

LANGUAGE AND THE BRAIN

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Aims of the Lecture.

- ▣ Provide an introduction to the storage of Words and Language Processing.
- ▣ An Exploration into the Neuropsychology of Language.
- ▣ Discuss issues that challenge neuroscience in relation to Language processing.
- ▣ Consider more recent neuro-scientific research in relation to mono, bilinguals and multi-linguals.
- ▣ Consider research exploring language laterality – what does this mean for left handers.

The Storage of Words and Concepts

- ▣ Psycholinguistics
- ▣ Mental Lexicon (mental store of word information)
 - Semantic Information
 - Syntactic Information
 - Word Forms

- ▣ A normal adult (native) speaker has passive knowledge of approximately 50,000 words
- ▣ Mental Lexicons must be organised in a highly efficient manner.
- ▣ How do we organise these lexicons?

Auditory Neighbourhood.

- ▣ Number of words that differ from the target word by only one phoneme.
- ▣ Studies have shown that words that have more neighbours = identified more slowly.
- ▣ E.g. Hate
 - late, mate, fate, rate, eight, bait etc.

Neuropsychology of Language

- ▣ Studies of brain damaged/ diseased patients have provided numerous insights into language
- ▣ One of the more difficult areas to assess.
- ▣ Why?

Aphasia

- ▣ Aphasia – Aphatos (Greek Word – Speechless)
- ▣ Impairment in language comprehension and/or production that accompany neurological deficits.
- ▣ Aphasia = collective term, there are specific types of Aphasia (e.g. Wernicke's Aphasia)
- ▣ Common = 40% of all strokes.

Aphasia

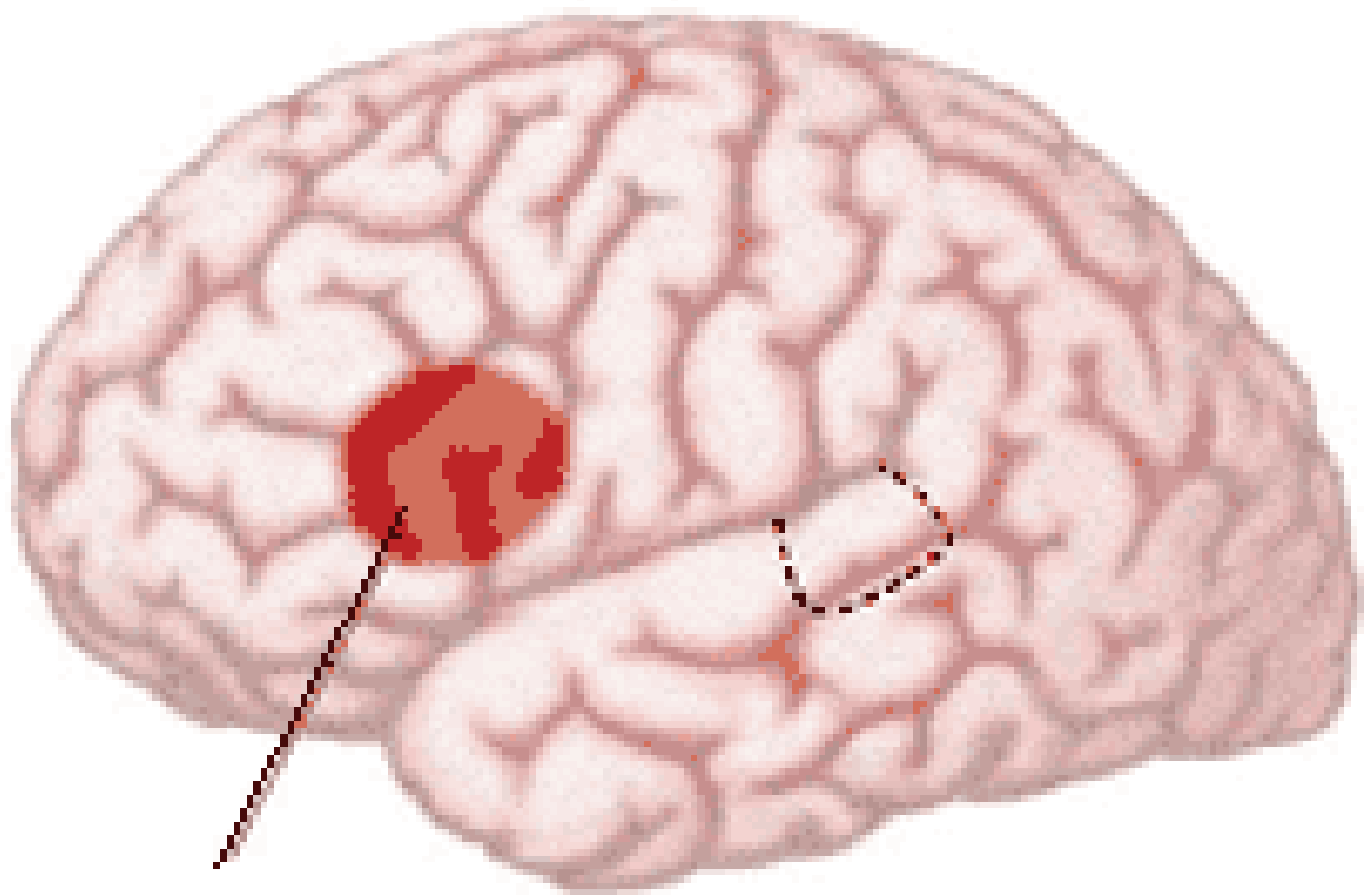
- Primary Aphasia
 - Problems with the language processing mechanisms
- Secondary Aphasia
 - Language issues as a result of memory impairments, attention disorders or perceptual problems.

History of Language Research

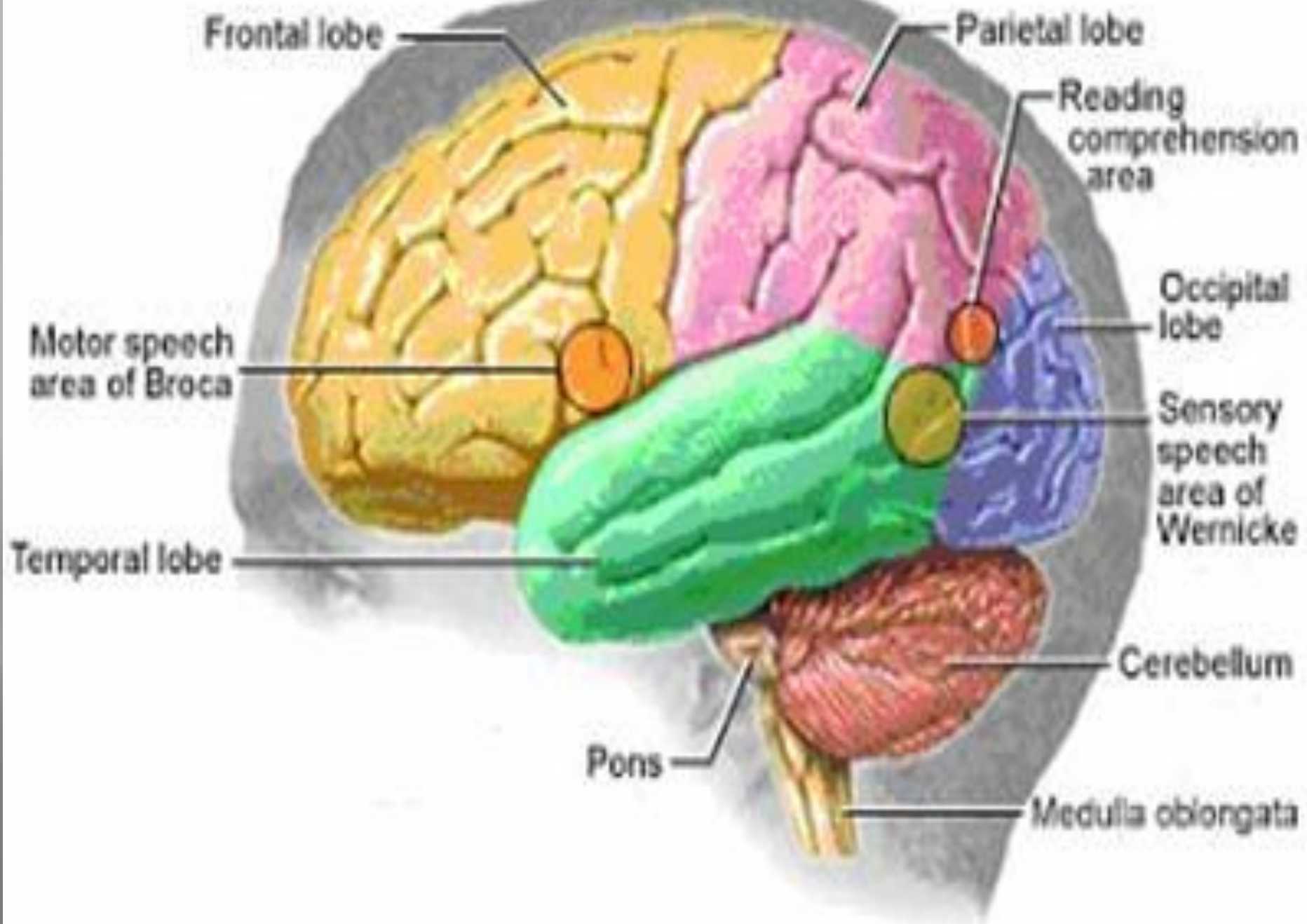
- ▣ Jean-Baptiste Bouillaud
 - Brain Injured Patients
 - Language resided in the Frontal Lobe

- ▣ Paul Broca
 - Patient called 'Tan' - autopsy
 - Brain lesion in the posterior portion of the left inferior frontal gyrus (Broca's area).

- ▣ Broca's studies noted that patients with language problems also generally had right hemiparesis.
- ▣ Led to the deduction that speech is localised in 'Broca's Area' – Inferior frontal lobe of the left hemisphere.

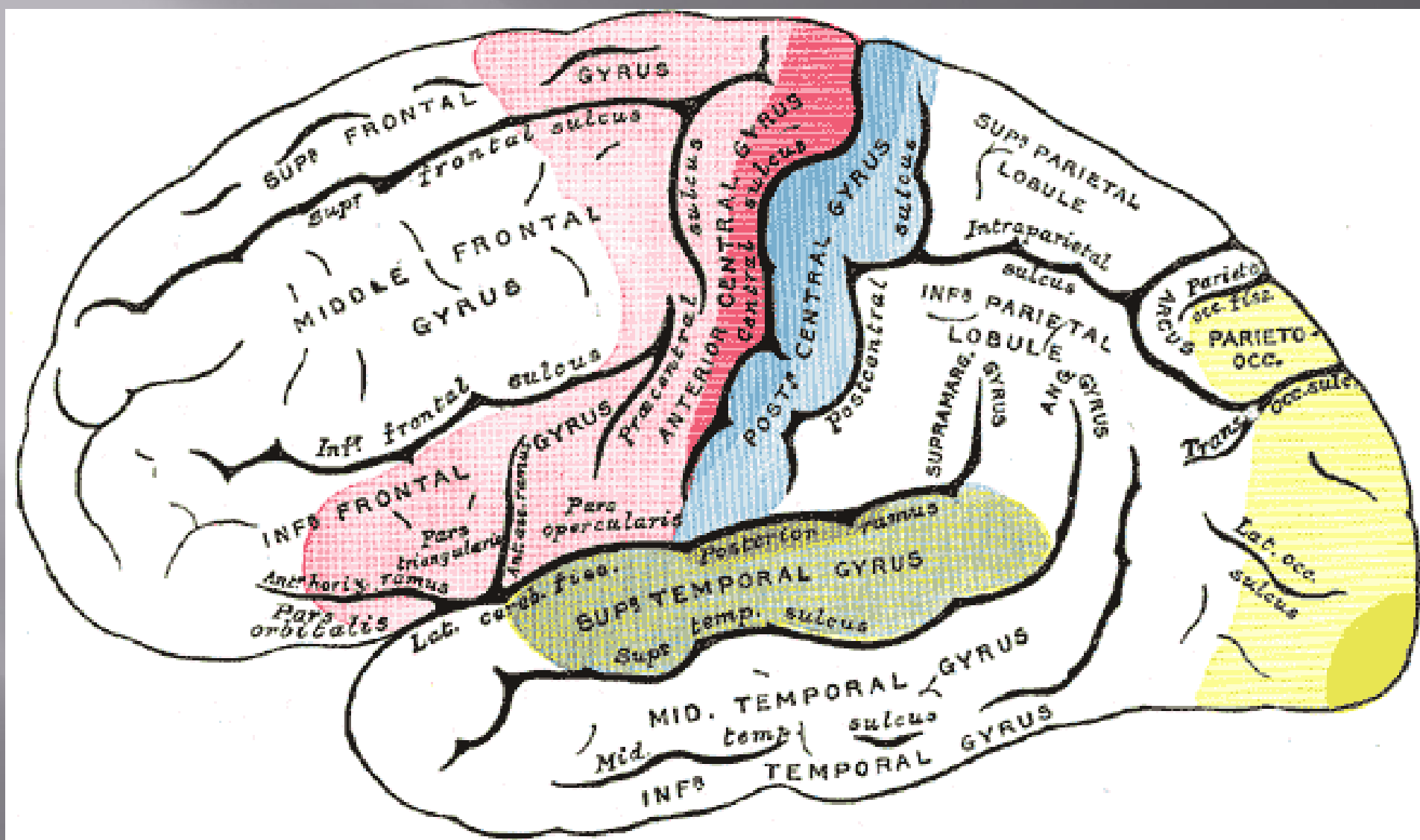


Broca's Area



Carl Wernicke

- ▣ His stroke patients had fluent speech but spoke nonsensical sounds, words and sentences.
- ▣ Deficits in comprehending what was spoken to them.
- ▣ Autopsy revealed damage to the posterior region of the Superior temporal gyrus.

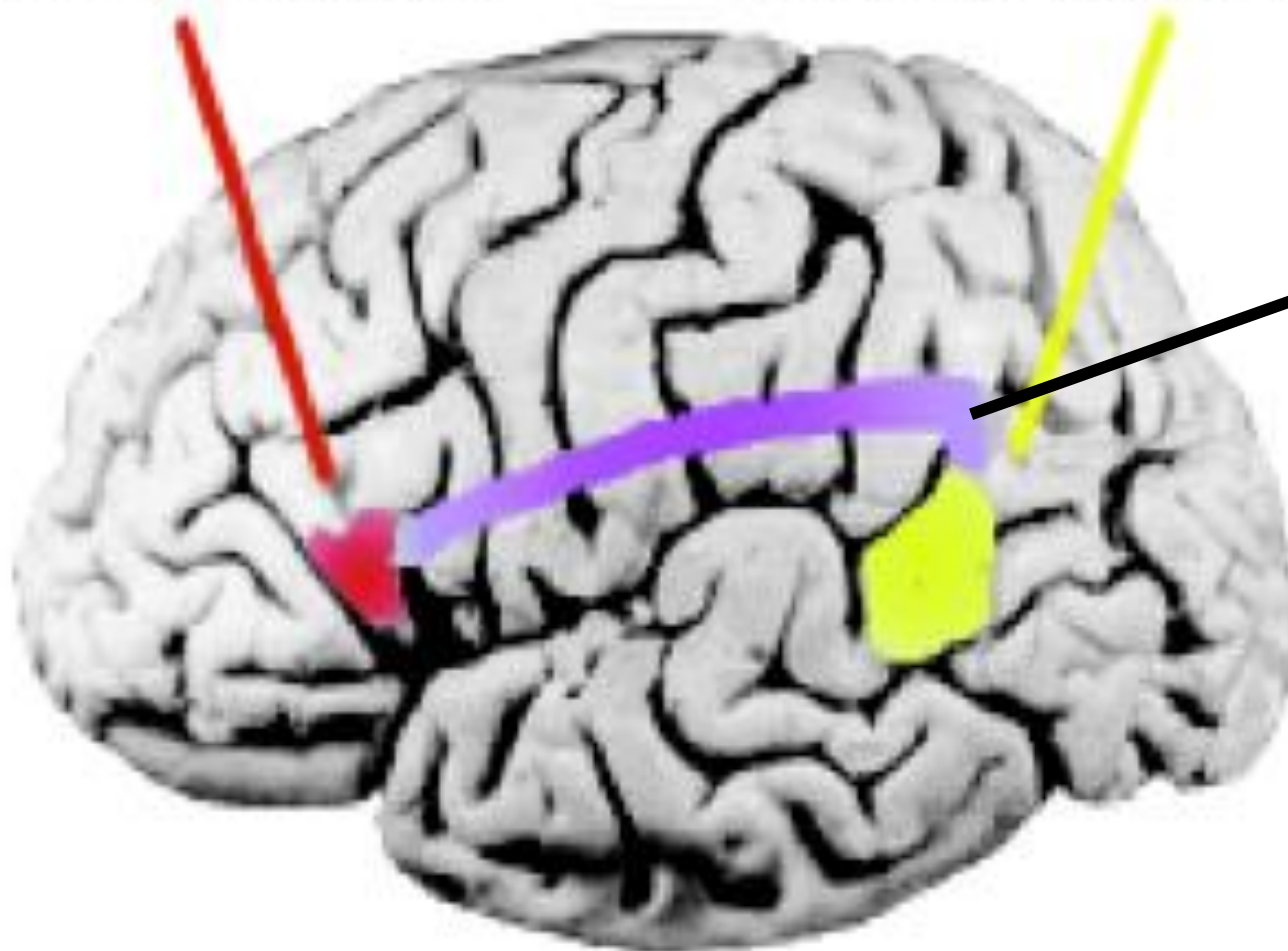


- ▣ Wernicke concluded that this region participated in the auditory storage for words – as it was located close to where auditory processing takes place.

- ▣ Wernicke's area
 - Damage produces poor language comprehension – lost word related memories

Broca's area

Wernicke's area



Arcuate
Fasciculus

Classification of Aphasia

- ▣ Three main test parameters for language disorders
 - Spontaneous Speech
 - Auditory Comprehension
 - Verbal Repetition

Broca's Aphasia

- ▣ Speech difficulties
- ▣ Wide range of symptoms include
 - Unintelligible mutterings
 - Simple sentences that lack functional words or grammatical markers.

Broca's Aphasia

- Speech is often telegraphic and uneven.
- Dysarthria.
- Speech Apraxia.
- Sometimes the patient can sing, count and/or recite phrases.

Broca's Aphasia

- ▣ Can also have comprehension deficits.
 - E.g. Researcher – ‘The boy was hit by the girl. – Who hit whom?’
 - Patient – ‘Boy hit Girl.’

- ▣ Broca's aphasics do have grammatical knowledge, but can have deficits in processing the grammatical aspects of language.

- ▣ Broca's aphasia was related to damage to Broca's area.
- ▣ However, it has been challenged.
- ▣ What about these comprehension deficits?

- ▣ Other studies – Damage to Broca's area without speech deficits.
- ▣ Speech deficits in regions outside Broca's area
- ▣ Dronkers (1996) – only 10 out of 22 participants with lesions in Broca's area alone had Broca's aphasia.

- ▣ Broca's area on the surface of the cortex – grey matter.
- ▣ What about the white matter, deeper in the cortex?
- ▣ Donkers (1996)

- ▣ Tan
- ▣ CT scans of his brain
 - Lesions were extended beyond what Broca himself concluded.
 - Insular cortex and portions of the basal ganglia.
- ▣ Therefore, Broca's regions is not solely responsible for the deficits of Broca's aphasics.

Broca's Aphasia.

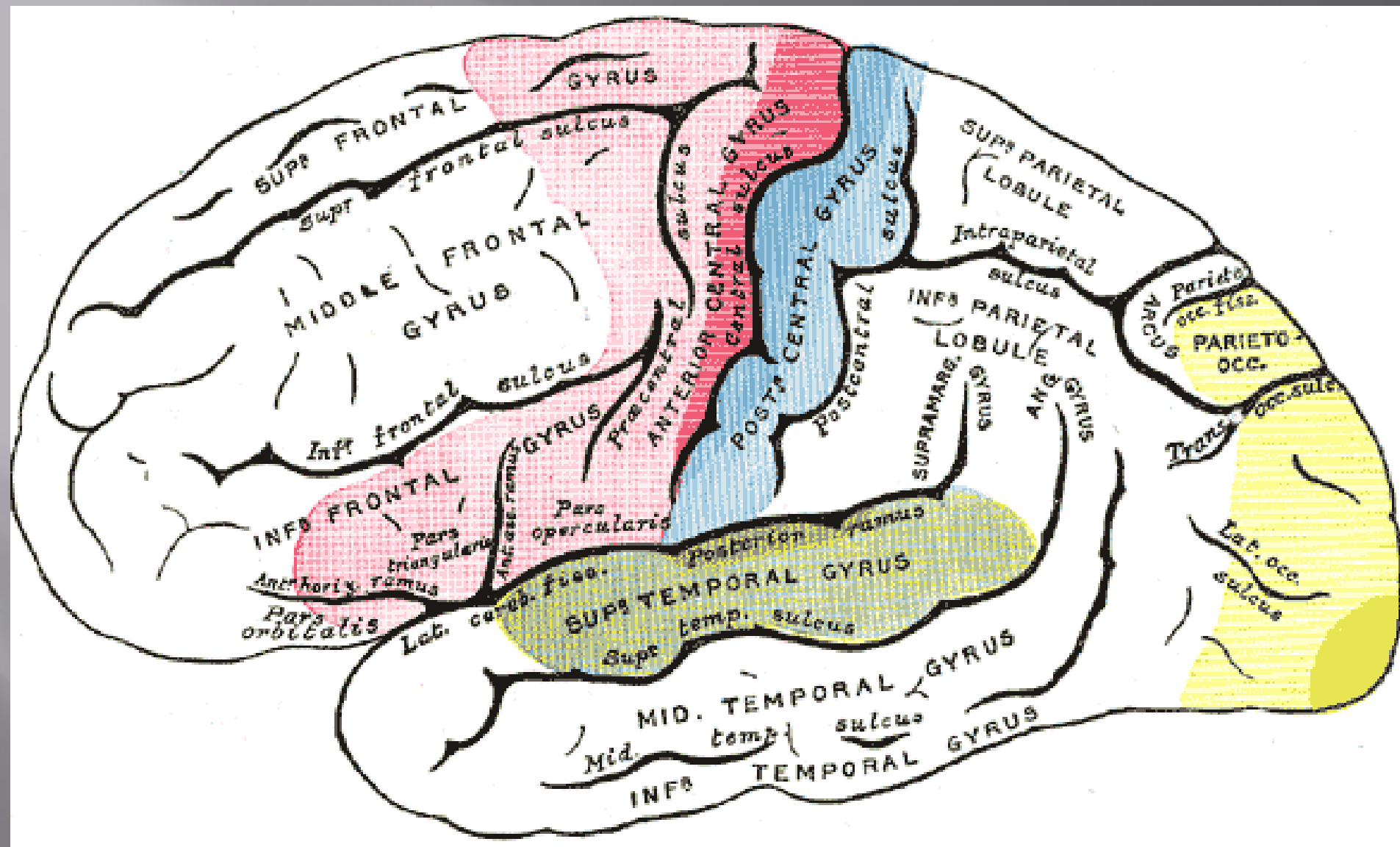
- ▣ <http://www.youtube.com/watch?v=f2IiMEbMnPM>

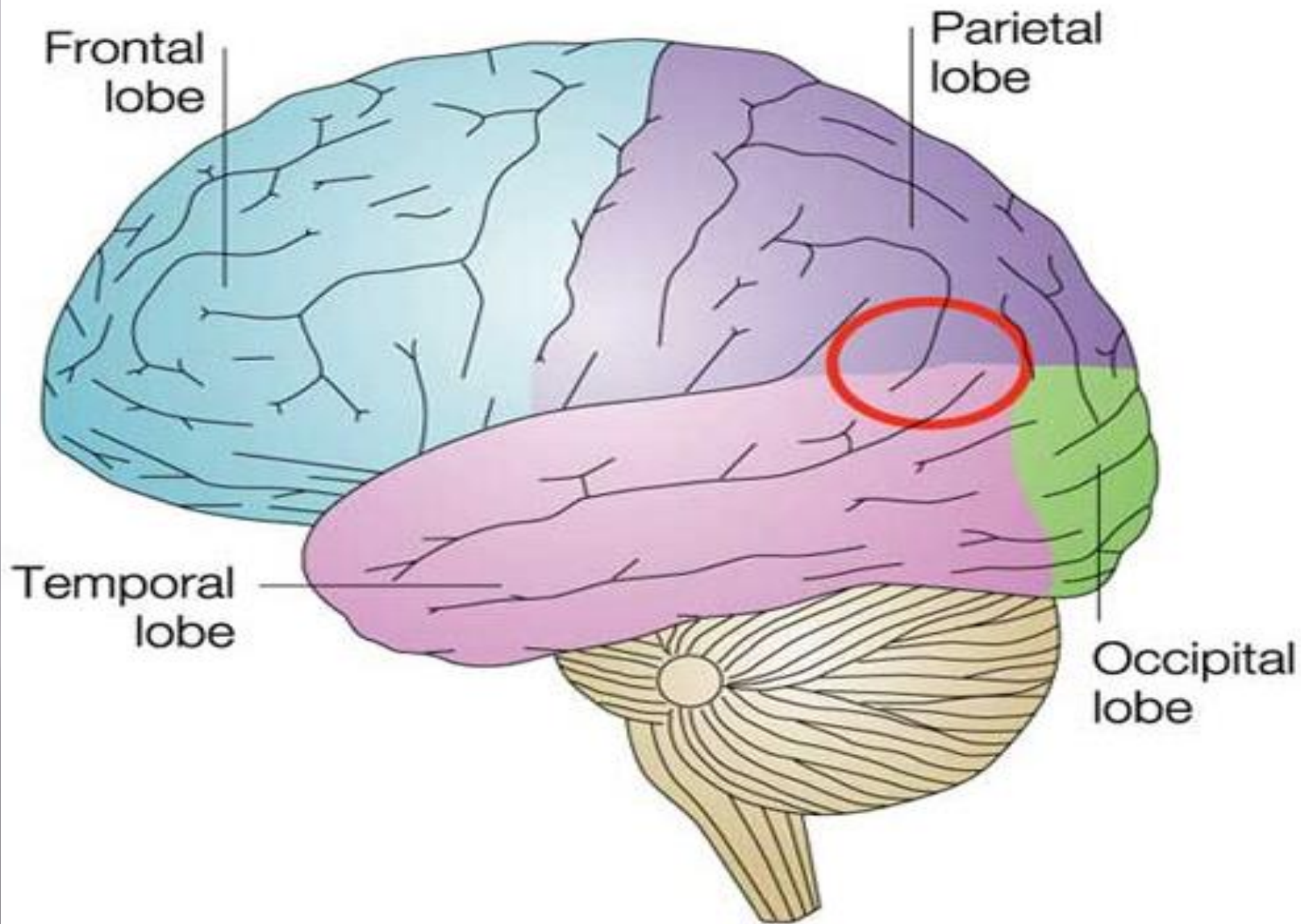
Wernicke's Aphasia

- ▣ Primarily a disorder of language comprehension
- ▣ Problems understanding spoken or WRITTEN language
- ▣ Can speak fluent sounding speech but the speech is meaningless.

Wernicke's Aphasia

- Wernicke's Area = Posterior third of the Superior Temporal Gyrus (STG)
- Originally deduced that Wernicke's Aphasia occurs at the Wernicke's Area.
- Subsequent studies/report have reported other areas
 - Junction between parietal and temporal lobe.





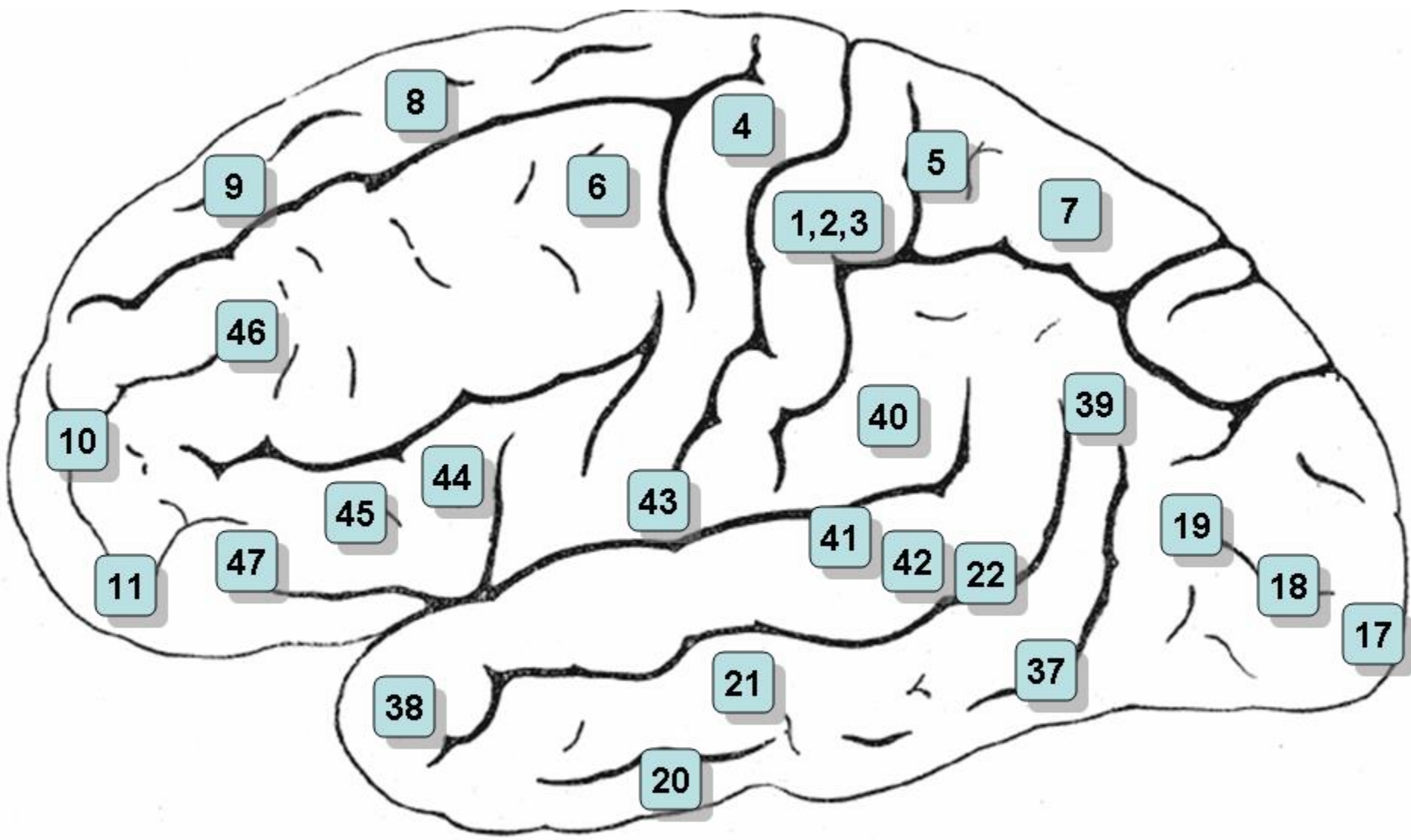


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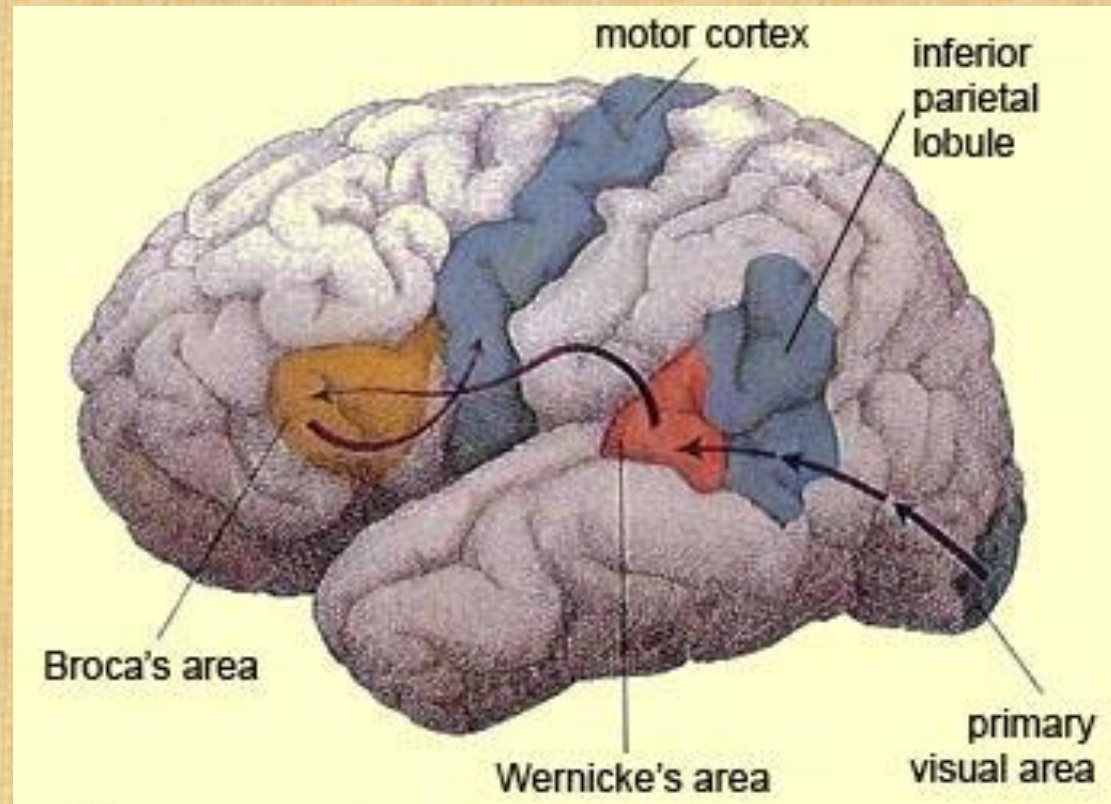
The Wernicke-Geschwind model (Geschwind, 1970, 1972, 1979)

- ▣ The meaning of words is represented in Wernicke's area.
- ▣ When a person listens to speech, word sounds are sent through the auditory pathways to the primary auditory cortex, Heschl's gyrus.
- ▣ From there, they are relayed to Wernicke's area, where the sense of words is extracted



To speak, word meanings must be sent over the arcuate fasciculus to Broca's area, where morphemes are assembled.

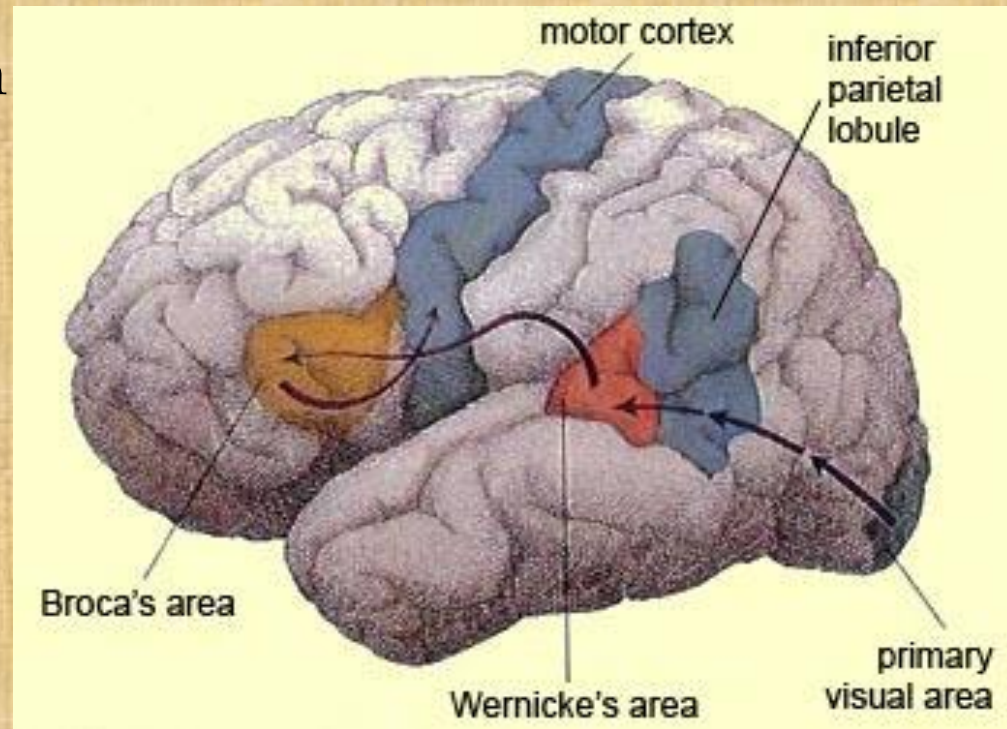
The model proposes that Broca's area holds a representation for articulating words



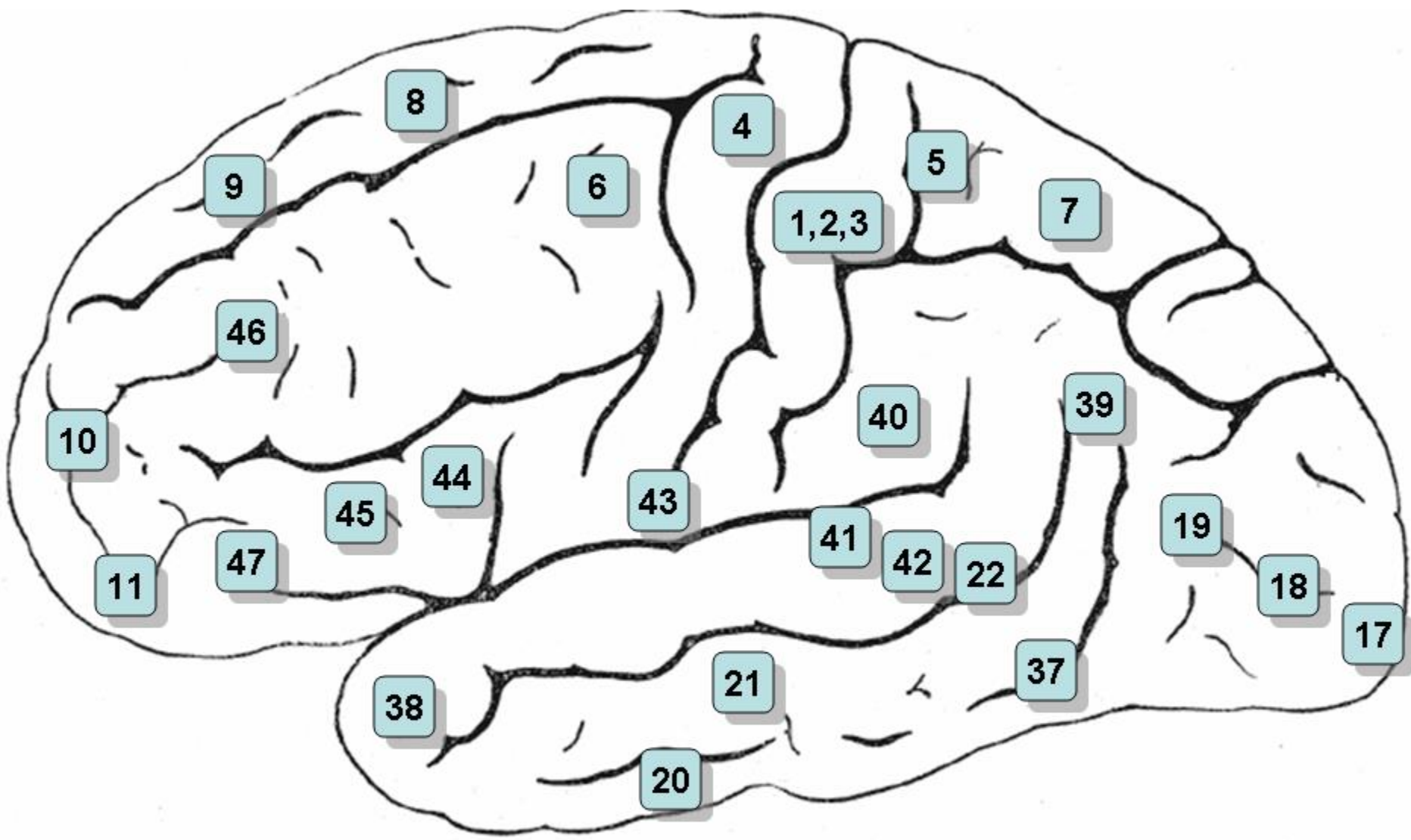
To answer a verbal question - progression of activity from the auditory cortex, to Wernicke's area, and then to Broca's area.

Broca's area then formulates articulation of the verbal response and sends the result to the facial area of the *motor cortex*

From there, instructions are sent to facial motor neurons in the brainstem, which relay movement commands to facial muscles which produces the speech



- ▣ Reading requires that information concerning handwritten or printed words be sent from visual areas 17, 18 and 19 to the angular gyrus (area 39).
- ▣ From there to Wernicke's area, which reads silently, or in conjunction with Broca's area, which reads aloud.



- ▣ <https://www.youtube.com/watch?v=3oef68YabD0>

Wernicke's Aphasia

- ▣ In one study out of 70 patients with Wernicke's Aphasia, 7 had damage confined to regions outside of Wernicke's area.
- ▣ Some patients – lesions in WA may be able to comprehend more in time.
 - Symptoms improved over time.

Recent Studies in Wernicke's Aphasia

- ▣ Persistent Wernicke's Aphasia is found in patients with not only damage to Wernicke's area but also in the surrounding cortex of the posterior temporal lobe.
- ▣ Damage to the white matter connecting temporal lobe language areas to other brain regions.

Recent Conclusions

- ▣ Whilst Wernicke's area is essential to language comprehension, damage to the area does not actually cause Wernicke's Aphasia
- ▣ Secondary damage due to tissue swelling causes more problems.

Wernicke's Aphasia.

- ▣ <http://www.youtube.com/watch?v=aVhYN7NTIKU>

What about sign language.

- ▣ People use hands and arms when they speak.
- ▣ Formal arrangement form the basis of sign language.
- ▣ Many similarities in form and fluency in comparisons to vocal language (Klima and Bellugi, 1979).

Sign Language.

- Meckler et al (1979).
 - Raised by deaf-mute parents, but used both spoken and sign language regularly.
- Accident.
 - Impairments in both spoken and sign language.
 - Same for people who can speak more than one vocal language.

Sign Language.

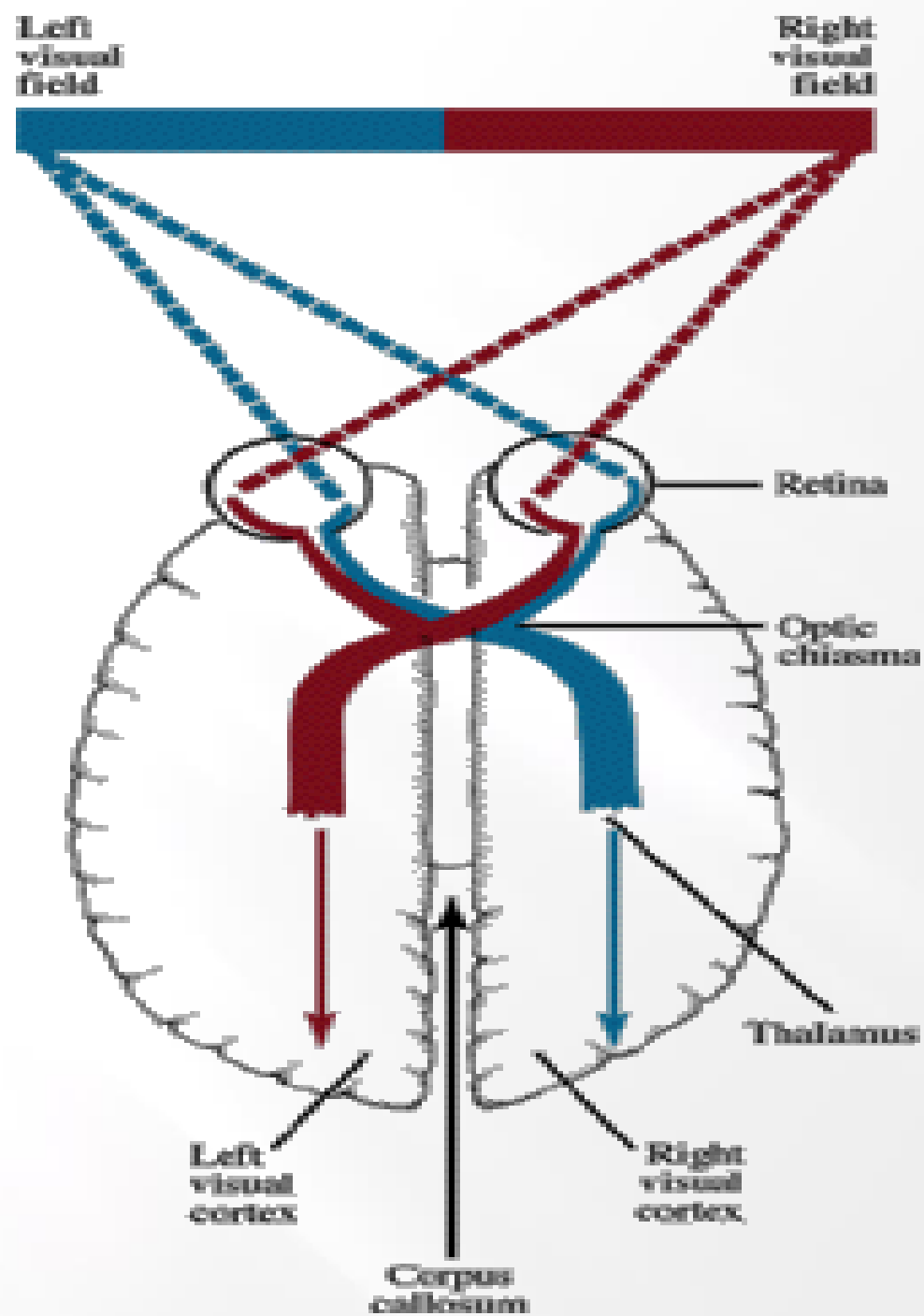
- ▣ Chiarello et al. (1982).
- ▣ Older deaf-mute woman.
- ▣ Stroke – damaged left Wernicke's area.
- ▣ Unable to generate sign language.

Split Brain Studies

- ▣ Split-Brain Studies
- ▣ Feel hidden object
- ▣ Named objects in Right Hand (Left Hem) but not their Left Hand (Right Hem).

Sperry et al (1956).

- ▣ Studies in Vision highlighted that items viewed in the left visual field activates the right occipital lobe
- ▣ And Vice Versa – Right Visual Field = Left occipital lobe.



Sperry.

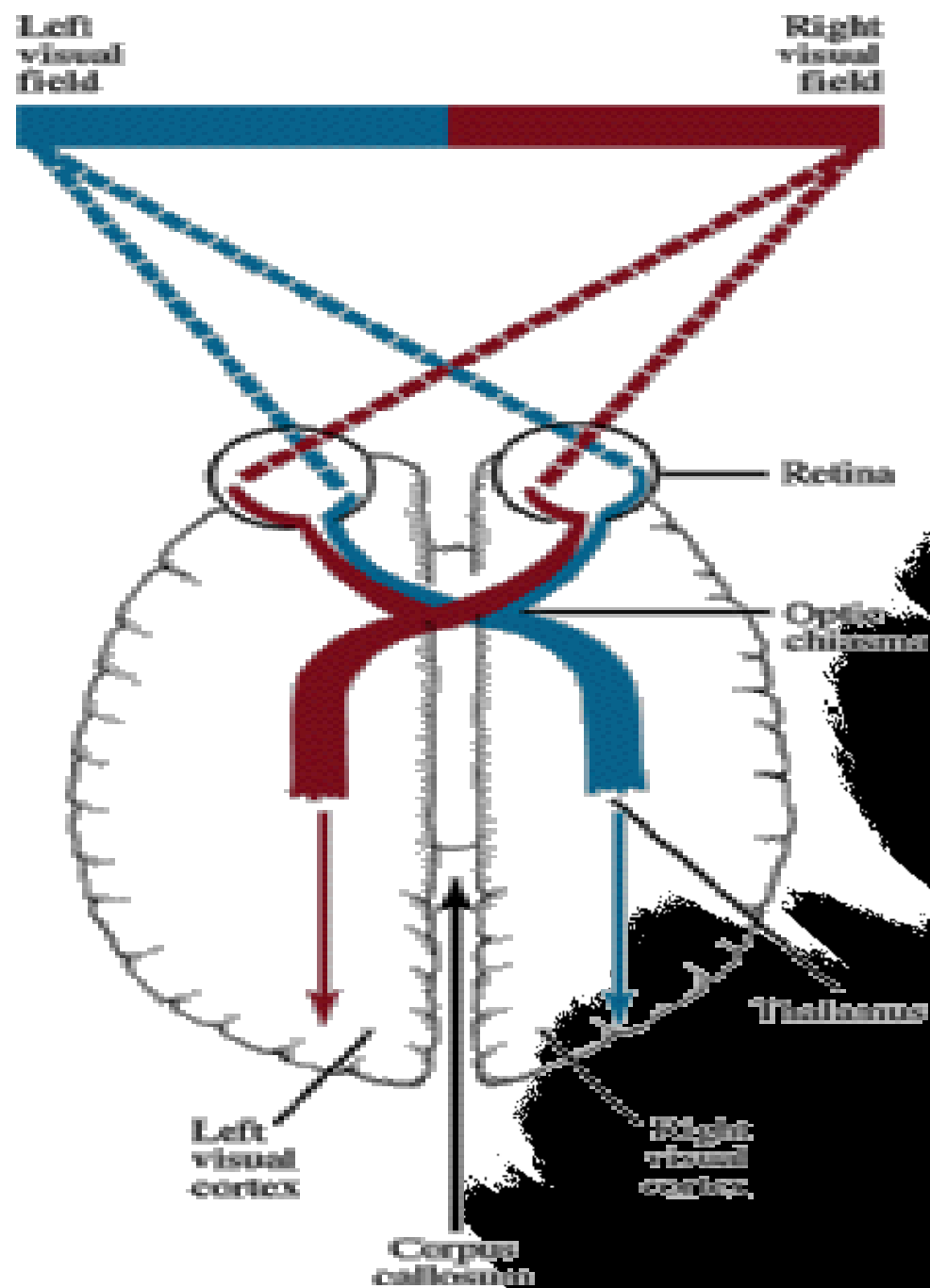
- Experiment: Split Brain Patients.
- Participants shown words (everyday words) shown only in the Left Visual Field, Right Visual Field
- Asked to name the word.

Findings.

- ▣ Participants could name words when only in the right visual field.
- ▣ Participants could not name objects when shown only in the left visual field.
- ▣ Why?

Sperry's conclusions.

- ▣ Left Hemisphere is the dominant area for language.
- ▣ Typically when we see information in the left visual field – this information goes to the right hemisphere... then to SAY it, it needs to be transferred back to the left hemisphere
- ▣ Split Brain Patients cannot do this.



Handedness.

- ▣ So what about the left handers?
- ▣ If Language activity is dominant in the left hemisphere and left handers are typically Right Hemisphere dominant... how to they talk?
- ▣ Sample issues for research studies using neuroimaging?

Does the Right Hemisphere do anything in Language.

- Well.... Yes.
- Zaidel (1976) – yes, recognise simple words.... Also involved in the emotional tone of verbal material.
- In addition.
 - Replicating Sperry's studies but with familiar faces and not printed words.
 - Left Visual Field (Right Hemisphere) better.

Handedness.

- ▣ Knecht et al, 2000.
- ▣ Right Hemisphere Dominance.
- ▣ 27% of Strong Left Handers.
- ▣ 15% in Ambidextrous Individuals.
- ▣ 4% in Strong Right Handers.

Current Trends in Neuroscience of Language.

- ▣ Language Lateralisation.
- ▣ Research has long suggested that the left hemisphere is the dominant area for language.
- ▣ But what about the Right Hemisphere?
- ▣ Role of the Right Hemisphere still quite unclear..... HOWEVER.....

Current Trends in Neuroscience of Language

- ▣ The number of patients demonstrating language deficits following right hemispheric damage (in equivalent areas of Broca's and Wernicke's) suggests that the right hemisphere does play a role.....
- ▣ Mitchell and Crow (2005) – Review of Literature on Brain Lesions and functional imaging stated that the RH plays a MAJOR role in.
 - Comprehension
 - Understanding Humour
 - Sarcasm
 - Metaphors
 - Indirect Requests
 - Language related to emotion.

Mitchell and Crow (2005)

- ▣ Difficulty with these higher order language functions seem to be a prevalent symptom of patients with Schizophrenia.
- ▣ Does this mean patients with Schizophrenia have Right Hemisphere dysfunction?
 - Barnett et al (2005) study suggests so.
 - ▣ Reaction times to stimuli in Left Visual Field and Right Visual Field between participants with Schizophrenia and a Control group.
 - Schizophrenia slow response to Left Visual Field Stimuli.
- ▣ However, Mitchell and Crow (2005) also consider that language is BILATERAL and therefore the disordered speech associated with Schizophrenia could be due to inter-hemispheric communication issues.
 - MORE RESEARCH NEEDED.

Mitchell and Crow (2005)

- ▣ Should we be revisiting, re-questioning the Wernicke-Geschwind model?

Monolinguals/Bilingualism/ Multi-Lingualism

- ▣ Another recent trend is to use imaging techniques to explore language areas and pathways in monolinguals, bilinguals and multi-linguals.
- ▣ Kim et al (1997) FMRI study suggested distinct cortical regions for late learners of a second language.
 - Distinct parts of Broca's area for later learners
 - ▣ Same aspects of Wernicke's area activated.
 - Early learners – same parts of Broca's and Wernicke's area activated for both languages.