

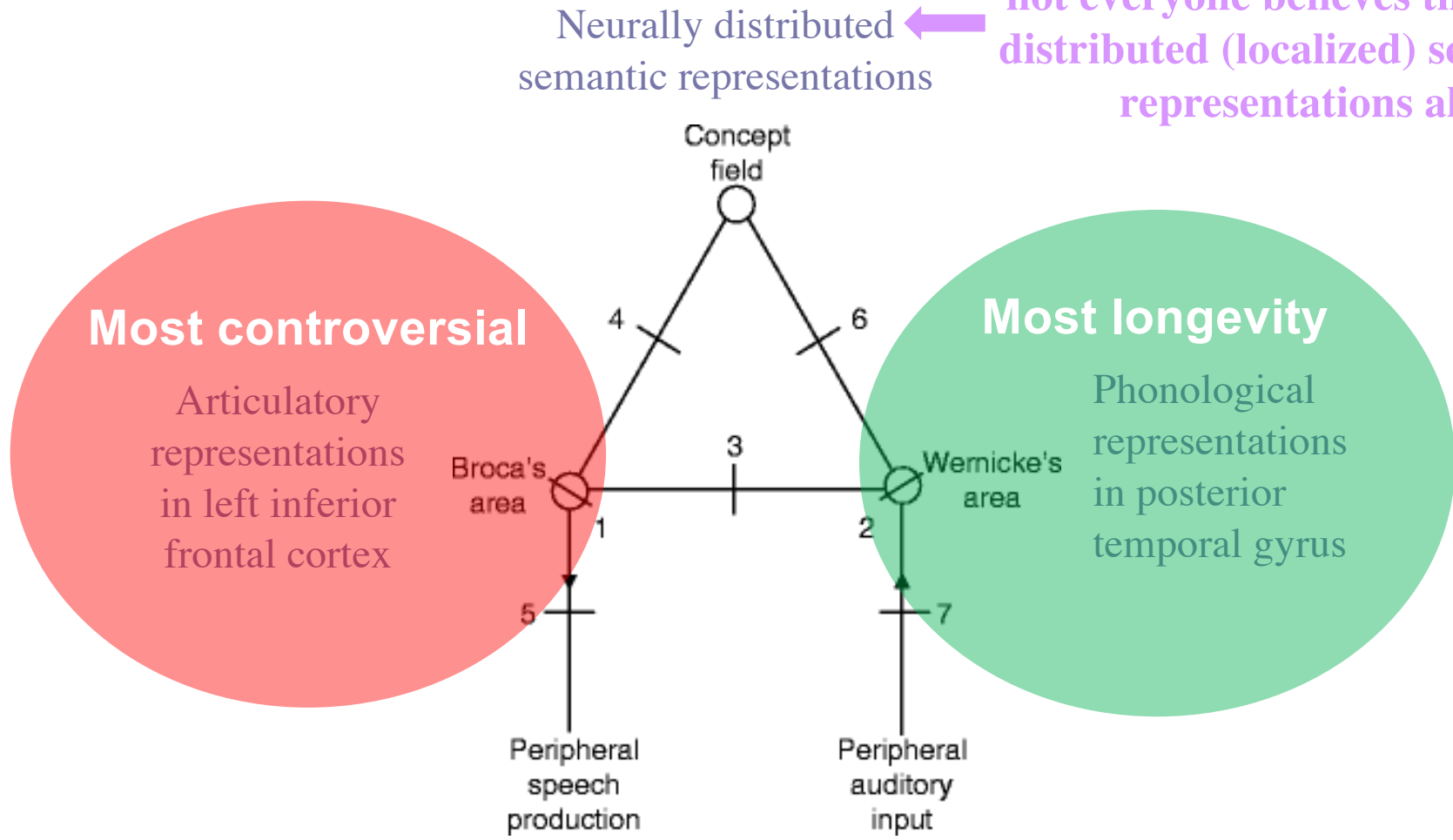
**What has happened to the
“Classic model”?**

Whether the Classic Model is right or wrong, it is incomplete as a model of the neurobiology of Language

- The classic model is limited to the single word level.
- It says nothing about how our brains put words together into larger expressions.
- But the ability to compose complex expressions from simpler parts is the essence of language, so the neural basis of language will ultimately need to say a lot about the neural mechanisms of composition.

Classic model today

Everyone agrees that distributed semantic representations exist but not everyone believes that non-distributed (localized) semantic representations also exist

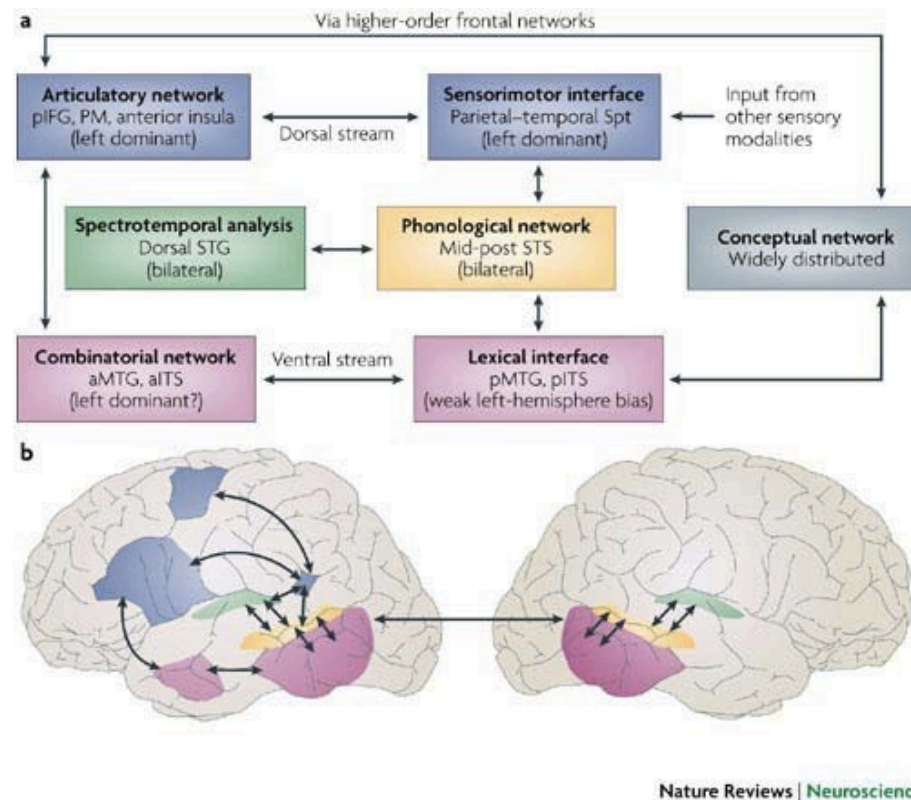


Connection between Broca's & Wernicke's areas:
arcuate fasciculus (3)

← Yup, still connected

Wernicke's area today

Neural basis of speech perception Hickok & Poeppel, 2015



The Encoding of Speech Sounds in the Superior Temporal Gyrus Gyol, Leonard, Chang, *Neuron* 2019

The human superior temporal gyrus (STG) is critical for extracting meaningful linguistic features from speech input. Local neural populations are tuned to acoustic-phonetic features of all consonants and vowels and to dynamic cues for intonational pitch. These populations are embedded throughout broader functional zones that are sensitive to amplitude-based temporal cues. Beyond speech features, STG representations are strongly modulated by learned knowledge and perceptual goals. Currently, a major challenge is to understand how these features are integrated across space and time in the brain during natural speech comprehension. We present a theory that temporally recurrent connections within STG generate context-dependent phonological representations, spanning longer temporal sequences relevant for coherent percepts of syllables, words, and phrases.

Wernicke's area today

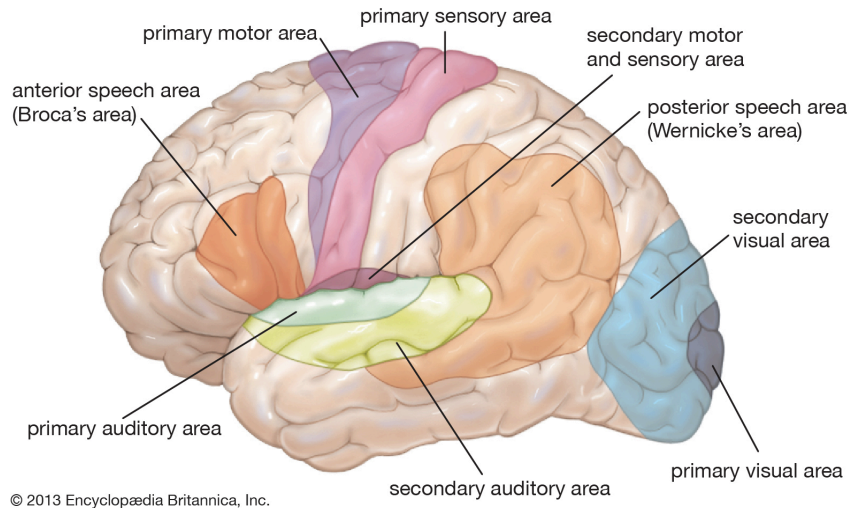
CLEAR:

Posterior superior temporal cortex
represents speech sounds.

NOT CLEAR:

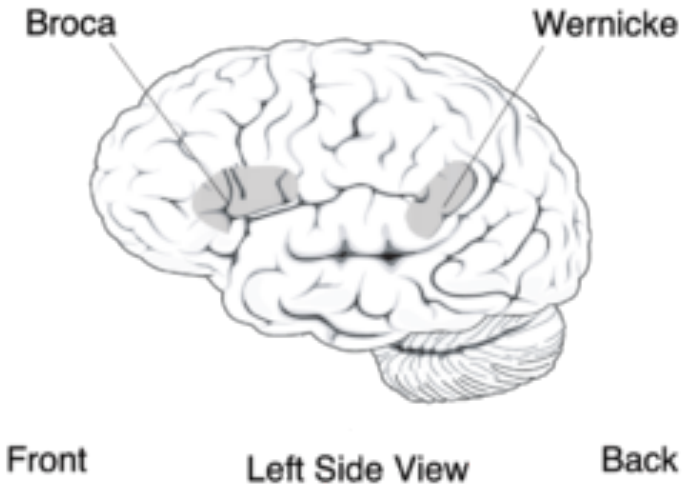
Where “Wernicke’s area” actually is.

Wernicke's areas revealed by Google Image...

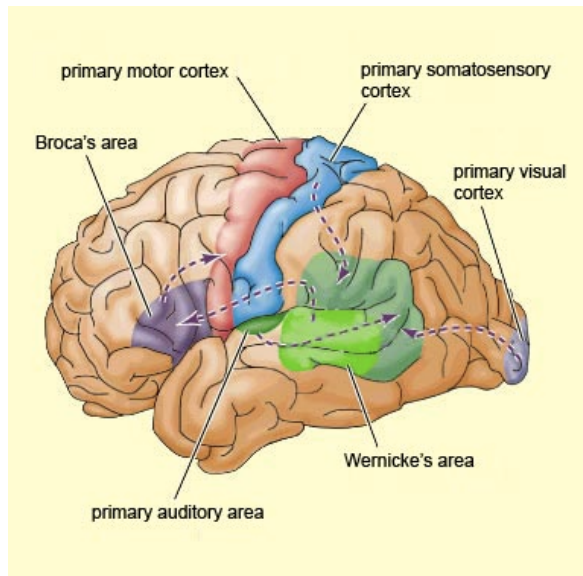


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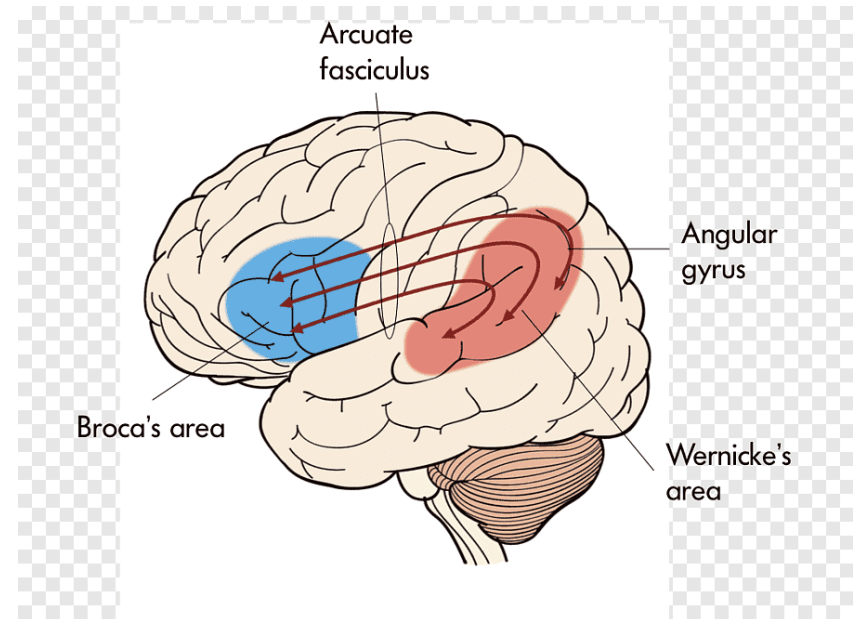
<https://www.britannica.com/science/Wernicke-area>



https://en.wikipedia.org/wiki/Wernicke%27s_area

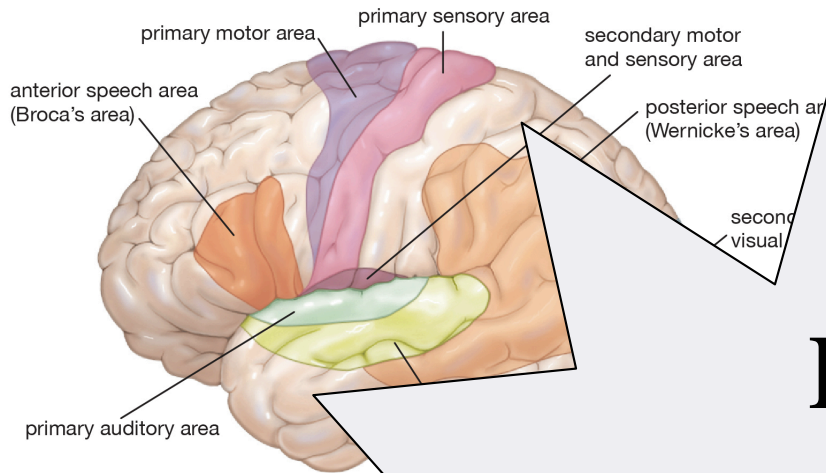


https://thebrain.mcgill.ca/flash/i/i_10/i_10_cr/i_10_cr_lan/i_10_cr_lan.html

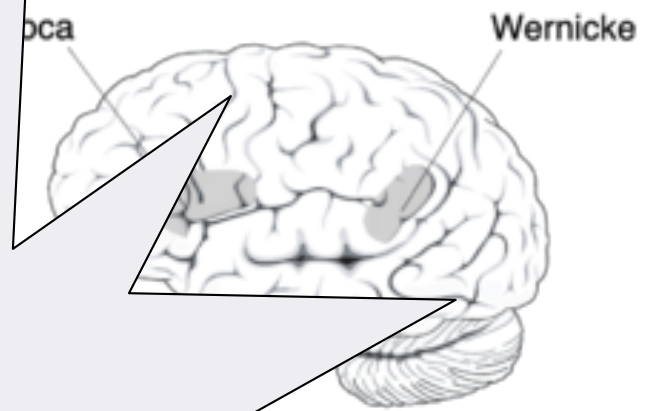


<https://www.pngegg.com/en/png-xmcmk>

Wernicke's areas revealed by Google Image...



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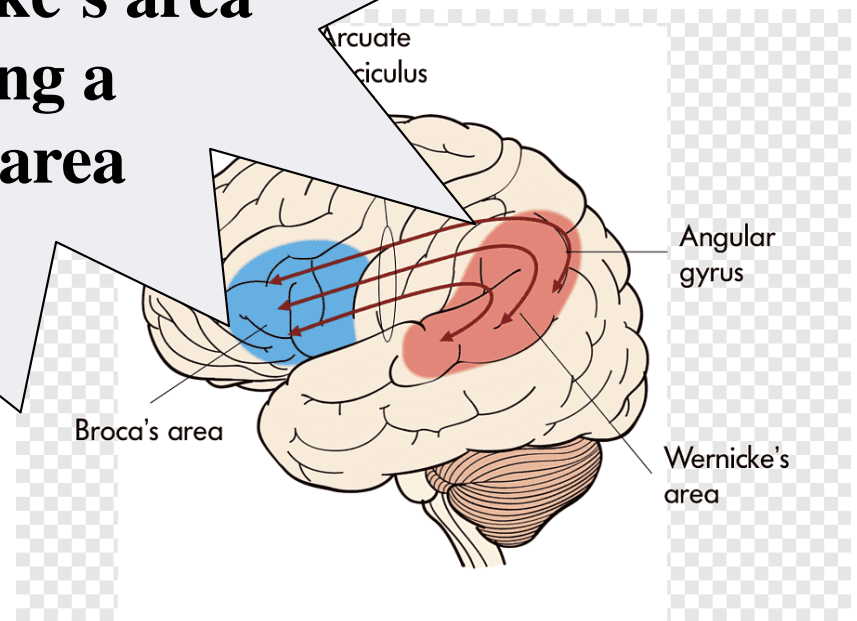
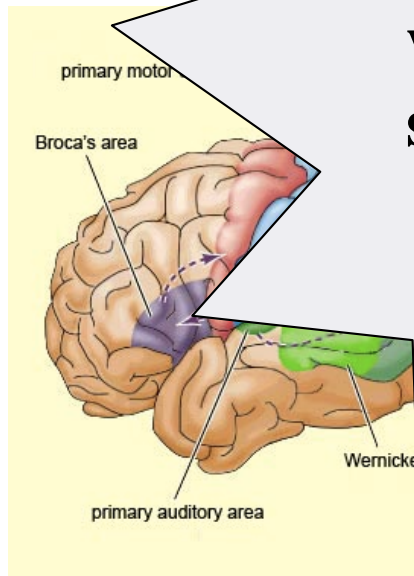


Left Side View Back

https://en.wikipedia.org/wiki/Wernicke%27s_area

Huh??

Pro tip: Don't use the term "Wernicke's area" when describing a specific brain area

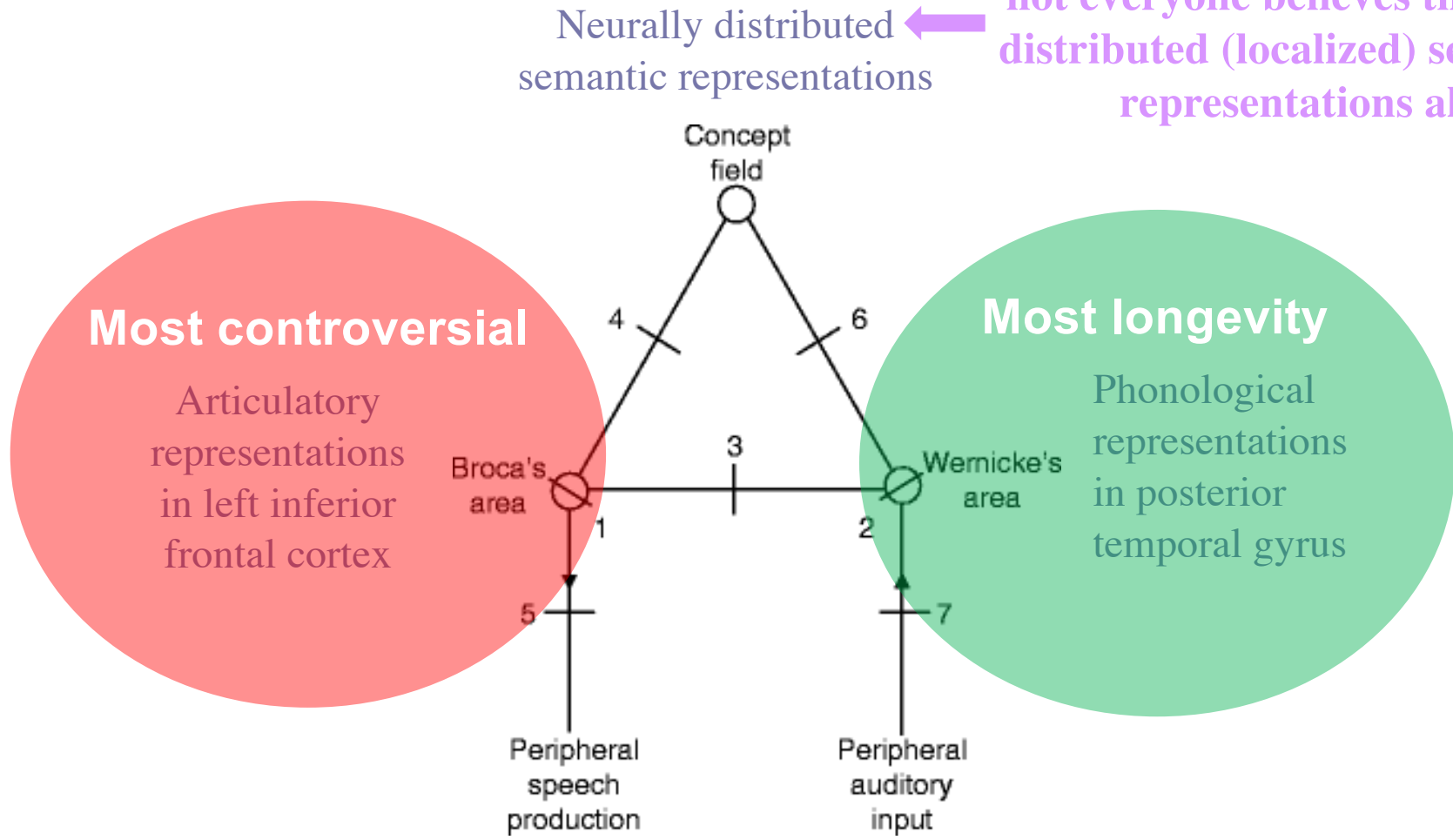


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Classic model today

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Connection between Broca's & Wernicke's areas:
arcuate fasciculus (3)

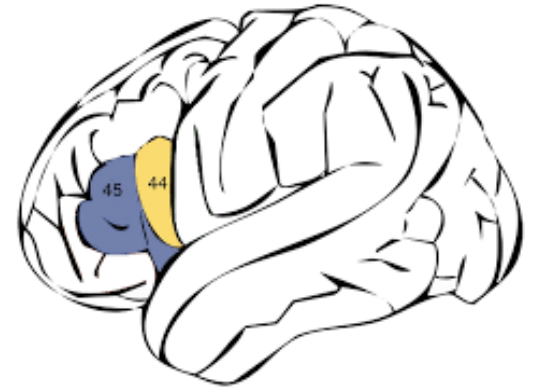
← Yup, still connected

Broca's area today

CLEAR:

Where Broca's area is:

BAs 44 & 45



https://en.wikipedia.org/wiki/Broca%27s_area

NOT CLEAR:

What Broca's area does

production

syntax

lexical access

morphology

Goodglass & Kaplan, 1983: Broca's aphasia not just a production problem.

- Broca's aphasics "may be confused by more complex spoken messages."
 - In particular, errors for expressions in which the canonical order of actor (agent) and acted-upon (patient) is reversed.
 - Easy: The girl chased the boy.
 (active)
 - Hard: The boy was chased by the girl ... (passive)
- Stromswold et al. (1996): "Localization of syntactic comprehension by positron emission tomography"**
- Difficult syntax engages Broca's area more than easy syntax in healthy participants.

→ Birth of a prominent (but problematic) hypothesis that Broca's area is the "syntax region" of the brain

Towards more nuanced theories of Broca's area and production

E.g.:

Broca's area is widely recognized to be important for speech production, but its specific role in the dynamics of cortical language networks is largely unknown. Using direct cortical recordings of these dynamics during vocal repetition of written and spoken words, we found that Broca's area mediates a cascade of activation from sensory representations of words in temporal cortex to their corresponding articulatory gestures in motor cortex, but it is surprisingly quiescent during articulation. Contrary to classic notions of this area's role in speech, our results indicate that Broca's area does not participate in production of individual words, but coordinates the transformation of information processing across large-scale cortical networks involved in spoken word production, prior to articulation.

Flinker et al. *PNAS* 2015

**The functional role of
Broca's area
remains controversial**

Further:

Today, we know that there is only a weak correlation between

- (a) damage in Broca's area**
- and**
- (b) Broca's aphasia**

Diagnosis of aphasia

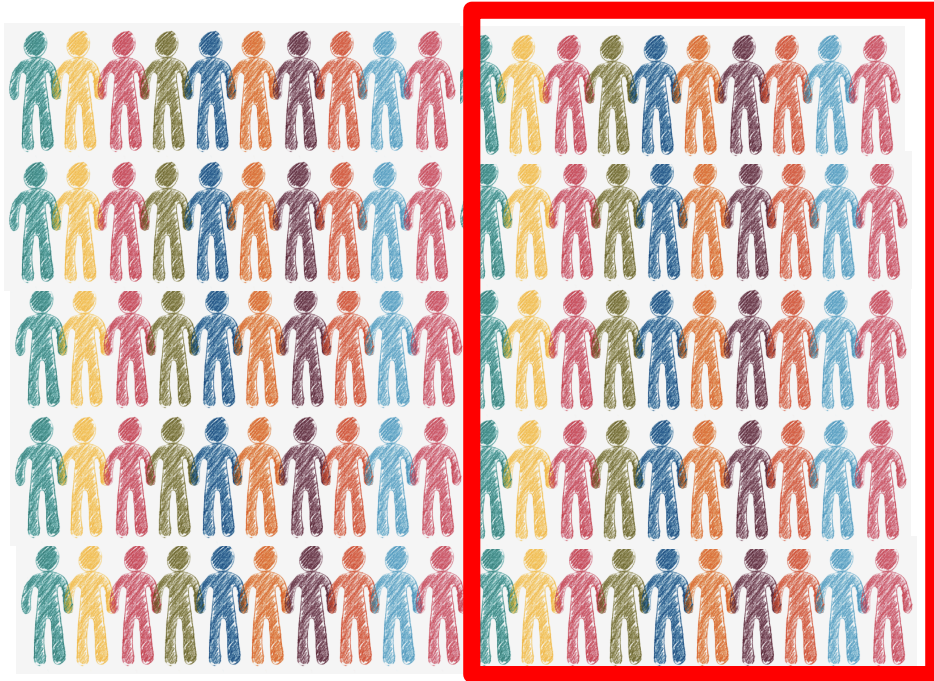
- Always done on the basis of performance on a battery of language tests, such as the Boston Diagnostic Aphasia Examination or the Western Aphasia Battery.
- Lesion site does not play into the diagnosis.
- Thus it is possible to have Broca's aphasia without having damage to Broca's area and Wernicke's aphasia without damage to Wernicke's area.



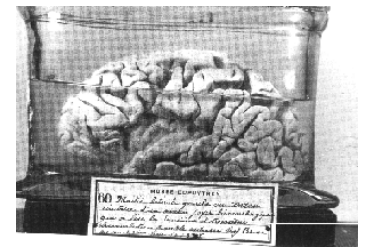
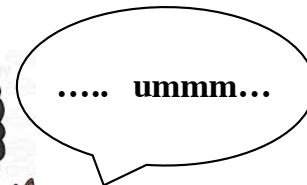
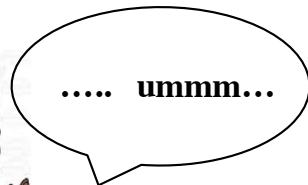
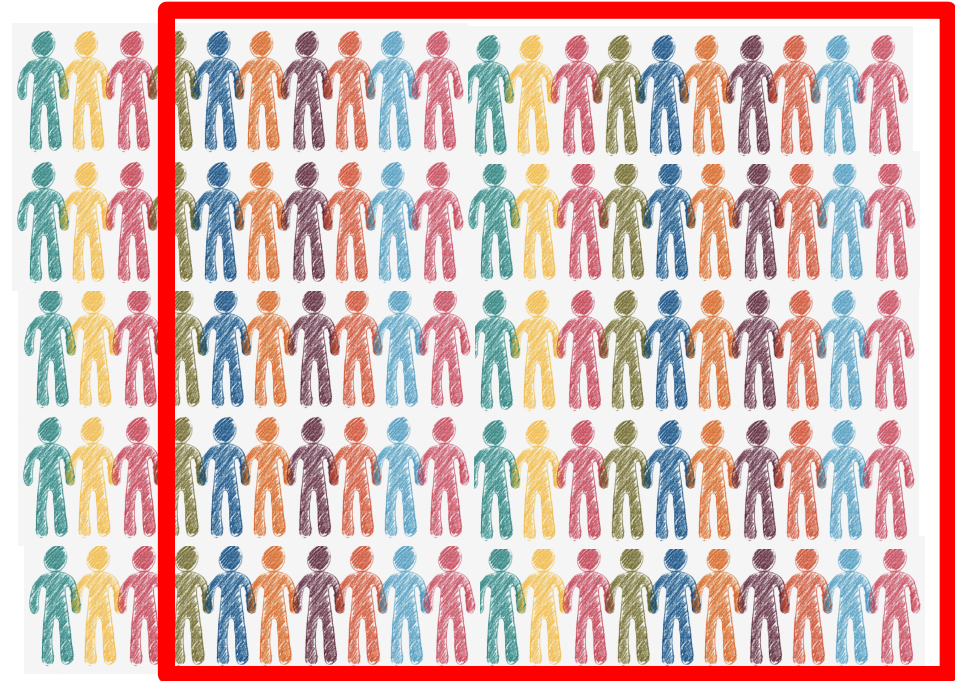
Nina Dronkers

Broca's area and Broca's aphasia

50-60 percent of patients with lesions in Broca's area have a persisting Broca's aphasia



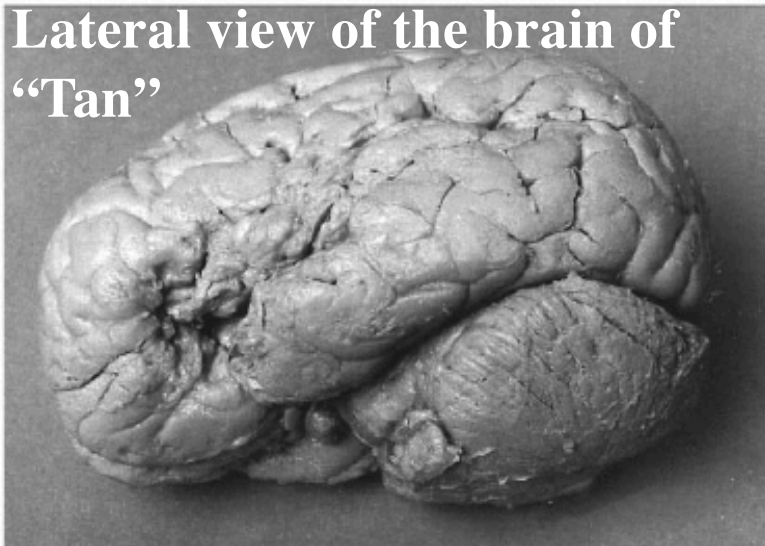
85 percent of patients with chronic Broca's aphasia have lesions in Broca's area.



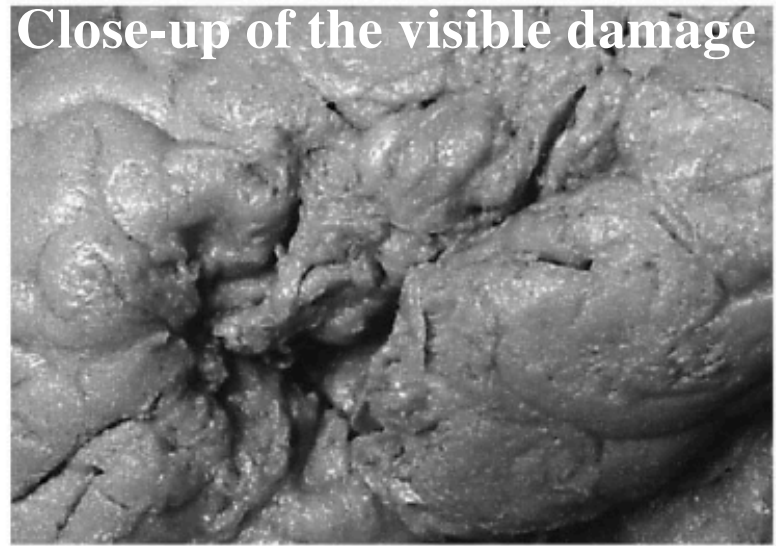
AND, turns out... (Dronkers et al., 2007)

- ... that even Broca's original patient, "Tan," had damage that was much more extensive than the left inferior frontal gyrus (aka Broca's area).
- Broca could not know this since he chose to not dissect the brain and instead preserved it in alcohol in a Paris museum.
- Thanks to this, it has been possible to imagine the brain with high resolution MRI...

A Lateral view of the brain of "Tan"

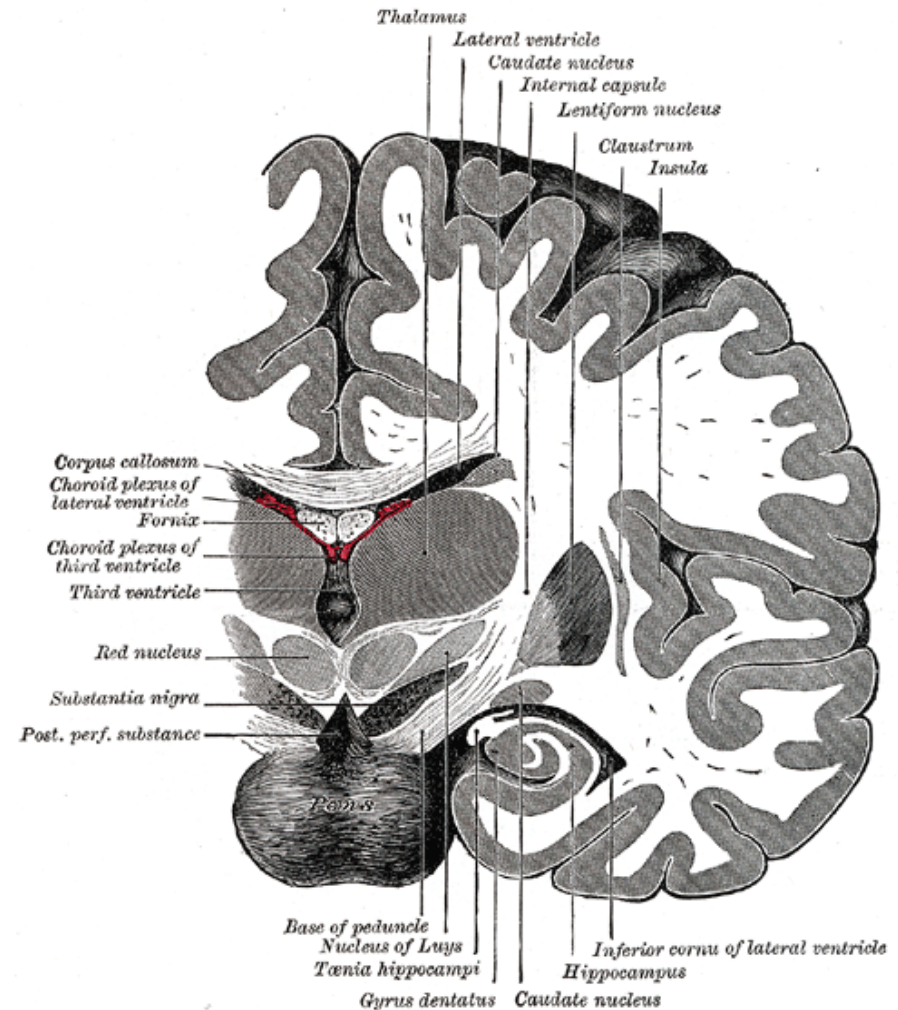


B Close-up of the visible damage



In Broca's original case, significant damage throughout the left hemisphere, both cortically and subcortically (Dronkers)

- The left hemisphere was clearly smaller and distorted due to the destruction of cortex and white matter throughout the hemisphere.
- Lesion sites:
 - **left inferior frontal gyrus**
 - **deep inferior parietal lobe**
 - **anterior superior temporal lobe**
 - **extensive subcortical involvement** (including the claustrum, putamen, globus pallidus, head of the caudate nucleus and internal and external capsules)
 - **The insula was completely destroyed.**
 - **The entire superior longitudinal fasciculus, along with other frontal-parietal white matter.**
 - **The medial subcallosal fasciculus**
- The right hemisphere was unaffected



- If Broca had had access to modern brain imaging, his conclusions about the brain organization of language would have been very different. The highly simplistic “classic model of language” probably would have never existed.

Recovery

- During the first three months after stroke, lots of reorganization can happen, even complete, spontaneous recovery.
- The subjects in aphasia studies are not recent stroke victims but rather patients whose situations have stabilized.
- Lots of variability in the extent to which recovery occurs later on.
- All this complicates our ability to use aphasiology to inform brain function.