

Language and the human brain

Brain and Language

- What will be covered?
 - A brief survey of brain structure.
 - Some types of language disturbance that result from brain damage.
 - The autonomy of language faculty.

The human brain

- Composed of +/- 10 billion nerve cells (neurons).
- The highest level of the brain is the cerebral cortex (found only in mammals, and human has the greatest proportion of cortex).
- Language representation and processing resides in the cortex.



The human brain

- The brain is composed of cerebral hemispheres:
 - **Right hemisphere:** supervises left side of body
 - **Left hemisphere:** supervises right side of body
(Contralateral brain function.)
- Corpus callosum joins the hemispheres
 - Network of two million fibers
 - Allows the two hemispheres to communicate

Modularity of the brain

The brain is divided into distinct anatomical faculties that are directly responsible for specific cognitive functions.

Left hemisphere *is superior for language, rhythmic perception, temporal-order judgments, and mathematical thinking skills*

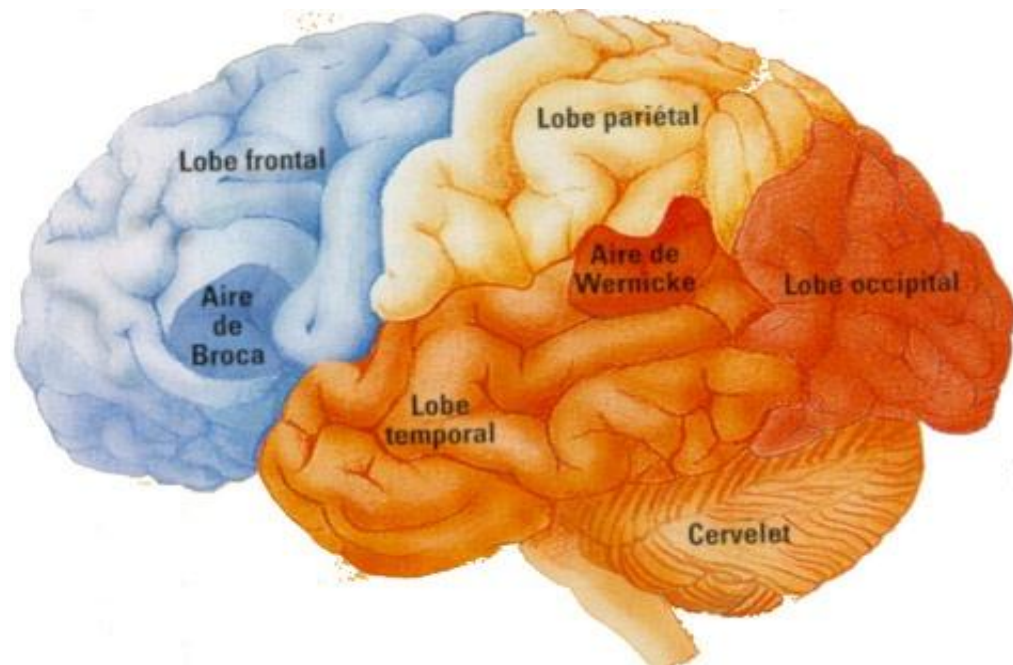
Right hemisphere *does better in pattern-matching tasks, recognizing faces, and spatial orientation.*

Localization/Lateralization

- Localization: different human cognitive abilities and behaviors are localized in specific parts of the brain
- Lateralization: any cognitive function that is localized primarily in one side of the brain
 - Language is lateralized to the left hemisphere.

Localization/Lateralization

In almost all right-handed individuals, and most left-handed individuals, language is left-lateralized.



Language Lateralization

- Split-brain patients: evidence for lateralization
 - In the past, some cases of severe epilepsy were treated by cutting the corpus callosum, severing the connection between the two hemispheres.
- Messages sent to the hemispheres cause different responses in split-brain patients.
 - Object placed in the left hand (right hemisphere): object can be used but not named
 - Object placed in the right hand (left hemisphere): object can be named and described immediately
- [Video](#)

Aphasia

- Aphasias provide evidence for localization of language
 - Aphasia: any language disorder due to brain damage caused by disease or trauma
 - Many aphasics are selectively language impaired.
 - Aphasics do not (necessarily) have cognitive or intellectual impairments.

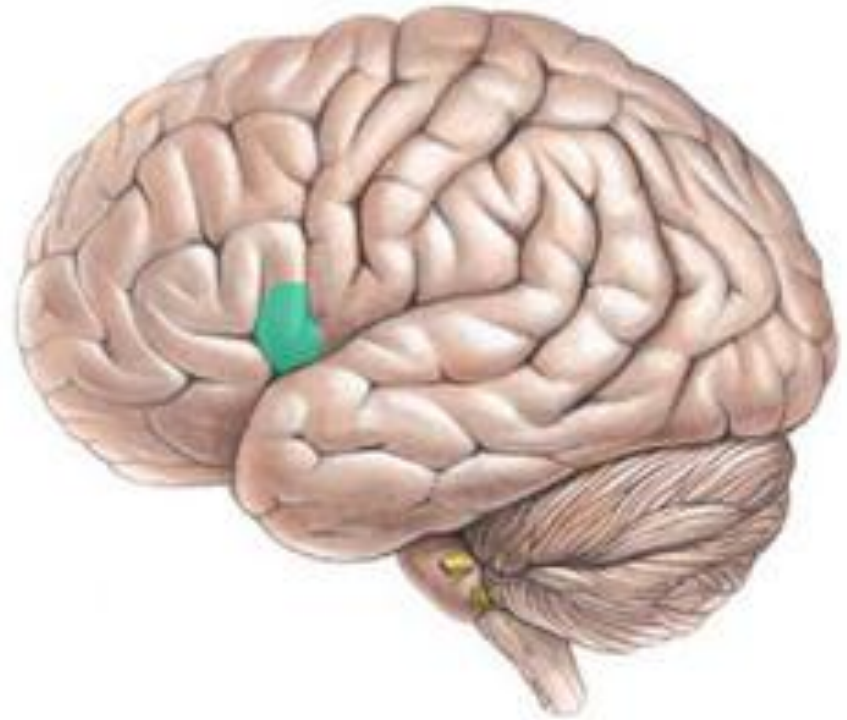
Broca's Aphasia

Paul Broca (French) in 1864 found that damage to the front part of the left hemisphere resulted in loss of speech.



Broca's Aphasia

- Broca's area:
left hemisphere, where
the frontal, parietal, and
temporal lobes meet



Broca's Aphasia

- Effects:
 - intelligence not necessarily affected
 - understanding not necessarily affected
 - production **severely impaired**
 - Trouble with function words (e.g. articles, prepositions, pronouns)
 - Trouble with inflectional morphology (e.g. *-ed*, *-s*)
 - Difficulties forming grammatical sentences
 - Difficulties understanding complex sentences (e.g. passives)

Broca's Aphasia

- Examples of Broca's aphasia:

"Yes ... Monday ... Dad, and Dad ... hospital, and ... Wednesday, Wednesday, nine o'clock and ... Thursday, ten o'clock ... doctors, two, two ... doctors and ... teeth, yah. And a doctor ... girl, and gums, and I."

"Me ... build-ing ... chairs, no, no cab-in-ets. One, saw ... then, cutting wood ... working ..."

Wernicke's Aphasia

Karl Wernicke (German) in 1874.

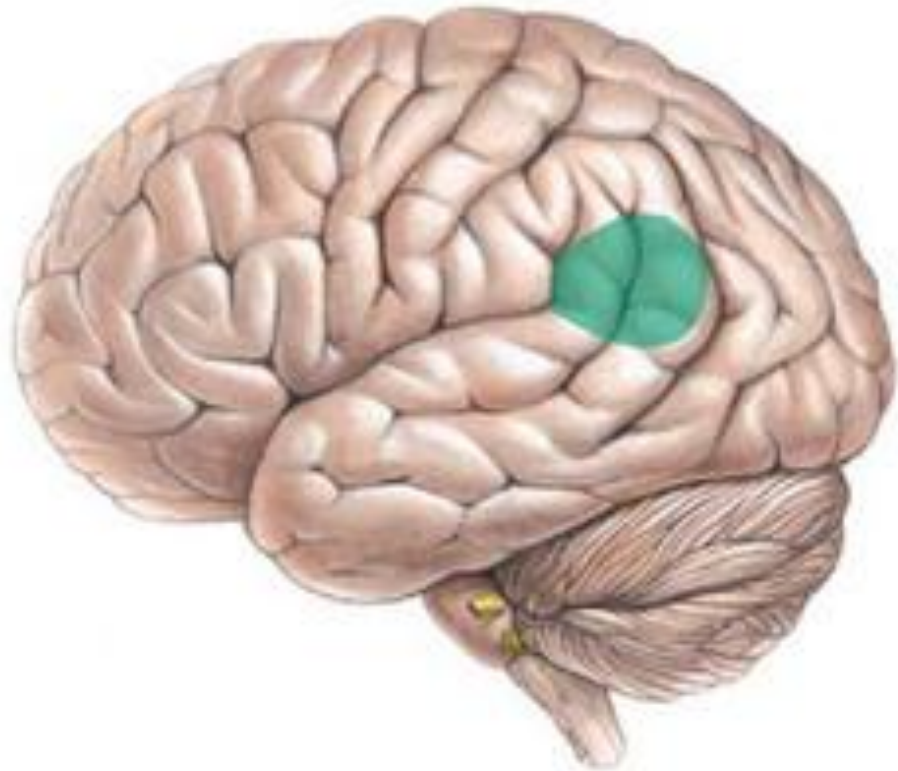
Wernicke's aphasia:

- *Fluent speech*
- *Good intonation*
- *Lexical errors*
- *Nonsense words*
- *“Word salad”*
- *Comprehension impaired*



Wernicke's Aphasia

- Wernicke's area:
In the parietal/temporal
region in the left
hemisphere



Wernicke's Aphasia

- **Examples of Wernicke's aphasia:**

- Doctor: How do you feel?
- Patient: I felt worse because I can no longer keep in mind from the mind of the minds to keep me from mind and up to the ear which can be to find among ourselves.

In conversation:

E = experimenter

P = patient

E: How are you today, Mrs. A?

P: Yes.

E: Have I ever tested you before?

P: No. I mean I haven't.

E: Can you tell me what your name is?

P: No, I don't I...right I'm right now here.

E: What is your address?

P: I cud if I can help these this like you know... to make it. We are seeing for him. That is my father.

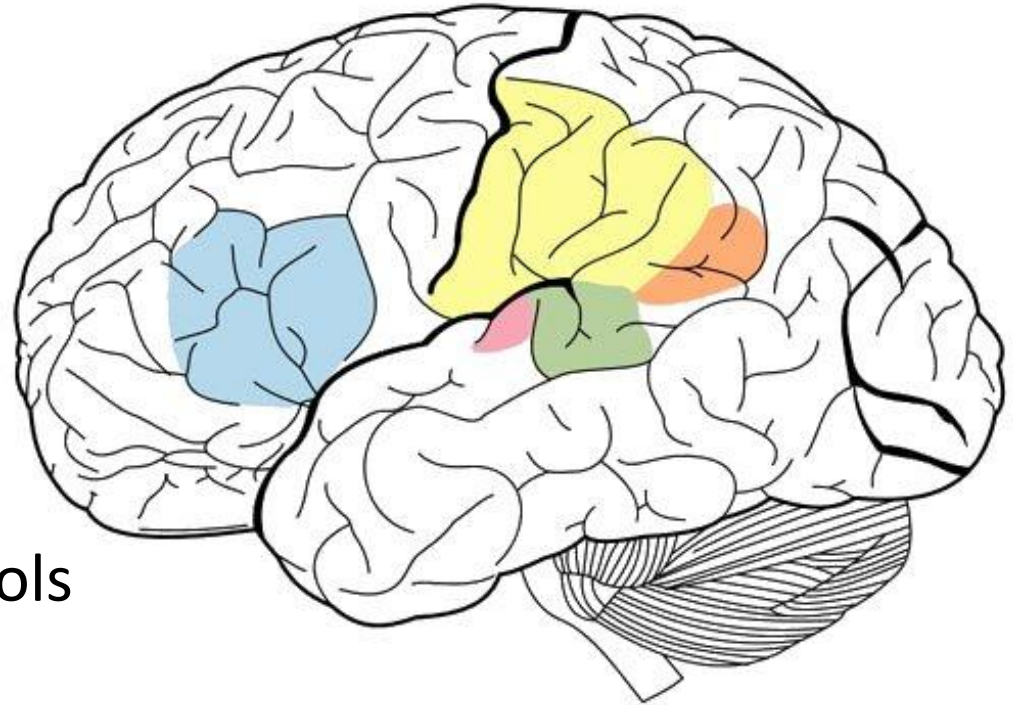
Broca's and Wernicke's Areas

- Broca's area controls

Syntax

- Wernicke's area controls

Semantics



- Broca's Area
- Wernicke's Area
- Supramarginal Gyrus
- Angular Gyrus
- Primary Auditory Cortex

Broca's and Wernicke's Areas

- In fact, although we have an idea of where the general language areas of the brain are, there are individual differences in the exact locations.
- We can see this in this [video](#), which also demonstrates:
 - one method of determining language regions of the brain
 - the brain stores lexical items in categories, which are located in distinct regions

Language Lateralization Again

- Is language totally left-lateralized?

Not completely.

- Some evidence comes:
 - Brain lesions
 - Hemispherectomy patients

Language Lateralization Again

- Brain Lesions
 - Language usually does not develop normally in children with early left-hemisphere brain lesions, but...
 - Babbling, vocabulary-learning delayed in children with right-hemisphere brain lesions.

Language Lateralization Again

Hemispherectomy: removing one hemisphere of the brain

In adult hemispherectomy patients:

- left cerebral hemisphere removed
 - *lose most but not all of their linguistic competence*
 - *lose the ability to speak and process complex syntactic patterns*
 - *retain some language comprehension ability*
- right cerebral hemisphere removed
 - *difficulty in understanding jokes and metaphors*
 - *cannot use loudness and intonation as cues to whether a speaker is angry, excited, or merely joking.*

So, the right hemisphere also has a role in normal language use.

Plasticity

- To some extent, the brain may reassign functions to different areas of the brain. This is due to the *plasticity* of the brain.
 - Left hemisphere is predisposed to learn language.
 - During language development, the right hemisphere can take over many language functions if necessary.

Plasticity

- Child hemispherectomy patients are able to reacquire a linguistic system, albeit delayed.
- In adults, the right hemisphere cannot take over linguistic functions anymore.
- Plasticity of the brain decreases with age.

Language autonomy

Is language faculty already present at birth, or is it derived from more general intelligence?

Children with SLI (Specific Language Impairment):

- have difficulties in acquiring language, but
- do not have brain lesions responsible for language difficulties
- have no other cognitive deficits

→ Language ability \neq General Cognition

→ Grammatical faculty is separate from other cognitive abilities

Language autonomy

Christopher

IQ = 60-70

- Unable to button his shirt or play tic-tac-toe
BUT...
- Remarkable **language skills**
 - Could read at age 3
 - Knows many languages from different families (Germanic, Slavic, Turkic) → **polyglot**
 - Easily learns new languages

→ **Language ability ≠ General Cognition**



Language autonomy

Evidence from *aphasia*, *SLI*, and the asymmetry of abilities in *linguistic savants* strongly supports the view that language faculty is autonomous, genetically determined, and consists of multiple brain modules...

It is not derived from more general intelligence.

Resources

- Split Brain video:
 - <http://www.youtube.com/watch?v=aCv4K5aStdU>
 - <http://www.youtube.com/watch?v=82tIVcq6E7A>
- BBC *Brain Story*
 - <http://www.youtube.com/user/KosmosLF>