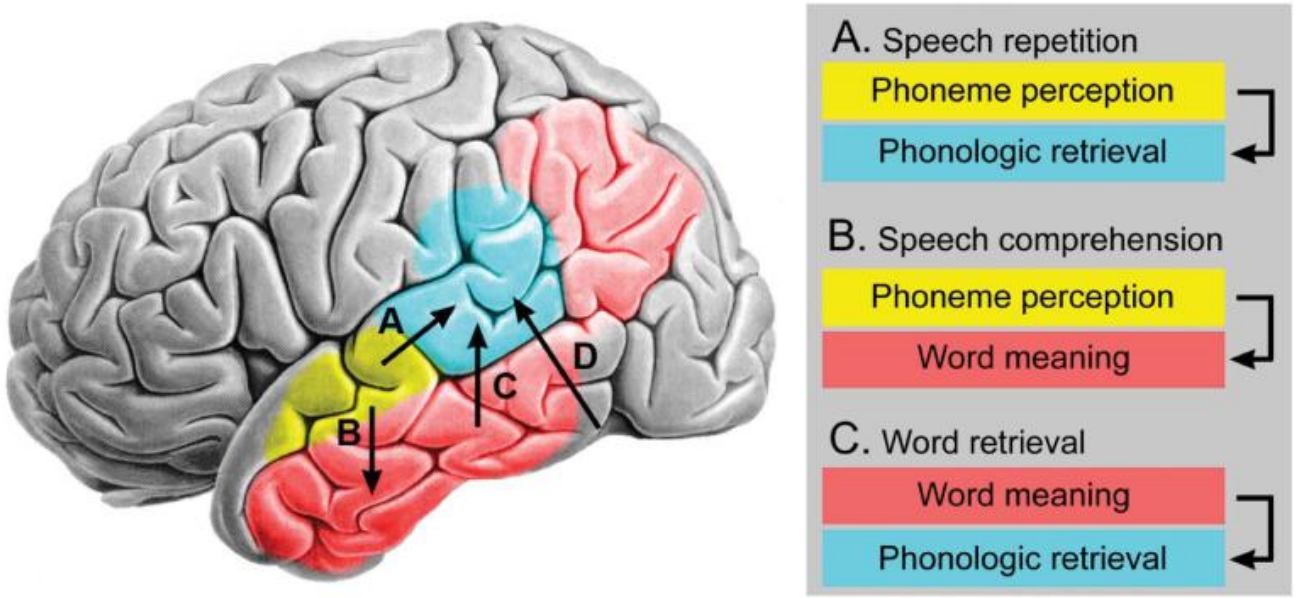
Arcuate fasciculus (and related tracts)

Broca area ("sound-maker")

Wernicke area ("word form storehouse")

This is the CLASSICAL model

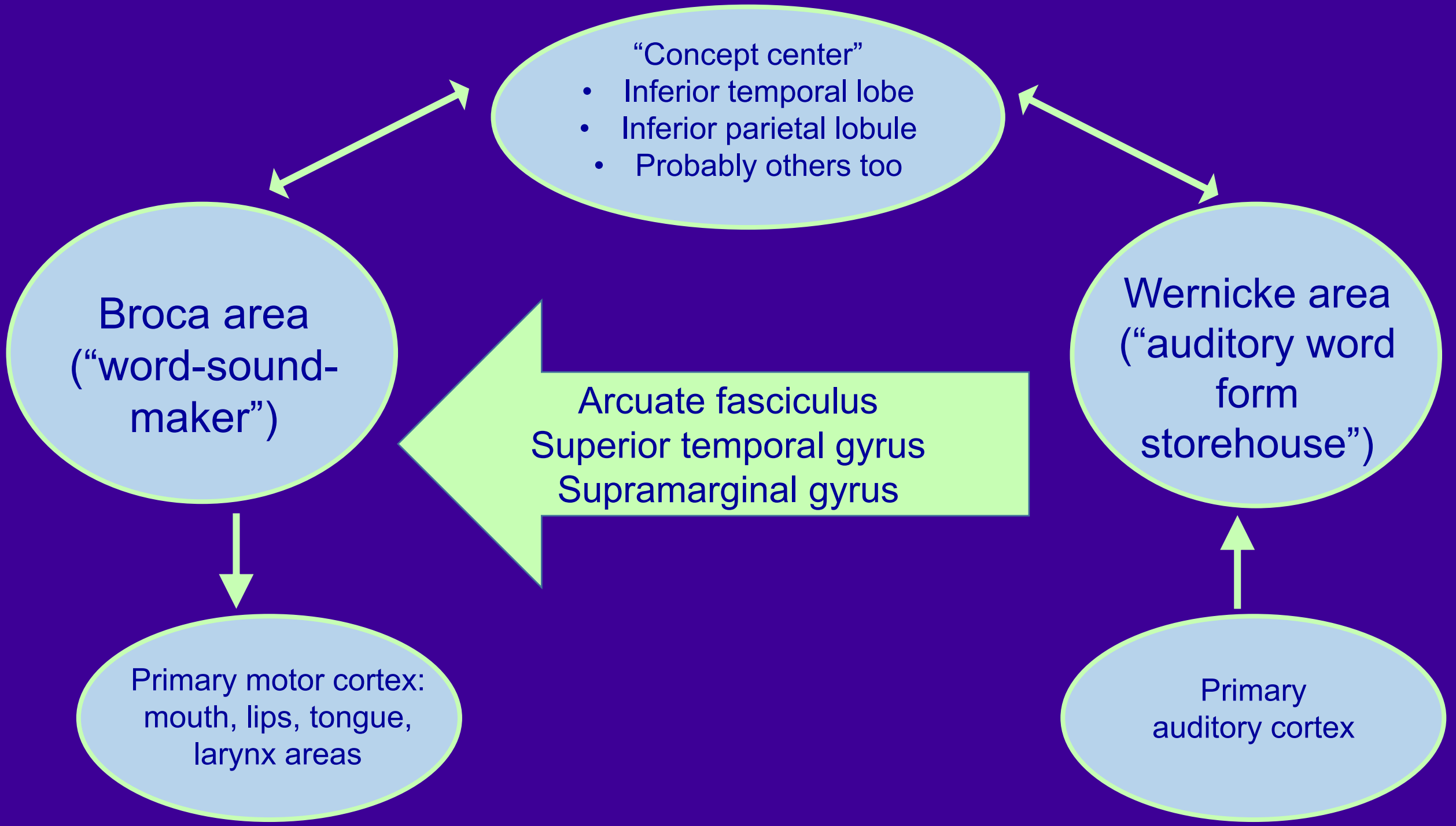
Figure 3 Posterior language systems



A functional model of major posterior language systems. Yellow indicates a bilateral speech phoneme perception system. Blue indicates the Wernicke area, which supports prearticulatory phonologic retrieval. Red indicates the temporal and parietal components of a distributed system for word meaning (semantic) representations. Speech repetition requires the pathway designated A in the figure, as well as more anterior parietal and frontal regions (not shown) that support articulatory preparation and execution. Spoken word comprehension involves the pathway marked B in the figure, which maps perceived phoneme sequences to word concepts. Communicative speech production, in which the speaker retrieves words to express concepts, requires the pathway marked C, which maps concept representations onto phonologic representations. Pathway D indicates a direct mapping from visual word forms to phonologic representations, required for reading aloud. Background brain image reproduced with permission from Springer.

Binder JR. The Wernicke area: Modern evidence and a reinterpretation. Neurology. 2015 Dec 15;85(24):2170-5. doi: 10.1212/WNL.0000000000002219. Epub 2015 Nov 13. PMID: 26567270; PMCID: PMC4691684.

This is probably a more ACCURATE model of what Wernicke area actually does. And Broca area is also involved in processing syntax.


"Concept center"
• Inferior temporal lobe
• Inferior parietal lobule
• Probably others too
Broca area ("word-sound-maker")
Arcuate fasciculus
Superior temporal gyrus
Supramarginal gyrus
Wernicke area ("auditory word form storehouse")
Primary motor cortex: mouth, lips, tongue, larynx areas
Primary auditory cortex

- Crossed aphasia
  - Aphasia in a RIGHT-handed person following a RIGHT hemisphere lesion
  - Rare presentation of aphasia

- Right hemisphere language
  - Right hemisphere DOES have some language functions in right-handed people
    - Overlearned/automatic language
      - Prayers
      - Pledge of allegiance
      - Sequences
        - Days of the week
        - Months of the year

- Right hemisphere language
  - Swear words
    - At least, is function you can still do if you only have right hemisphere language
    - One published case of an individual who lost the ability to swear (and also lost other overlearned/automatic speech; other language functions were WNL)
      - Occurred due to a R hemisphere stroke
        - In R basal ganglia

- Right hemisphere language
  - Prosody
    - Tone of voice
    - Recognizing humor
    - Sarcasm

- Right hemisphere language
  - Singing familiar songs
    - Happy birthday
    - Often preserved in individuals with aphasia following L hemisphere CVA
    - Music is mostly a right-hemisphere function
      - At least melody is R hemisphere function; rhythm may be L hemisphere function
      - For most people, R hemisphere is dominant for music; L hemisphere is more dominant for professional musicians

- Aphasia: deficit in ability to use (propositional) language
  - Can involve deficits in:
    - Fluency
    - Comprehension
    - Repetition
    - Naming
    - Combinations of these
      - Everyone with aphasia has a deficit in naming: to name, you have to be able to identify and then produce the correct word
        - “Sound-maker”, “auditory word form storehouse”, and the connections between them and the rest of the brain all have to be intact
        - If this is the case, you do not have an aphasia

- Aphasia can also cause agrammatism
  - Loss of function words like:
    - ‘the’, ‘he’, ‘she’, ‘but’, etc
    - Agrammatism more common in nonfluent aphasias
    - In fluent aphasias, grammar may be preserved even when content of discourse is empty/incomprehensible
  - Loss of ability to comprehend grammatically/syntactically complex sentences
    - “The boy was hit by the girl”

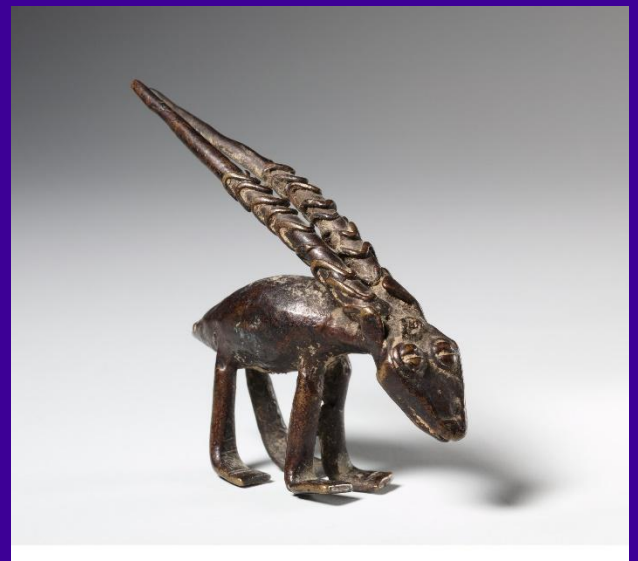
- Aphasia can be classified as fluent or nonfluent
  - Avoid the terms "expressive aphasia" and "receptive aphasia"
  - If you have an aphasia, by definition you have trouble expressing yourself!

Classification of aphasias

	Fluency	Comprehension	Repetition	Naming
Broca aphasia	✗	Relatively ✓	✗	✗
Wernicke aphasia	✓	✗	✗	✗
Conduction aphasia	✓	✓	✗	✗
Transcortical motor aphasia	✗	✓	✓	✗
Transcortical sensory aphasia	✓	✗	✓	✗
Mixed transcortical aphasia	✗	✗	✓	✗
Global aphasia	✗	✗	✗	✗
Anomic aphasia	✓	✓	✓	✗

- Rare forms of aphasia:
  - Aphemia:
    - Complete inability to speak
      - Muteness is generally UNCOMMON in most aphasias (other than aphemia)
- Pure word deafness:
  - Inability to comprehend spoken words
  - All other language modalities and ability to hear intact
  - Due to disconnection between L primary auditory cortex and Wernicke area

- Aphasia is a COGNITIVE deficit, not a motor one
  - IE, aphasia and dysarthria are totally different and unrelated things
    - Though can coexist if damage to areas serving language abilities (Broca area, Wernicke area, connections between the 2, etc) and areas serving motor function of the mouth and tongue (primary motor cortex, cranial nerves)
- Apraxia of speech:
  - A problem with skilled movement of toungue/mouth, not a problem with language



Assessment of Aphasias

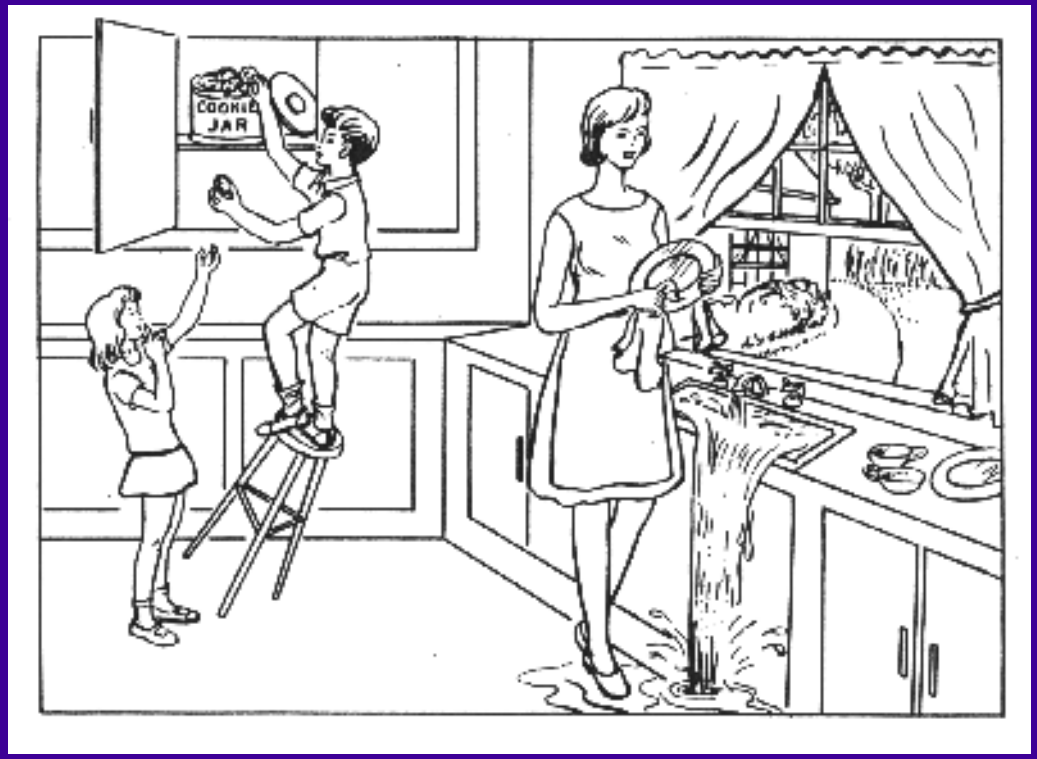
Assessing language function

- Need to evaluate:
  - Fluency
  - Comprehension
  - Repetition
  - Naming

- Sometimes, presence/absence of aphasia is clear from your conversation with the patient
- But to pick up on more subtle deficits, need to formally assess each of the above domains

Fluency

- Listen to patient's spontaneous discourse or their answers to your questions
- Show a picture with a lot going on in it, and ask the patient to describe what is happening
  - Cookie theft picture
    - Free/public domain, online, in the NIH Stroke Scale



Comprehension

- Observation of whether patient can follow conversation and do what you ask him/her to do during the exam
- Ask patient to follow commands
  - Start simple and get more complex
  - Simple command
    - “Close your eyes”
  - Complex commands
    - 2-step command
      - “Point to the table, then point to the window”
    - Syntactically reversed command: hardest type to do
      - “Before you point to the ceiling, point to the floor”
- Ask patient to answer yes/no questions
  - “Does a stone float on water?”
  - “Do you put your shoes on before your socks?”

Repetition

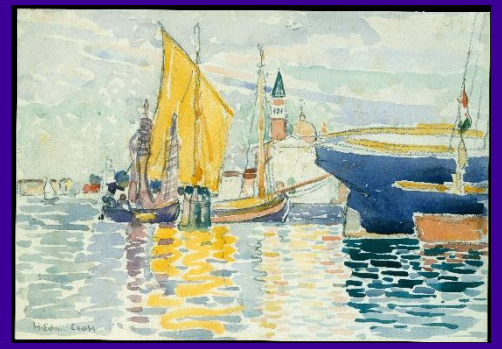
- Observe for echolalia
  - Doctor: “How are you doing today?”
  - Patient: “How I am doing today.”
- Ask patient to repeat to command
  - Simple sentence
    - “Today is a good day”
  - Agrammatical phrase
    - “No ifs, ands, or buts”
  - Syntactically complex sentence
    - “If I were here, she would go”

Naming

- Observe patient's conversation for word-finding difficulty and using the wrong word
- Show the patient objects/pictures and ask him/her to name them
  - Simple objects
    - Naming pictures from the NIH Stroke Scale
    - Multiple real objects in room
  - Parts of objects
    - Pencil eraser
    - Sole of shoe
  - Colors
  - Fingers
  - Can have trouble with just one of these categories even if others are ok

Aphasia batteries for bedside/clinic use

- Western Aphasia Battery-Revised Bedside Tool (WAB-R)
  - Not free, have to buy
  - Takes about 10-15 minutes
  - More challenging than MAST
  - Classifies aphasias by type (e.g., Broca, Wernicke, etc)
- Mississippi Aphasia Screening Test (MAST)
  - Free/public domain, available online
  - Takes about 10-15 minutes
  - Won’t detect more subtle aphasias because fairly easy test
  - Does not classify aphasia types



- Patients with aphasia may show better comprehension / fluency on topics that are personally relevant
  - E.g., when asked to talk about their family, the patient gets more words out and what they say makes more sense than when they're asked to describe what's going on in a random picture from an aphasia battery