Week 6:
Language & Neurolinguistic Disorders (Ch 8)

NOTE CHANGE IN ORDER OF TOPICS
(SEE COURSE WEBSITE)
Odds & Ends

- **Homework #3**
  - Will be posted on web & sent by email tomorrow

- **Exam #1**
  - Passed out at beginning of class
  - We will review Exam 1 solutions (these will NOT be posted online);
    debriefing and review of important concepts & segue to topic for today
    (Language; see change in order of topics this month – on course website)
Exam 1: Distribution class scores
Outline for today

• Language & Language disorders
  – Introduction to language & linguistic subsystems
  – Aphasias (language impairments)
    • The “classical” model
    • Challenges to the classical model
    • Impairment of specific language subsystems (syntax, semantics, phonology, orthography)
  – Imaging language function in healthy individuals

– Reading & writing impairments
  • Reading impairments (alexia/dyslexia)
  • Writing impairments (agraphia/dysgraphia)
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What is Language?

Language Subsystems

Systems of rules for linking form, meaning, including:

- **Phonetics**: speech sounds (*phones*)
- **Phonology**: (language-specific) rules for combining sounds sound patterns (*phonemes*);
- **Morphology**: smallest units of meaning (*morphemes*) & rules for combining them to form words
- **Orthography**: written word forms
- **Syntax**: Rules for combining words to form *sentences*
- **Semantics**: *meaning*; word-level (*lexical*) and sentence -level (*propositional*) meaning; closely linked to nonlinguistic conceptual representation
- **Pragmatics**: Effects of *context* on meaning & choice of linguistic form; social-psychological factors
Anatomy of Language

• Some organizing concepts:
  – Anterior vs. Posterior language: Meaning & Form as an elaboration of sensory & motor systems?
    • Wernicke-Geschwind anatomical model
  – Linguistic vs. “extra-linguistic” factors
    • competence-performance distinction in linguistics
    • “core language” abilities interact with domain-general skills (e.g., working memory); debates over modularity
  – Different subsystems in language
    • Semantics: left inferior frontal cortex (esp. pars orbitalis/BA 47); superior & inferior temporol cortex
    • Phonology: left inferior frontal cortex (exp. Pars triangularis/BA 44); left posterior temporal cortex
    • Orthography: occipitotemporal cortex (left fusiform gyrus)
Some of the main brain regions involved in language processing

Démonet et al., *Physiological Reviews* (2005)
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Recall: Lesion Studies

- Most naturally occurring lesions in humans are due to *cerebrovascular accidents* (CVA or “stroke”), which are caused by obstruction of blood vessels.

- Surgical lesions (*ablations*) may be performed in special circumstances, e.g., when a chronic condition such as epilepsy is resistant to pharmaceutical treatment.
Recall: Early double dissociation

Broca (1824-1880)  Wernicke (1848-1904)

Courtesy of Will Graves
Figure 16.1
The drawing of the kitchen story, part of the Boston Diagnostic Aphasia Test.
Wernicke’s Area (~BA 22)
“Wernicke’s” Patient

“The man eats with cookies and a wood stool. The window has a lash window loses both near his formica. His water is falling near his sink. Some of a few dishes, also his utensils are not shown. His curtains are light numbers, also dark lines. His tables have some and Hardware figures water is near and a facet. The girl wants some cookies.”
Broca’s Area (~BA 44)
“Broca’s” Patient

“ah...boy....cookies... falls.”
But what does this mean?

- Production vs. comprehension?
- Syntax vs semantics?

How to carve up language deficits?
How to carve up language functions?
Broca–Wernicke–Lichtheim Model
Arcuate fasciculus
Aphasic Syndromes

- Apraxia of speech (AOS): speech deficit (motor programming)
- Agraphia: writing deficit
- Anomia: naming deficit (retrieval or loss?)
- Agrammatism: omission of closed-class words, morphosyntax
- Paragrammatism/paraphasia: substitutions
- Aphemia: articulatory deficit
- Alexia
  - Alexia with agraphia
  - Alexia without agraphia
- Dyslexia
  - Deep dyslexia
  - Surface dyslexia
- Word deafness
<table>
<thead>
<tr>
<th>Type of aphasia</th>
<th>Primary symptoms</th>
<th>Brain lesion to</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensory (Wernicke's) aphasia</td>
<td>General comprehension deficits, neologisms, word retrieval deficits, semantic paraphasias.</td>
<td>Posterior perisylvian region; postero-superior temporal, opercular supramarginal, angular and posterior insula gyri; planum temporale.</td>
</tr>
<tr>
<td>Production (Broca's) aphasia</td>
<td>Speech production deficits, abnormal prosody, impaired syntactic comprehension.</td>
<td>Posterior part of the inferior frontal and precentral convolutions of the left hemisphere.</td>
</tr>
<tr>
<td>Conduction aphasia</td>
<td>Naming deficits and impaired ability to repeat non-meaningful single words and word strings.</td>
<td>Arcuate fasciculus; posterior parietal and temporal regions: left auditory cortex; insula; supramarginal gyrus.</td>
</tr>
<tr>
<td>Deep dysphasia</td>
<td>Word repetition deficits; verbal (semantic) paraphasia.</td>
<td>Temporal lobe, especially regions which mediate phonological processing.</td>
</tr>
<tr>
<td>Transcortical sensory aphasia</td>
<td>Impaired comprehension, naming, reading and writing; semantic irrelevancies in speech.</td>
<td>Temporo-parieto-occipital junction of the left hemisphere.</td>
</tr>
<tr>
<td>Transcortical motor aphasia</td>
<td>Transient mutism and telegrammatic, dysprosodic speech.</td>
<td>Connection between Broca's area and the supplementary motor area; medial frontal lobe; regions anterolateral to the left hemisphere's frontal horn.</td>
</tr>
<tr>
<td>Global aphasia</td>
<td>Generalized deficits in comprehension, repetition, naming and speech production.</td>
<td>Left perisylvian region, white matter, basal ganglia and thalamus.</td>
</tr>
</tbody>
</table>

Table 8.1a Types of aphasia, their symptoms and main lesion sites

Week 6 (3/4/2009)                          Psych 433 (Frishkoff)
<table>
<thead>
<tr>
<th>Type</th>
<th>Site of damage</th>
<th>Spontaneous speech</th>
<th>Comprehension</th>
<th>Paraphasia</th>
<th>Repetition</th>
<th>Naming</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broca’s</td>
<td></td>
<td>Non-fluent</td>
<td>Good</td>
<td>Common</td>
<td>Poor</td>
<td>Poor</td>
</tr>
<tr>
<td>Wernicke’s</td>
<td></td>
<td>Fluent</td>
<td>Poor</td>
<td>Uncommon</td>
<td>Poor</td>
<td>Poor</td>
</tr>
<tr>
<td>Conduction</td>
<td></td>
<td>Fluent</td>
<td>Good</td>
<td>Common</td>
<td>Poor</td>
<td>Poor</td>
</tr>
<tr>
<td>Global</td>
<td></td>
<td>Non-fluent</td>
<td>Poor</td>
<td>Variable</td>
<td>Poor</td>
<td>Poor</td>
</tr>
</tbody>
</table>

**Table 8.1b** Symptomatology of aphasia
Schematic summary of lesion results
Recall: Limitations of lesion studies

- No temporal information
- Uncertainties in localization
  - Diaschisis
  - Brain plasticity & reorganization
- Only as good as our experiments
- Variability across subjects
Recovery from aphasia

• Intensive speech therapy
• Roughly 1/3 recover within the first 3 months
• Possibility of full recovery much less likely after 6 months
• Proposed mechanisms:
  – Peri-lesional tissue
  – Homologous areas in right hemisphere
Patient lesion distribution

Blasi et al., Neuron (2002)
Ricardo went out shopping to buy some fruit. He bought a pound of pears, and a large juicy watermelon. He also went into the off-licence and bought three bottles of wine. He walked home along by the river and watched the men rowing the boat. A very beautiful girl was sitting on a bench so he sat next to her. She had long blonde hair and big blue eyes. Ricardo said 'Good morning, it's a lovely day.' She turned to him and smiled showing lovely white teeth. Ricardo offered her one of his pears. They talked happily for half an hour and then Ricardo asked her out to dinner; she agreed and they met outside the restaurant at 7.30 pm.

**Figure 8.4a** Some examples of John Hale's writing following his stroke and, inset, John and his wife Sheila

*Source: From Hale 2003.*
Figure 8.4b,c  Continued

Source: From Hale 2003.
Darling Polly,
I am glad Joan is all right. I am sure she was better for these three weeks. Sheila and I are well. We went to St. Petersburg with friends for a week.
Love,
John

20 September 1998
Dear Miranda,

Thank you for the delicious dance on Friday. I was flattered to be on your party list and to participate...

Love
John

Source: From Hale 2003.
Pure Word Deafness from Left STG Infarction

Stefanatos et al. (JINS, 2005)
Expressive/Receptive Dichotomy

• Damage to Frontal regions ⇒ “Expressive” aphasia
  – Anterior Cingulate
  – Inferior prefrontal gyrus (esp. frontal operculum)
  – Anterior insula

• Damage to Frontal regions ⇒ “Receptive” aphasia
  – Wernicke’s area (BA22)
  – Angular gyrus
  – Supramarginal gyrus
  – Inferior temporal cortex

...But lesion data are by no means that tidy (many frontal patients have deficits in comprehension, and many posterior patients have speech deficits). Thus, frontal/posterior generalization may be of limited diagnostic value. Theoretical value is still debated.
“Challenges” to the classical model

• Caramazza et al.: Difference between Broca and Wernicke aphasia is one of syntax (Broca) and semantics (Wernicke) rather than a difference between expressive and receptive functions. (nonsense)

• Also, long-lasting damage typical of Broca or Wernicke aphasia has to involve tissue beyond the cortical surface of these areas (e.g., underlying white matter damage)
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Neuroimaging healthy adults

Passive Viewing

Passive Listening

Speech (Production)

Speech (Repetition)
FIGURE 9.10 Main brain regions involved in semantic, syntactic, and phonological aspects of language processing. In this diagram, regions involved in semantics are shown in dark blue, regions involved in syntax are shown in light blue, and regions involved in phonology are shown in grey. Anterior language areas, such as Broca’s area, are involved in syntactic processing. They also are involved in effortful retrieval of phonological and semantic aspects of words. Posterior language areas are involved in semantic processing as well as phonological processing.

Banich, 2002
Repetition of a spoken word

(a) Speaking a heard word

Motor cortex

Arcuate fasciculus

Broca’s area

Primary auditory cortex

Wernicke’s area
Repetition of a written word

(b) Speaking a written word
Specific language functions

• Spoken word recognition
  – Auditory feature extraction: bilateral superior temporal
  – Linking phonological information to word meaning: left temporo-parietal

• Spoken word production
  – Naming vs. “automatic” speech

• Grammatical representation of words
  – Function vs. content words
  – Nouns vs. verbs
  – Mental grammar vs. mental lexicon (regular vs. irregular words)
  – “left-frontal region may mediate the lexicon and the temporo-parietal cortex the grammar” (not consistent with Caramazza findings, and probably too simple)

• Sentence production
  – Speech is agrammatic in Broca aphasia, implicating BA 44
ERP markers of syntax: The LAN & P600/SPS

The man hoped to *enjoy* the meal ...

The man hoped to "*meal* the "enjoy..."

LAN (~300-500ms)

P600/SPS (~800-1000 ms)
ERP markers of semantics: The “N400” effect
ERP markers of phonology

Terminal words of spoken sentences that violate contextually developed phonological expectations (as in 1b) elicit this fronto-centrally distributed ERP component that peaks in the late 200 ms range (270–310 ms) and is earlier than and distinct from the N400 reflecting pure semantic anomalies (1c) (see also Section 9.2.3). In combined violations of phonological and semantic expectations (1d), the Phonological mapping negativity (PMN) precedes the N400 (Figures 9.1 and 9.2(b)).

1a) Father carved the turkey with a knife (expected word: knife)  
1b) The pigs wallowed in the pen (mud)  
1c) The gambler had a streak of bad luggage (luck)  
1d) The winter was harsh this allowance (year)

Steinhauer & Connolly, 2009
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To be continued next week…

(after we wrap up this unit, the full set of slides will be posted)