Language & Brain

Ling 240
so far..

- Abstract rules and patterns of language

  - pot → pots \(/s/\)
    pond → ponds \(/z/\)
    poise → poises \(/\text{Iz}/\)

  - nasalization \(/n/\)

  ![Diagram]

  \([n] [m] [\text{\eta}]\)

  - S → NP Aux VP
    Invert NP and Aux in forming Yes/No questions
Cognitive Neuroscience of Language

• Study of language in the context of brain

• How is the grammar of human language computed in the human brain?

• Interdisciplinary approach:
  – Linking linguistic representations & operations to biological phenomena via explicit models
starting with a model

Auditory patterns → Phonological structure ← Syntactic Structure ← Thought

Motor instructions ← Language

When

What

How
Cognitive Neuroscience of Language

• Methodologies
  - neuropsychological deficit-lesion studies
  - Wada test
  - dichotic listening
  - Split-Brain experiments
  - Neuroimaging experiments
    - positron emission tomography (PET)
    - functional Magnetic Resonance Imaging (fMRI)
  - magnetoencephalography (MEG)
  - electroencephalography (EEG)
Aphasia

Speech & language disorders affect millions of Americans

– Aphasia
  • stroke
  • Traumatic Brain Injury
  • affects over 1 million Americans

– 80,000 new cases of acquired aphasia every year
  (www.ASHA.org)
Linking language to the cortex

• 1861: Paul Broca
  - treated a patient named Leborgne, who could only say “Tan.. Tan.. Tan..” yet could comprehend speech well

• … Leborgne dies 6 days later

• Broca presents the work at the *Anthropological Society Meeting* in Paris shortly after…

Paul Broca
(1824-1880)
From Hickok, G. language slides
Linking language to the cortex

- 1861: Paul Broca (French neurologist)
  - treated a patient named Leborgne, who could only say “Tan.. Tan.. Tan..” yet could comprehend speech well

- Similar lesion in the right hemisphere affect speech little
Broca’s Aphasia

DF (stroke at age 39)

“Were you in the coast guard?”
“No, et, yes, yes, …ship…Massachu…chusetts…Coastguard…years.”
“Yes, sure. Me go, er, uh, P.T. nine o’cot, speech…two times…read…wr…ripe, er, rike, er, write…practice…get-ting better.”
“Are you able to understand everything on TV?”
“Oh, yes, yes…well…al-most.”

“cookie jar … fall over … chair … water … empty … ov … ov… [Examiner: “overflow”] Yeah.
Broca’s Aphasia (a.k.a. agrammatism)

- slow & effortful speech with poor articulation
- word finding difficulty (Anomia)
- Fairly intact comprehension
- telegraphic style of speech, lack of *function* words (e.g., determiners, prepositions)
- verbs mostly not conjugated
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Speech Production (articulatory) area?

Broca’s area
Wernicke’s Aphasia

1876: Carl Wernicke

- Stroke patient with lesion to left superior temporal lobe
  - Fluent but nonsensical speech
  - Comprehension problem

Carl Wernicke (1848-1904)
Wernicke’s Aphasia

“Boy, I’m sweating, I’m awful nervous, you know, once in a while, I get caught up, I can’t mention the tarripoi, a month ago, quite a little, I’ve done a lot well, I impose a lot, while, on the other hand you know what I mean…”

“I called my mother on the television and did not understand the door..”

“You know that smoodle pinkered and that I want to get him round and take care of him like you want before."
Wernicke’s Aphasia

- fluent but meaningless speech
- switching words (paraphasia)
- nonsense words (neologism)
- Comprehension of spoken or written language
- unaware of mistakes

Near auditory cortex

auditory comprehension area?
double dissociation

- Broca’s aphasics
  - production deficit, normal? comprehension

- Wernicke’s aphasics
  - Comprehension deficit, fluent production

→ independent selective deficit
Classic model of language processing
(Wernicke-Geschwind model)

Articulatory speech production

Auditory comprehension

From Hickok, G. language slides

Geschwind 1979
Scientific American
Classic model of language processing
(Wernicke-Geschwind model)

From Hickok, G. language slides

Geschwind 1979
Scientific American
Problems with the classic model

Lack of consistent relation between lesion area and deficit

- 70 Wernicke’s aphasics, 10% showed lesion to Wernicke’s area
- 22 patients with lesion to Broca’s Area, 10 had Broca’s Aphasic symptoms
Problems with the classic model

Broca’s Aphasics show comprehension deficit

“The boy hit the girl” who hit who? 100%
“The boy was hit by the girl” who hit who? 50%

• who saw the pictures?
  “He showed her the baby pictures”
  “He showed her baby the pictures”

Broca’s aphasia as impairment in (parts of) syntax?
Broca’s aphasia in ASL

• Lesion is in LH
  – Halting effortful signing
  – Single sign utterance
  – Absence of syntactic, morphological marking
  – Agreement errors in **spatial syntax**
  – intact **spatial mapping**
  – Intact visuo-spatial processing
Spatial syntax

- **Spatial Syntax**: grammatical usage

- **Spatial mapping**: indicates spatial reference (talking about where furniture is located)
- Both may involve same hand movement

' The girl hit the boy'
ASL aphasia

• Lesion is in RH
  – normal phonology, morphology, syntax
    Normal **spatial syntax**
  – Impaired visuo-spatial processing
    (Drawing, spatial construction, line orientation judgment)
  – Impaired **spatial mapping**
  – Left visual space neglect
# ASL aphasia

<table>
<thead>
<tr>
<th>Spatial syntax</th>
<th>LH lesion</th>
<th>RH lesion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spatial mapping</td>
<td>✓</td>
<td>Impaired, left hemisphere neglect</td>
</tr>
</tbody>
</table>

- LH lesion: impaired
- RH lesion: ✓
ASL aphasia

- Broca’s (left hemisphere) aphasic ASL signers show deficit only in linguistic domain (same movements in non-ling environment not affected)

  → Linking Broca’s (temporal left hemisphere) to grammar
  → Modality-independent grammar system
  → Organization of grammar similar between ASL and hearing
Contributions from aphasia studies

• Broca found language deficit with left hemisphere lesion, but not with right hemisphere lesion → linked language to the left hemisphere

• certain functions are processed in certain areas of brain (localizationist view)
  • first model of language in brain
    – Provided predictions that can be tested empirically

• Rules and patterns of mental grammar are abstract enough to be shared between hearing and ASL signers
To study how language works in brain, **decompose** language into subcomponents (phonology, syntax, semantics, etc).

This breakdown seems to be on the right track, given parallelism seen between aphasia in hearing and ASL signers.
But what about things like…

• distinctive features?
• c-command?
• morpheme?
• phrase structure?

• How are these abstract representations computed in the brain?
• Further decomposition based on the linguistic theories is needed
MRI vs. fMRI

MRI studies brain **anatomy**.

Functional MRI (fMRI) studies brain **function**.

From Jody Culham’s “fMRI for Dummies”
Sources of progress

• Linguistics & Psycholinguistics

• Cognitive Neuroscience

• More advanced aphasiology