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# (Sign) Language & the Brain

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24.900 Guest Lecture

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# Outline

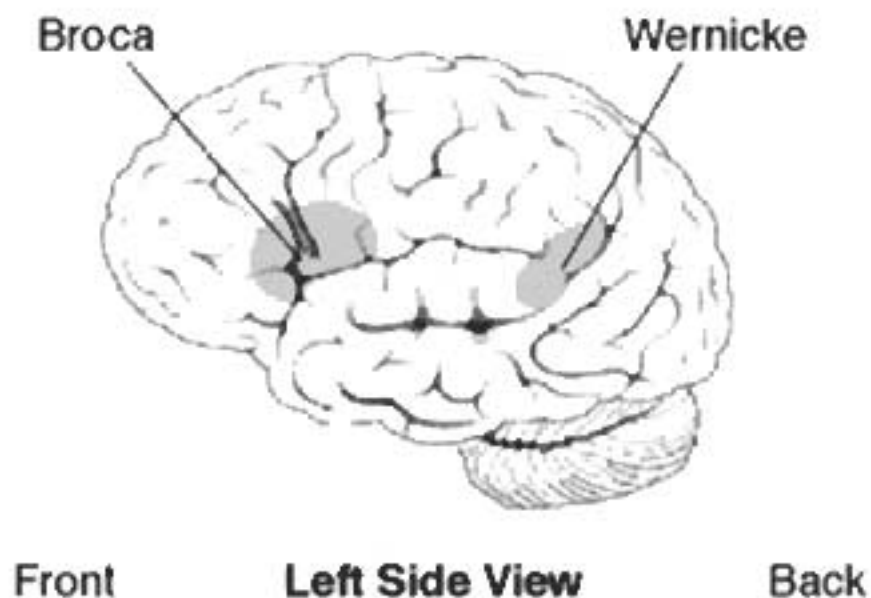
- Brain Morphology/Lateralization of function
  - Aphasia/Disorders in spoken language
  - Sign Language & the Brain
    - SLs: language or gesture?
    - Lateralization
    - Aphasias in deaf and hearing signers
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# Lateralization

- One of the key findings in the past 150 years of brain research: language processing seems **left hemisphere (LH) lateralized**.
  - Evidence comes from:
    - Aphasia studies (Dax 1836, Broca 1861, Liepmann 1900s) found that only patients with LHD had speech difficulties.
    - Wada Test (sodium amytal): only LH knock-out leads to language probs
    - Dichotic listening & speech shadowing: more accurate with speech heard by right ear (=LH!)
    - Brain Imaging: greater LH activation during language task
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# Brain Regions associated with Language



<http://www.nidcd.nih.gov/health/voice/aphasia.asp>

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# Some problems with simple view

- LHD children recover (apparently) normal language functions by puberty
  - Split brain patients are able to understand certain linguistic utterances, even when presented only to the right hemisphere.
  - Lateralization facts differ depending on handedness and gender.
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# Types of Aphasia

- Wernicke's Aphasia
    - Prototypical case: structure without meaning
    - Empty speech, echolalia
  - Broca's Aphasia
    - No function morphemes
    - Effortful, halting speech
  - Anomia: inability to retrieve phonological form
    - Caused by damage to left hemispheric angular gyrus
    - Examples
      - Shown scissors he says, "It's a nail file." Told it should be "scissors" he repeats "Yes, that's right. Of course it's not a nail file, it's a nail file."
      - [Shown a comb] "This is something I comb my hair with."
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# Wernicke's Aphasia

## ■ Symptoms

- Fluent, often grammatical speech that's nonsensical (paraphasias, neologisms, gibberish)
  - Poor comprehension and repetition
  - Acute cases ("jargon aphasia"): structure is recognizable but word selection seems nearly arbitrary
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# Boston Aphasia Diagnostic Exam

## “Cookie Theft” Story

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# Wernicke Aphasic on Cookie Theft Story

“Well this ... mother is away here working her work out o’here to get her better, but when she’s looking, the two boys looking in the other part. One their small tile into her time here. She’s working another time because she is getting, too.”  
(Goodglass, 1983)

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# A Wernicke's Aphasic

**SP:** Could you tell me where you are?

**Frank:** ... Yes, er, I just don't feel too good.

**SP:** Are you in hospital at the present time?

**Frank:** ... That is really one thing, really I feel bad you know. Mm ... I'm not really feeling too good.

**SP:** What's wrong with you, Frank?

**Frank:** Well I don't know, to be honest you just er, there will be a few days I feel shy. Saturday was bad, I get bad, Sunday and today.

**SP:** Where do you live?

**Frank:** ... I don't know, to be honest, we've got a lot of things my dad.

**SP:** Do you live in East Keilor?

**Frank:** ... Sorry? Yeh well fair outside things, you can't do warn. I can talk but I can't show up myself. I can't put the voice. It would be one thing if I could talk. But I can't talk so people can see it.

**SP:** Are you married, Frank?

**Frank:** ... I was news to due to be.

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# A jargon Aphasic

**Interviewer:** Can you tell me your address, Tom?

**Tom:** Four and pleasant, Plain Sodars. [There is no such district]

**Interviewer:** How long have you lived there?

**Tom:** I think that was only five, no eight prentices. Small plut be in there.

**Interviewer:** How old are you?

**Tom:** 80, 85 no 83 cheldren. [His age is 83 years old]

**Interviewer:** What month is it?

**Tom:** Today? Well that would be ten. If I say, it used to be called Naym Prentice.

**Interviewer:** If I said it was May, what would you say?

**Tom:** That's correct, Naym Prentice.

**Interviewer:** Could you count up to ten?

**Tom:** A, B, C, D, E, F, M, P, M.

**Interviewer:** No, say after me: 1, 2.

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# Broca's Aphasia

## ■ Symptoms

- Slow, effortful speech
- Telegraphic Agrammatism: lack of function words, affixes
- Cookie theft story (Helm-Estabrooks et al., 1981)

"Well ... see ... girl eating no ... cookie ... no ... ah ... school no ... stool ...ah ... tip over ... ... and ah ... cookie jar ... ah ... kid ... no ... see ... water all over ... spilled over ... yuck ... Mother ... daydreaming."

- Unsurprising: Broca's Area is near speech motor control areas of brain
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# But, Broca's Aphasics show *comprehension* errors, too

## ■ Passive vs. Active sentences

- Test sentences
    - John hit Mary.
    - John was hit by Mary.
  - Shown two pictures: one of John hitting Mary, and one of Mary hitting John.
  - Asked: "Which picture shows what the sentence says?"
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# But, Broca's Aphasics show *comprehension* errors, too

## ■ Passive vs. Active sentences

### □ Test sentences

■ John hit Mary.  Above chance

■ John was hit by Mary.  chance

□ Shown two pictures: one of John hitting Mary, and one of Mary hitting John.

□ Asked: "Which picture shows what the sentence says?"

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But... Broca's Aphasics show  
*comprehension* errors, too

## English Relative Clauses

- Subject extracted RCs

The [dog<sub>i</sub> [that *t<sub>i</sub>* chased the cat] ] is brown = *above chance*

- Object-extracted RCs

The [dog<sub>i</sub> [that the cat chased *t<sub>i</sub>* ] ] is brown = *chance*

Maybe Object RCs are more difficult to process?

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## Or maybe it's an artifact of linear order?

RCs in Chinese, a head-final language: RCs have reversed linear order w.r.t. English

- Subject-extracted RCs

[ [ *t* chased cat that] dog] is brown. = *chance*

- Object-Extracted RCs

[cat chased *t* that] dog] is brown. = *above chance*

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# But, it's not that simple

- OK on object questions

Who did the horse chase *t*?

*above chance*

Who *t* chased the horse?

*above chance*

- Bad on “scrambled” passives [Korean]

key-ekey saja-ka mul-hi-eyo

*chance*

*dog-by lion-Nom bite-Pass-C*

‘The lion was bitten by the dog’

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# Some things BAs *do* know

- The number of arguments a predicate takes
    - Active
      - The children sang/\*threw.
    - Passive
      - The boy was followed \*(by) the girl.
  - The syntactic reality of traces
    - Filled gaps
      - Who did John see (\*Joe)?
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# But they *do* have different grammars

## ■ NP Movement

- ✓ John seems that it is likely to win.

## ■ Wh-movement

### □ *That*-trace

- ✓ Which woman did David think that saw John?

### □ Superiority

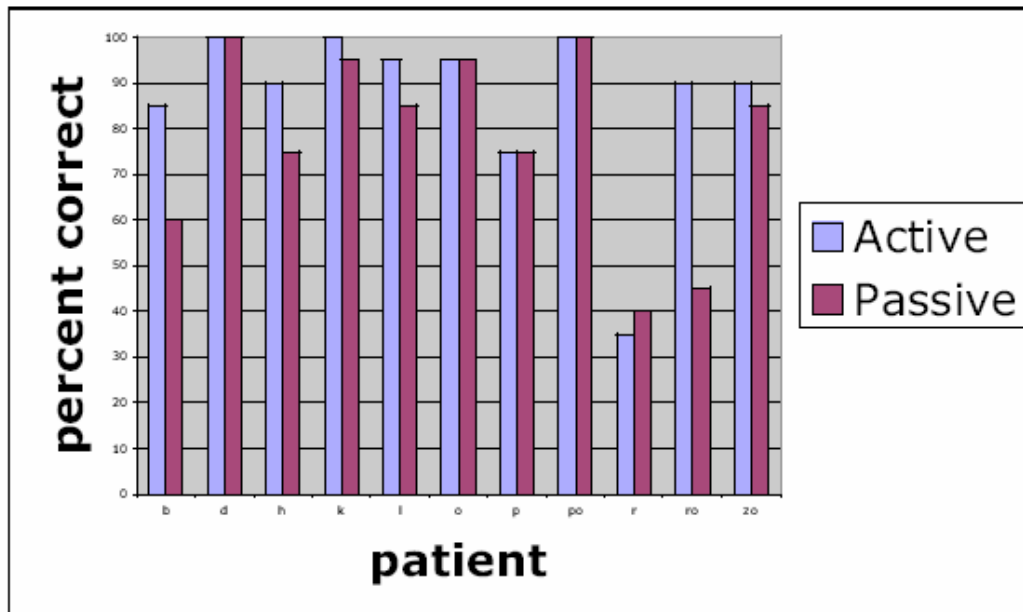
- ✓ I don't know what who saw.

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✓ = good for BA but bad for controls.

# General Problem

- Deficits aren't absolute – effects are gradient



BAs performance on picture-naming (data from Kolk & van Grunsven 1985)

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# The Upshot

- BAs grammatical judgments show problems interpreting structures with movement.
  - But comprehension results suggest that *all* movement isn't the problem.
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# The study of signed languages

- Gesture/Iconicity in SLs
  - Not as prevalent or obvious as you might think!
    - Cross-linguistic variation: encoding handshape, motion
    - Discrimination of sign by non-signers



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# Sign language & lateralization

- SLs pattern like spoken languages
    - = LH dominant
  - Why might this surprise us?
    - Use of visual-spatial system (RH is dominant for non-language tasks)
    - Naïve view of sign = pantomime
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# Lateralization of sign language

- 'Intact' signers – fMRI, ERP
    - Faster, more accurate responses when stimulus is presented to LH
    - More activation of LH during language tasks
  - Wada test of a hearing signer
    - sign and speech both affected in LH knockout
    - No effect (on language) of RH knockout
  - Cortical stimulation mapping
    - left temporal lobe stimulation → handshape errors
    - Broca's area → problems with articulation of signs
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# Brain Damage in Signers

- What are the effects of left vs. right hemisphere damage in users of a signed language?

see images from Hickok and Bellugi 1995

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# Brain Damage in Signers

- RHD signers: pattern like controls



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# Brain Damage in Signers

- LHD vs. RHD: **Aphasia results from LHD only**



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# Dissociation of abilities

- Language/grammar deficiencies from LHD
    - Ability to use and comprehend pantomime but **not** grammatical or fluent sign (Corina, Poizner et al 1992)
    - Inability to use facial expressions as grammatical morphemes (Kegl & Poizner 1997)
      - ...even though they can use emotionally expressive gestures
    - Difficulty with use of signing space for grammar (e.g., coreference)
      - ...even though they can construct non-linguistic spatial representations (Hickok, Say et al 1996)
      - Also: problems when real space and grammar collide
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# More on dissociation... the flipside

- Non-linguistic (affective, spatial) deficiencies from RHD
    - Intact ability to use facial expressions as grammatical morphemes
      - ...but they cannot use emotionally expressive gestures
    - Intact use of signing space for grammar (e.g., coreference)
      - ...but they cannot construct non-linguistic spatial representations
    - Discourse-level difficulties
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# Non-fluent (Broca's) Aphasia in signers

- Disruption of signing is equivalent to disruption of speech

(Why might we assume otherwise?)

- Problems with hand coordination, motion

- equivalent to difficulty observed with coordinating lips, tongue, larynx in speakers

- ***specific to language*** – *Not* simply a motor control problem: repetition, etc., of non-meaningful gestures remains intact

- Omission of grammatical morphemes

- Halting, effortful signing

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# Non-fluent (Broca's) Aphasia

- Compare the speech of a Broca's aphasic...
    - *Examiner*: What brought you to the hospital today?
    - *Patient*: Yeah... Wednesday... Paul and dad... Hospital... yeah... doctors, two... an' teeth  
(from Goodglass 1993)
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# Non-fluent (Broca's) Aphasia

- ...to the signing of a Deaf Broca's aphasic:

(Examiner's signs given in English. CAPS = signs; D-A-S-H = fingerspelling)

- Examiner: What else happened?
  - Patient: CAR... DRIVE... BROTHER... DRIVE... I... S-T-A-D [attempts to gesture "stand up"]
  - Examiner: you stood up?
  - Patient: YES... BROTHER... DRIVE... DUNNO.. [attempts to gesture "wave goodbye"]
  - Examiner: Your brother was driving?
  - Patient: YES... BACK... DRIVE... BROTHER... MAN... MAMA... STAY... BROTHER..DRIVE...  
(from Poizner et al, 1987)
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# Non-fluent (Broca's) Aphasia

- In both cases, subject/topic is relevant
  - No syntactic structure
  - No use of tense/aspectual/agreement morphemes
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# Fluent Aphasia: “Paul D.”

- Deaf man, fluent in English and ASL, worked as an editor and journalist pre-stroke

- Pre-stroke writing sample, from a letter:

I have never liked splinter groups. They weaken rather than strengthen an important cause, especially when the good of ALL people is concerned. You hit the nail on the head when you stated with truth that Judaism is synonymous with humanitarianism. Humanitarianism can best be served when everyone is pulling together to enhance the cause rather than to maintain “a house divided against itself.” This is especially applicable to our deaf world where the need is acute for people of all faiths and ideals to work hand in hand to better their welfare.

(from Poizner et al, 1987)

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# Fluent Aphasia: “Paul D.”

- Compare to his writing 3 years post-stroke (a description of the Capitol):

I spoke to the axiom in the window. I sprintered the Green aside the window. Many times as I looked at the Capitol I wonder the many times were engaged at the same time by the representatives as they behaved the problems. The 48 states wherein the problems threshed by the senators finally thunbured [thundured?] to the impression. And the gathering of the warrior.

(from Poizner et al, 1987)

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# Fluent Aphasia: “Paul D.”

- Language is highly fluent and structured...
  - ...but bizarre word choice renders it almost incomprehensible
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# Paul D.'s signing, post-stroke

- Examiner's signs given in English.
- Notations: CAPS = signs; D-A-S-H = fingerspelling; \* = ungrammatical; [...] = ASL grammatical morpheme. (from Poizner et al, 1987)
- *Examiner*: What are your plans for the next few months?
- *Paul D.*: I \*PLAN-[habitual] T-O SEARCH-[durational] FIND MISTAKE. PLAN \*H-A-Y H-A-V-E TO TELL-YOU EVERYTHING. ALL-WORKED-OUT. PAPER... \*NOT. WELL...
- Translation: "I (have been planning) to always search to find mistakes. Planning, (hay) have to tell you everything. Make it all work out. The paper... (it isn't). So..."

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# Paul D.'s signing

- *Examiner*. What paper are you referring to?
  - *Paul D.*: TALK-BACK-FORTH \*MY \*W-A-Y LIST-  
[seriated external] PAPER, JOT-DOWN. BEFORE  
IN THERE<sub>a</sub> CALIFORNIA. \*SIT-DOWN<sub>b</sub> IN  
\*THERE<sub>b</sub>...
  - Translation: “We were talking back and forth (in my way). Lots of lists and papers and writing down. Back in California, I sat down.”
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# Paul D.'s signing

- ❑ Attempts (unsuccessfully) to use tense/aspect morphemes
  - ❑ Apparently irrelevant to topic
  - ❑ Ungrammatical use of coreference in signing space
  - ❑ Interesting: Paul D.'s lesion is NOT in the classic Wernicke's aphasia site!
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# Things we're still confused about

(not exactly an exhaustive list)

- “Real” relationship between language dysfunction and:
    - Location of lesion
    - Extent of lesion
    - Age at onset/trauma causing brain damage (resilience of children)
  - Global/discourse-related contribution of RH vs. local/sentential contribution of LH
    - ...i.e., this has been an idealized discussion
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