Psych 56L/ Ling 51: Acquisition of Language

Lecture 4

Biological Bases of Language II

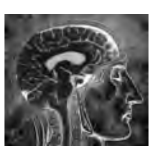
Announcements

Be working on HW1 (due 1/20/11)

Be working on bio bases review questions

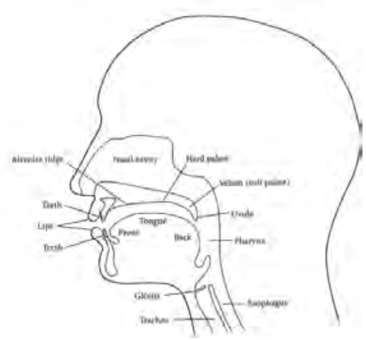
Check out the reference material on the webpage

Anatomy & Language



The Human Vocal Tract: A Finely Honed Instrument

Speech is produced when air from the lungs exits the larynx and is filtered by the vocal tract above the larynx: glottis, pharynx, uvula, velum, hard palate, tongue, nasal cavity, alveolar ridge, teeth, lips.



Human Speech Apparatus: Pros and Cons

Larynx: most speech-specific feature of the human vocal tract.

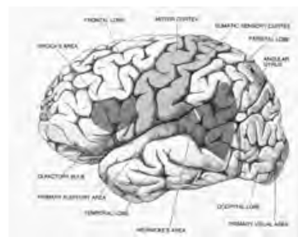
Compared to other mammals, human larynx is very low.

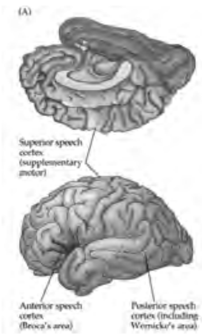
- The good: Low larynx helps produce a wider variety of speech sounds.
- The bad: Humans are more likely to get food caught in the trachea and choke.

Lower mouth shape: accommodate the lower larynx

- The good: Help support lower larynx.
- The bad: Lead to overcrowded teeth and impacted wisdom teeth.

Brain areas associated with language

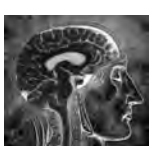




Functional Architecture

Functional architecture: how the brain is organized to do what it does (that is, how it is organized to accomplish some function)

Neurolinguistics: study of the brain with relation to language functioning. One big question: is there a separate chunk of brain (or dedicated brain activity = a functional “organ”) specifically for language?



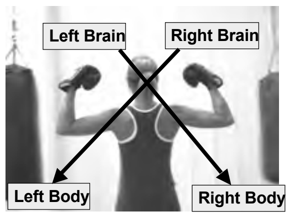
Methods of Neurolinguistic Investigation

Lesion studies: correlate missing bits of brain (lesions) with missing bits of psychological functioning.

One very interesting kind of missing brain bit: split or damaged corpus callosum, found in split brain patients

Methods of Neurolinguistic Investigation

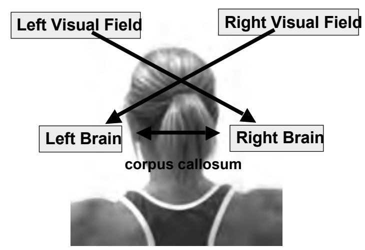
- Contralateral connections in the 1860s: investigators apply electric currents to brains of anesthetized animals and made an interesting discovery.

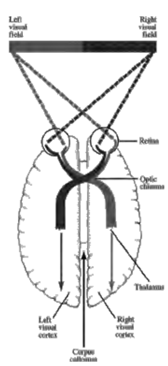


Note on connections:

Contralateral: across
Ipsalateral: same side

Hemispheres & Visual Field





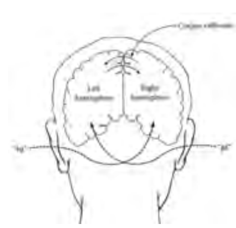
Information Flow:

LVF → RH → LH

RVF → LH → RH

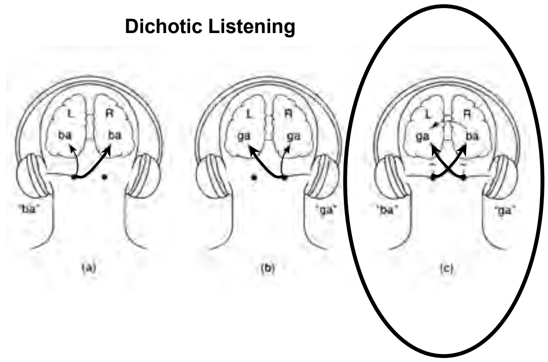
Methods of Neurolinguistic Investigation

Dichotic listening tasks: use the fact that contralateral connections from the ears to the brain are stronger than ipsalateral connections. Experimenters present two tasks at the same time, one to each ear, and ask subjects which one is perceived.



If they say the left ear's stimulus, then the right side of the brain processes that signal. If they say the right ear's stimulus, then the left side of the brain processes that signal.

Dichotic Listening



Methods of Neurolinguistic Investigation

ERPs: Event-related brain potentials, gauged via electrode caps. The location of ERPs associated with different mental activities is taken as a clue to the area of the brain responsible for those activities.

Good: non-invasive, relatively undemanding on the subject, provide precise timing on brain events

Bad: poor information on exact location of ERP since just monitoring the scalp

Methods of Neurolinguistic Investigation

Brain-imaging techniques: gauge what part of the brain is active as subjects perform certain tasks

PET scans: Positron emission topography scans
- subjects inhale low-level radioactive gas or injected with glucose tagged with radioactive substance
- experimenters can see which parts of the brain are using more glucose (requiring the most energy)

http://www.learner.org/vod/vod_window.html?pid=1615

Methods of Neurolinguistic Investigation

Brain-imaging techniques: gauge what part of the brain is active as subjects perform certain tasks

fMRI scans: functional magnetic resonance imaging
- subjects have to be very still inside MRI machine, which is expensive to operate
- experimenters can see which parts of the brain are getting more blood flow or consuming more oxygen

Methods of Neurolinguistic Investigation

Brain-imaging techniques: gauge what part of the brain is active as subjects perform certain tasks

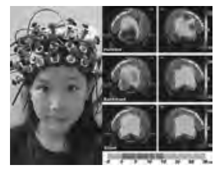
MEG: Magnetoencephalography
- subjects have to be very still
- experimenters can see which parts of the brain are active

Video of word recognition in brain (10 sec long): http://www.mrc-cbu.cam.ac.uk/facilities/meg/

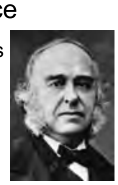
Methods of Neurolinguistic Investigation

Brain-imaging techniques: gauge what part of the brain is active as subjects perform certain tasks

Optical Topography: Near-infrared spectroscopy (NIRS)
- transmission of light through the tissues of the brain is affected by hemoglobin concentration changes, which can be detected



Where is language located? Left hemisphere evidence

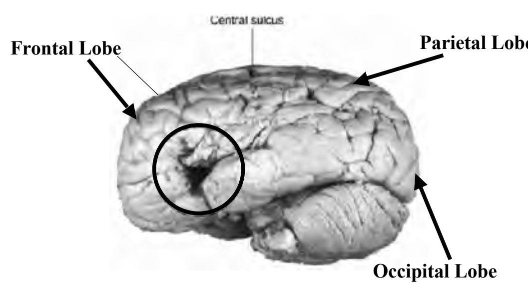


From brain injury and aphasia (when language is severely impaired):

Paul Broca's lesion studies
- "Tan", who had left hemisphere lesion and loss of language abilities

Functional asymmetry: damage to the left hemisphere seems to cause language problems (whether it is spoken or signed) while damage to the right hemisphere seems to cause non-linguistic visual-spatial information processing problems.

Broca's Aphasia



Broca's Aphasia

Patients have trouble producing speech, mostly content words (nouns and verbs) with few grammatical morphemes

"Yes… ah… Monday… er… Dad and Peter H… [his own name], and Dad…. er… hospital… and… ah… Wednesday… Wednesday, nine o'clock…"

Videos of sample speech from a Broca's aphasic:

http://www.youtube.com/watch?v=f2IiMEbMnPM

http://www.learner.org/vod/vod_window.html?pid=1574

(from 2:58-6:16)

Broca's Aphasia

Broca's aphasics & comprehension:

Relatively good comprehension of some sentences:

Can understand sentences like these:

The dog bit the woman.

The apple that the boy is eating is red.

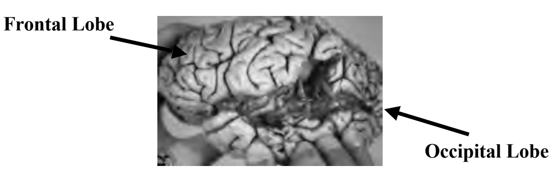
…but not these (because their meaning can't be inferred from the meaning of the nouns and verbs alone):

The car is pushed by the truck.

The girl whom the boy is pushing is tall.

Wernicke's Aphasia

- Patients with posterior lesions in the left hemisphere
- Speech is fluent
- But comprehension is impaired



Wernicke's Aphasia

Patients have speech that is "syntactically full but semantically empty"

"I feel very well. My hearing, writing been doing well. Things that I couldn't hear from. In other words, I used to be able to work cigarettes I didn't know how…"

Video of sample speech from a Wernicke's aphasic:

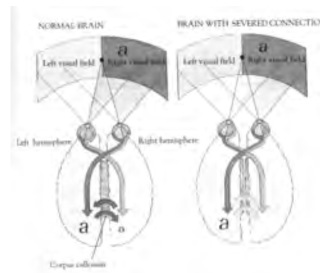
http://www.youtube.com/watch?v=aVhYN7NTIKU

Comprehension is very low.

Where is language located?

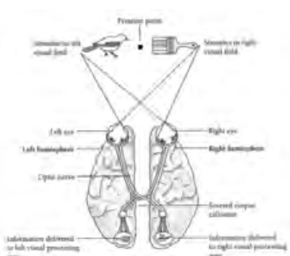
Where is language located? Left hemisphere evidence

From split-brain patients (with severed corpus callosum - no communication between hemispheres)



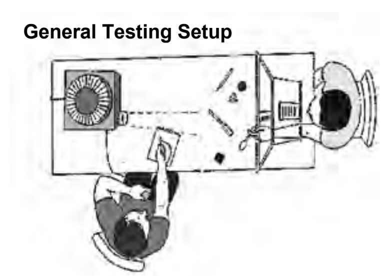
Where is language located? Left hemisphere evidence

From split-brain patients (with severed corpus callosum - no communication between hemispheres)



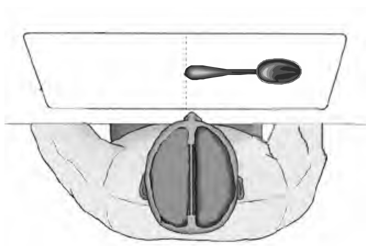
Can't *say* what they saw on the left side, but can draw with their left hand.

Testing Split Brain Patients



Testing Split Brain Patients

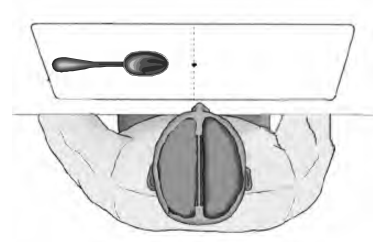
Name that object
(picture in RVF)



Patient says: "Spoon!"

Testing Split Brain Patients

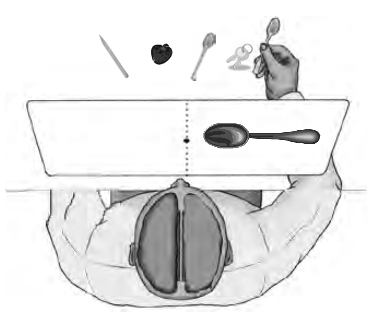
Name that object
(picture in LVF)



Patient: *(says nothing)*
Researcher: "Did you see anything?"
Patient: "Nope."

Testing Split Brain Patients

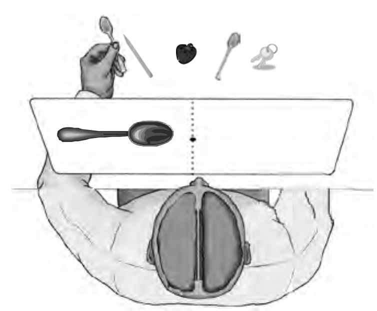
Pick up the object displayed (picture in RVF)



<u>Right</u> Hand: Pulls out spoon
Left Hand does nothing

Testing Split Brain Patients

Pick up the object displayed (picture in LVF)



<u>Left</u> Hand: Pulls out spoon!
Right hand does nothing

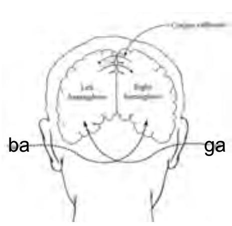
Left Hemisphere rationalizing behavior of Right Hemisphere

Typical Split Brain Patient

- Left Brain:
  - Normal Language Use
  - No easily detectable deficits.
- Right Brain:
  - Some rudimentary word recognition.

Where is language located? Left hemisphere evidence

From normal adults: dichotic-listening experiments



Normal adults have a right-ear advantage

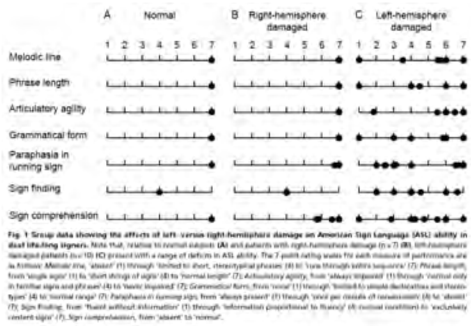
Evidence for Left Hemisphere Lateralization from American Sign Language

- Deaf Signers with Left Hemisphere Damage:
  - Language Deficit. Aphasic.
- Deaf Signers with Right Hemisphere Damage:
  - Visuo-Spatial Deficits.
  - No easily detectable language deficits.
- Left Hemisphere implicated in language

Poizner, Klima, & Bellugi (1987)

Hickok et al. 1998: ASL lateralization evidence

Left hemisphere damage leads to language damage



Why the left hemisphere?

Left hemisphere may process information more analytically.

Trained musicians process music in the left hemisphere. Normal (untrained) people process it on the right.

Left hemisphere may be better at executing well-practiced routines, while right is better at responding to novel stimuli.

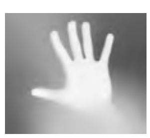
Language, for adults, is a well-practiced routine.

Where is language located? Not-just-left hemisphere evidence

Sometimes, aphasia doesn't result when there is left hemisphere damage.

Sometimes, aphasia results when there is right hemisphere damage.

In some people (usually left-handed people), language is controlled by the right hemisphere.



Where is language located? Not-just-left hemisphere evidence

Right hemisphere contributions to language: tone contour, emotional tone, jokes, sarcasm, figurative language interpretation, following indirect requests

(much of this falls under pragmatics)

Evidence: right hemisphere lesion patients

Right hemisphere activated by semantic processing, while left hemisphere activated primarily by syntactic processing

Evidence: ERP studies

Evidence: late language learners who aren't as proficient with syntax, and have language located primarily in right hemisphere

How does a left hemisphere specialization for language develop?

Equipotentiality hypothesis: left and right hemispheres have equal potential at birth

Prediction: dichotic listening and brain injury in children show less specialization for language than adults

Invariance hypothesis: left hemisphere specialization available at birth

Prediction: dichotic listening and brain injury data from children should look like the corresponding data from adults

How does a left hemisphere specialization for language develop?

fMRI studies: newborns and 3-month-old infants show greater left-hemisphere than right-hemisphere activation in response to speech stimuli (as do adults)

- But also greater left-hemisphere activity in response to non-speech sounds, suggesting general bias to process sounds in left hemisphere (older children [10-month-olds] and adults process non-speech sounds with right hemisphere)

How does a left hemisphere specialization for language develop?

Summary from experimental studies:

Language processing appears to be specialized to the left hemisphere as early as researchers can test it.

But the infant brain is not the same as the adult brain - specialization/lateralization continues to increase as the brain matures.

How does a left hemisphere specialization for language develop?

Childhood aphasia: Aphasia nearly always results from left hemisphere damage and rarely from right hemisphere damage (Woods & Teuber 1978)

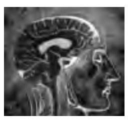
However, immature brain is not organized the same way as the mature brain.

- children more likely to suffer Broca's aphasia (non-fluent aphasia) than Wernicke's
- children tend to recover better from brain damage, with younger children recovering better than older children

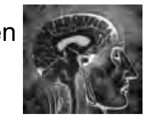
Neural plasticity in children

Plasticity: the ability of parts of the brain to take over functions they ordinarily would not serve - ex: right hemisphere taking over language functions if left hemisphere is damaged.

However, plasticity isn't the perfect solution - ex: subtle syntactic impairments in these cases suggest that the right hemisphere isn't as good at parts of language as the left hemisphere is.



Neural plasticity in children



How plasticity works:

The child's brain has much redundancy (extra synaptic connections.)

Maturation = pruning unnecessary connections

What's necessary: what gets used (where child's brain activity is).

Once connections are pruned, redundancy is lost and particular functions become localized.

Neural plasticity in children

But wait - young children use their right hemisphere (somewhat) for language. Since there's language activity, why does the right hemisphere lose its language functionality?

Maturation hypothesis: adult language brain structures develop in the left hemisphere and take over (specialization is genetically determined)

Process change hypothesis: children change the way they process language, and the new way is more in line with the left hemisphere's natural capacities. (specialization is result of process change)

Neural plasticity in adults, too?

Rasmussen & Milner (1977)

Normal Speakers

		SPEECH REPRESENTATION		
Handedness	No. of Cases	Left	Bilateral	Right
Right	140	134 96%	0 0%	6 4%
Left or mixed	122	86 70%	18 15%	18 15%

Speakers with left hemisphere damage

		SPEECH REPRESENTATION		
Handedness	No. of Cases	Left	Bilateral	Right
Right	42	34 81%	3 7%	5 12%
Left or mixed	92	26 28%	17 19%	49 53%

Can recover somewhat by using right hemisphere for language?

Genetic Basis of Language Development

Heritability of individual differences

Twin studies: assess how similar/different monozygotic (identical) and dizygotic (fraternal) twins are

Stromswold (2001): heritable factors account for 25-50% of variance in normal children's language abilities; 50-60% of variance in impaired children's language abilities

Heritability of individual differences

Twin studies: assess how similar/different monozygotic (identical) and dizygotic (fraternal) twins are

Difference between grammatical and lexicon development:

genetic factors account for 25% of syntactic differences and 5% of variance among vocabulary (Stromswold 2006). In general, biological contribution to syntactic development is greater than biological contribution to lexical development.

Genetics of language impairment

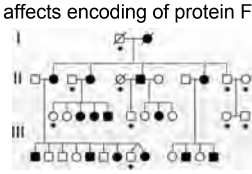
Language impairment runs in families.

- language-impaired children are far more likely to have language-impaired family members
- monozygotic twins are more likely to share a language impairment

Genetics of language impairment

Language impairment runs in families.

- KE family (16 of 30 members had language impairment)
  - affected members had poor language abilities and severe difficulties with the motor skills involved with speech production
  - single dominant gene appeared to be the cause: mutation on gene that affects encoding of protein FOXP2 (Fisher 2006)

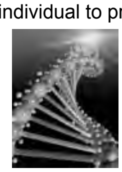


…however, this is only one genetic part of language development

In summary…

There does seem to be a strong biological/genetic component of language development - but it's certainly not the only factor involved.

Moreover, while at least one specific genetic component involved with language development has been discovered, it's still unknown how this component interacts with the rest of the genetic makeup of an individual to produce normal linguistic development.



Questions?

You should be able to do all the homework questions in HW1, and review questions for bio bases up through (24)