Psych 56L/ Ling 51:
Acquisition of Language

Lecture 4

Biological Bases of Language II

Announcements

Be working on HW1 (due 1/23/14)

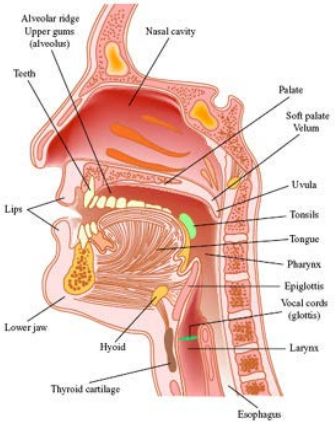
Be working on bio bases review questions - remember that collaboration is strongly encouraged

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.

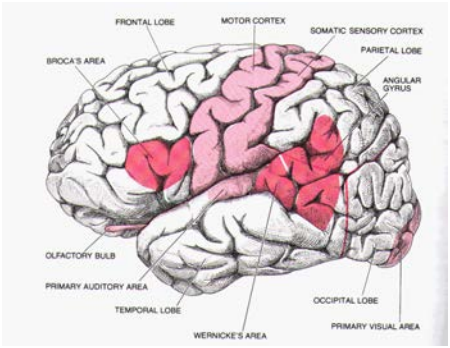
The bad: Humans are more likely to get food caught in the trachea and choke.

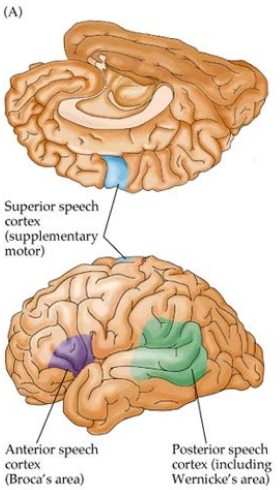
Lower mouth shape: accommodate the lower larynx

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?

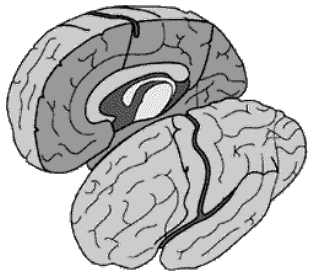
A brain without language: Insights during a stroke

http://www.ted.com/talks/jill_bolte_taylor_s_powerful_stroke_of_insight.html

(about 10:30 through 13:22 of 18:41 minute video)

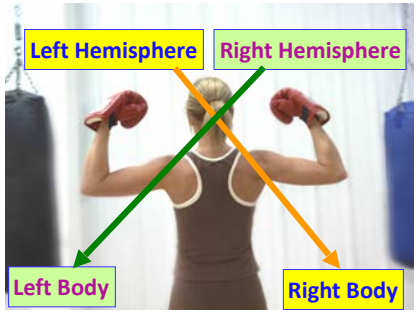
Methods of neurolinguistic investigation

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



Methods of neurolinguistic investigation

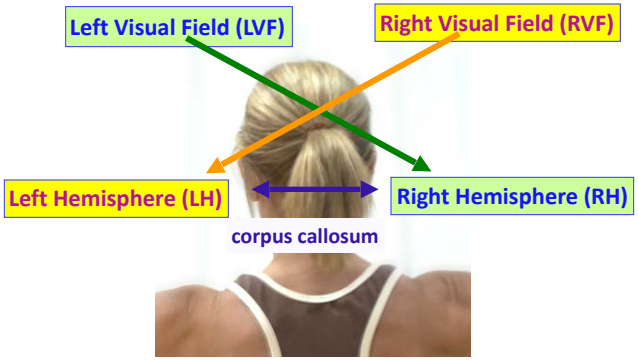
- Contralateral connections in the 1860s: investigators apply electric currents to brains of anesthetized animals and made an interesting discovery.

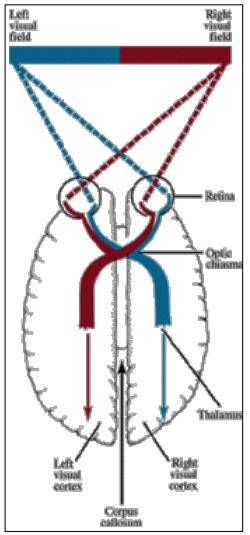


Note on connections:

Contralateral: across
Ipsalateral: same side

Hemispheres & visual field





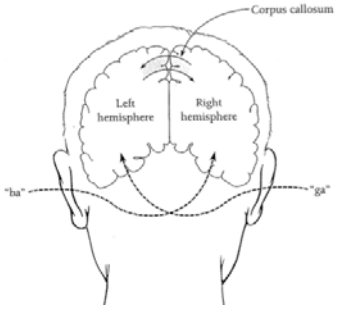
Information Flow:

LVF → RH → LH

RVF → LH → RH

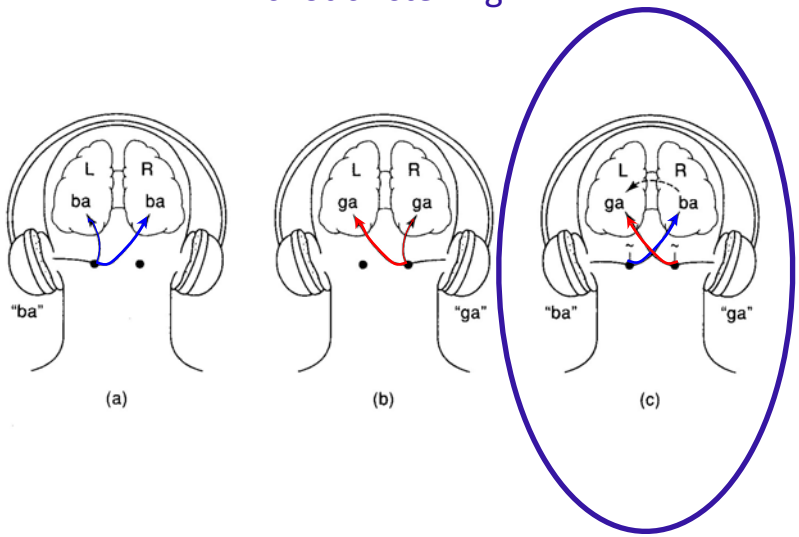
Methods of neurolinguistic investigation

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

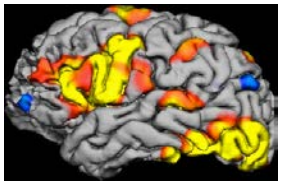
http://www.youtube.com/watch?v=5KXIDUo18aA
[Language Processing in the Brain: 6:26 long]

Methods of neurolinguistic investigation

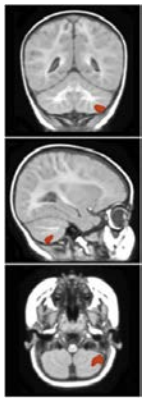
Brain-imaging techniques: gauge what part of the brain is active as subjects perform certain tasks

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

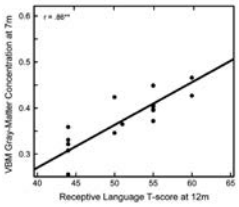


Methods of neurolinguistic investigation

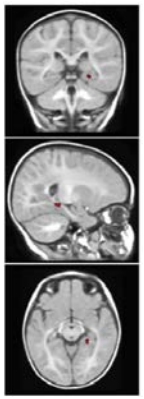


fMRI findings (Deniz Can, Richards, & Kuhl 2013) testing 7-month-olds:

Receptive language ability (comprehension) at 12 months strongly associated with early gray-matter concentration in the right cerebellum and early white-matter concentration in the left posterior limb of the internal capsule.

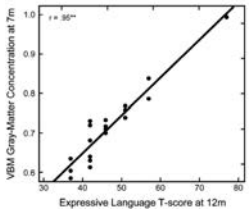


Methods of neurolinguistic investigation



fMRI findings (Deniz Can, Richards, & Kuhl 2013) testing 7-month-olds:

Expressive language ability (production) at 12 months strongly associated with early gray-matter concentration in the right hippocampus.



Methods of neurolinguistic investigation

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

MEG: Magnetoencephalography

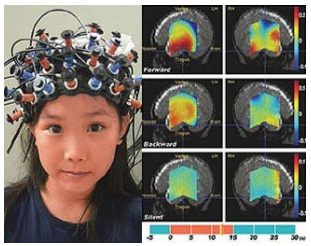
- subjects have to be very still
- experimenters can see which parts of the brain are active

Methods of neurolinguistic investigation

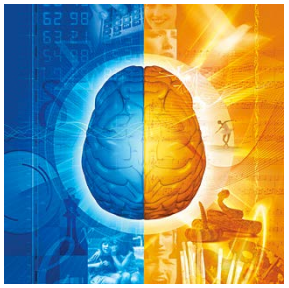
Brain-imaging techniques: gauge what part of the brain is active as subjects perform certain tasks

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

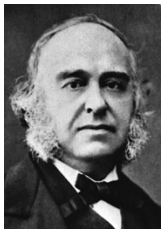


Where is language located? Left hemisphere evidence

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

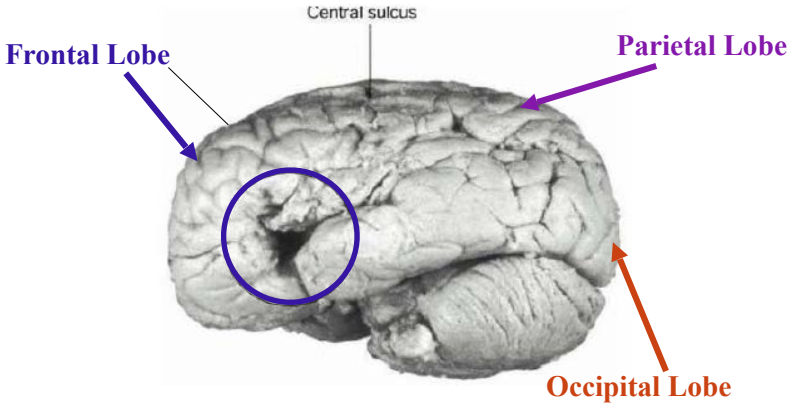
Paul Broca's lesion studies

- "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

Agrammatism: the omission of grammatical information in speech output

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

Video of sample speech from a Broca's aphasic:
http://www.youtube.com/watch?v=f2IiMEbMnPM

However, there are also issues with understanding more complex grammatical forms.

http://www.learner.org/vod/vod_window.html?pid=1574 [7:40 long]
(especially 2:43-6:16)

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.

Broca's aphasia

Broca's aphasics & comprehension:

A way to think about how Broca's aphasics understand utterances

"The dog bit the woman."
= {dog, woman, bite}

Most natural interpretation:
Dog is biter, woman is bitee.

Broca's aphasia

Broca's aphasics & comprehension:

A way to think about how Broca's aphasics understand utterances

"The apple that the boy is eating is red."
= {apple, boy, eat, red}

Most natural interpretation:
Boy is eater, apple is eatee, apple is red.

Broca's aphasia

Broca's aphasics & comprehension:

A way to think about how Broca's aphasics understand utterances

"The woman bit the dog."
= {woman, dog, bite}
Most natural interpretation:
Dog is biter, woman is bitee.


BUT

This isn't the actual meaning of the utterance.
So, a Broca's aphasic would struggle with it.

Broca's aphasia

Broca's aphasics & comprehension:

A way to think about how Broca's aphasics understand utterances

"The car is pushed by the truck."
= {car, truck, push}


Two natural interpretations:
Car is pusher, truck is pushee OR Truck is pusher, car is pushee

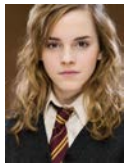
A Broca's aphasic wouldn't know which one is meant.

Broca's aphasia

Broca's aphasics & comprehension:

A way to think about how Broca's aphasics understand utterances

"The girl whom the boy is pushing is tall."
= {girl, boy, push, tall}




Several natural interpretations:
Girl is pusher, boy is pushee, girl is tall OR
Boy is pusher, girl is pushee, girl is tall OR
Girl is pusher, boy is pushee, boy is tall OR
Boy is pusher, girl is pushee, boy is tall OR

A Broca's aphasic wouldn't know which one is meant.

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…"

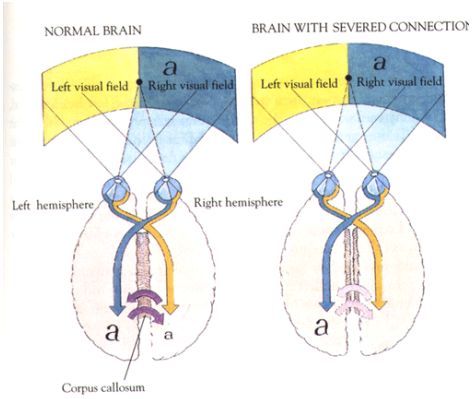
Videos of sample speech from Wernicke's aphasics:
http://www.youtube.com/watch?v=B-LD5jzXpLE
http://www.youtube.com/watch?v=aVhYN7NTIKU

Comprehension is very low.

Also, see http://www.learner.org/vod/vod_window.html?pid=1574 from about 6:20 through 7:40.

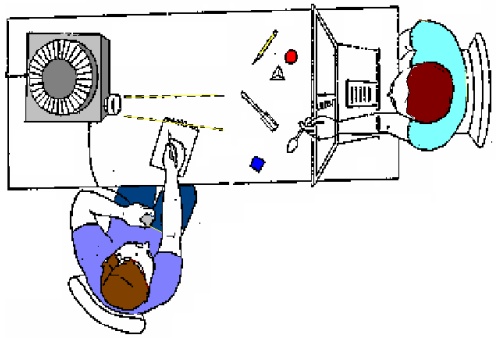
Split brain patients

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



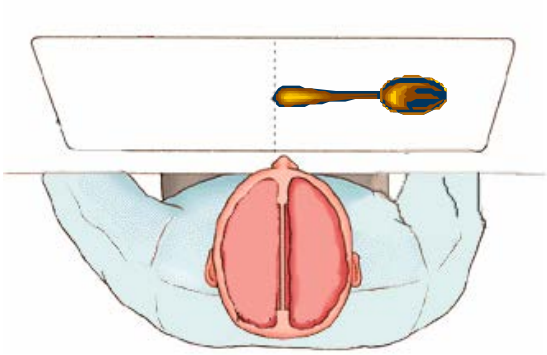
Testing split brain patients

General Testing Setup



Testing split brain patients

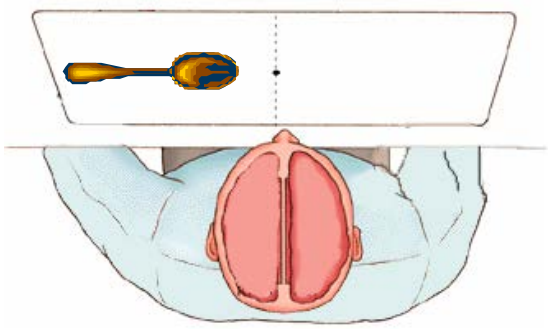
Name that object
(picture in RVF)



Patient says: "Spoon!"

Testing split brain patients

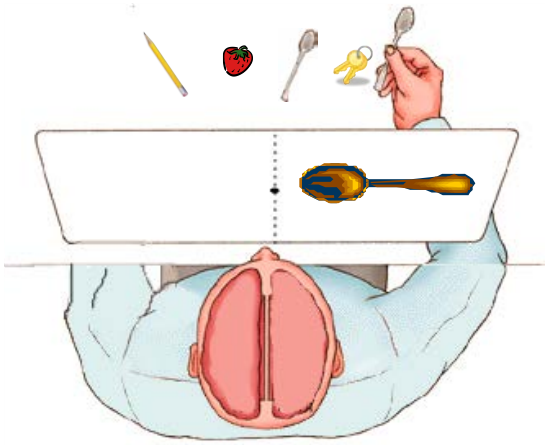
Name that object (picture in LVF)



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

Testing split brain patients

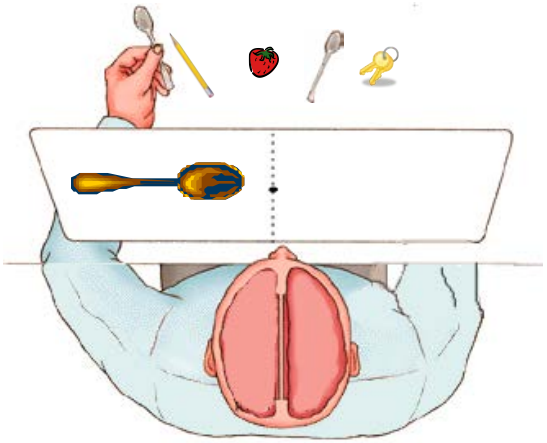
Pick up the object displayed (picture in RVF)



<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

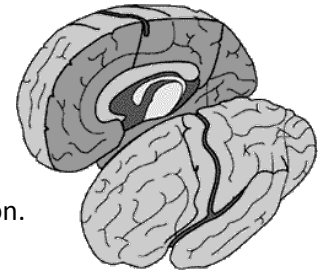
Left hemisphere rationalizing behavior of right hemisphere

Figure 3. Lateralization commands given to the mute right hemisphere

These tests were possible only in Cases P.S. and V.P. These same tests were not possible for J.W. and L.B. and N.G.

Typical split brain patient

- Left hemisphere:
  - Normal language use
  - No easily detectable deficits.
- Right hemisphere:
  - Some rudimentary word recognition.



Extremely useful walkthrough of a split brain study

http://ebooks.bfwpub.com/psychinquiry/shell.php?activity=simulate_splitbrain

Simulate a Split-Brain Experiment

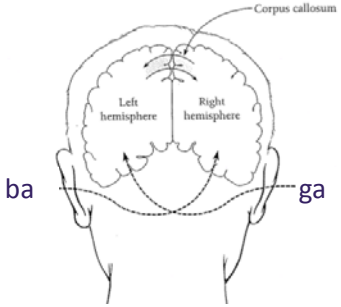
Simulate a Split-Brain Experiment

By Thomas E. Ludwig, Hope College

This activity will take about 15 minutes to complete

Dichotic listening experiments

From normal adults: dichotic-listening experiments



Normal adults have a right-ear advantage, which means the language signal heard in the right ear is consciously heard – the left hemisphere processes language stimuli more easily.

Evidence for left hemisphere lateralization from American Sign Language (ASL)

- Deaf signers with left hemisphere damage:
  - Language deficit. Aphasic.
- Deaf signers with right hemisphere damage:
  - Visuo-spatial deficits.
  - BUT…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 while right hemisphere damage does not

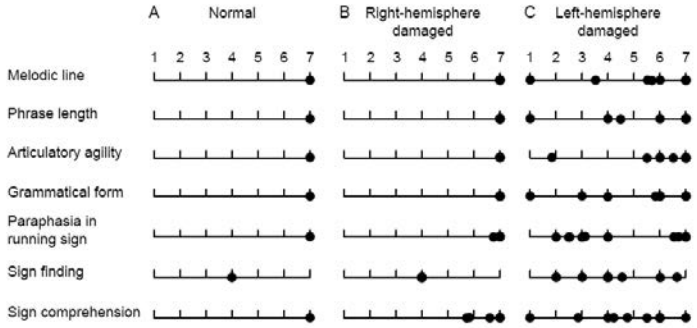


Fig. 1 Group data showing the effects of left- versus right-hemisphere damage on American Sign Language (ASL) ability in deaf life-long signers. Note that, relative to normal subjects **(A)** and patients with right-hemisphere damage (n = 7) **(B)**, left-hemisphere damaged patients (n = 10) **(C)** present with a range of deficits in ASL ability. The 7-point rating scales for each measure of performance are as follows: *Melodic line*, 'absent' (1) through 'limited to short, stereotypical phrases' (4) to 'runs through entire sequence' (7); *Phrase length*, from 'single signs' (1) to 'short strings of signs' (4) to 'normal length' (7); *Articulatory agility*, from 'always impaired' (1) through 'normal only in familiar signs and phrases' (4) to 'never impaired' (7); *Grammatical form*, from 'none' (1) through 'limited to simple declaratives and stereotypes' (4) to 'normal range' (7); *Paraphasia in running sign*, from 'always present' (1) through 'once per minute of conversation' (4) to 'absent' (7); *Sign finding*, from 'fluent without information' (1) through 'information proportional to fluency' (4; normal condition) to 'exclusively content signs' (7); *Sign comprehension*, from 'absent' to 'normal'.

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.

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

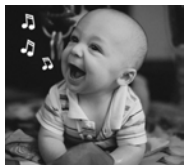
Some neurological similarities between language & music

Brandt, Gebrain, & Slevc 2012: "music is creative play with sound; it arises when sound meets human imagination"

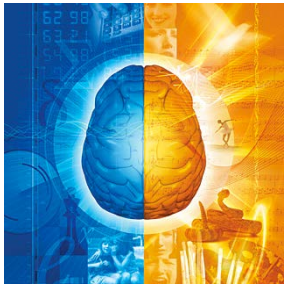
Language could be described the same way.

Both music and speech recruit a bilateral frontal-temporal network (Griffiths et al. 1999, Merrill et al. 2012).

Newborns show largely overlapping activation to infant-directed speech and to instrumental music (Kotilahti et al. 2010).



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



Aphasia & left-handers

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

Sometimes, aphasia *does* result when there is right hemisphere damage.

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

Right 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

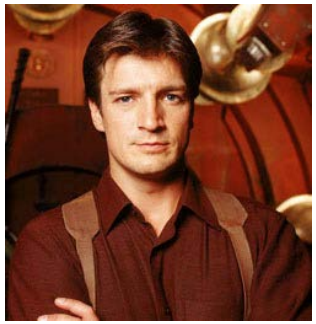
Recap

Researchers interested in the functional architecture of the brain with respect to language are interested in how the brain is organized to accomplish the function of language.

Broca's and Wernicke's aphasics, as well as split brain patients, indicate that certain areas of the brain seem to be integral for processing and producing language.

Many aspects of language seem to be lateralized in the left hemisphere on many people (such as syntax), though some language processing may be done in the right hemisphere (such as semantics/lexical meaning and pragmatics).

Questions?



You should be able to do up through question 7 on HW1 and up through question 27 on the bio bases review questions.

Extra Material

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.