Language and Hemisphere Laterality

OUTLINE

- Hemispheric Differences
  - Lateralization of Language
  - Evolution of language capabilities
- Case Studies
  - Split brain patients
  - Neglect patients
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LATERALIZATION OF FUNCTION

- Lateralization-Division of labor between the two hemispheres
- Commissures-Cross-over points of information in the brain
  - Corpus Callosum
  - Anterior Commissure
  - Hippocampal Commissure
  - Posterior Commissure
THE COMMISSURES

Language is most frequently encoded in the left hemisphere

- Clinical observations of aphasia following left hemisphere damage
- **Wada test** – knowledge of cerebral dominance helps guide neurosurgeons
  - Injections in R or L carotid arteries with *sodium amytal* – anesthetizes a single hemisphere
  - Yields sudden and total aphasia
The Wada Procedure

The Wada Procedure is a procedure, developed by Johns Hopkins Hospital, in which a solution of sodium amytal is injected into one or both sides of the brain to determine which side is dominant for language processing. The procedure is performed under anesthesia and involves monitoring the patient's response to the injection. If the injection is into the non-dominant hemisphere, the patient may experience temporary memory loss or confusion. If the injection is into the dominant hemisphere, there may be no change in cognitive function. The procedure is used to determine the side of the brain that is responsible for language processing, which can be helpful in cases of brain injury or in planning surgery on the brain.

### Table A: Hemispheric Control of Speech in Relation to Handedness

<table>
<thead>
<tr>
<th>Handedness</th>
<th>Number of Cases</th>
<th>Speech Representation (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right</td>
<td>140</td>
<td>Left: 96, Bilateral: 0, Right: 4</td>
</tr>
<tr>
<td>Left</td>
<td>122</td>
<td>Left: 70, Bilateral: 15, Right: 15</td>
</tr>
</tbody>
</table>

Source: Rasmussen and Milner, 1977, Table 1.

The Anatomy of Language

The anatomy of language involves the activation of specific regions of the brain, particularly in the left hemisphere. The primary auditory area, which is responsible for hearing, is located in the temporal lobe. The secondary auditory cortex, which includes Wernicke's area (speech comprehension in the dominant hemisphere), is also located in the temporal lobe. Broca's area, which is responsible for speech planning and sequencing, is located in the frontal lobe. The motor cortex is responsible for the execution of speech movements and is also located in the frontal lobe. These regions work together to enable language production and comprehension.
CENTRAL PROCESSING OF SPEECH

- Tones are received by the primary auditory cortex
- Specialized areas of the secondary auditory cortex analyze tones recognized as speech

PATHWAY FOR LANGUAGE

- INPUT: Written - visual cortex, Verbal - auditory cortex
- Combine information through corpus callosum
- **Wernicke’s area** = language comprehension
- Broca’s area = language production
BROCA’S APHASIA

- Broca’s aphasia (BA): 1861, 51 year old man referred to as “Tan”
  - Understood what was said
  - Hearing was OK
  - Autopsy revealed damage to frontal lobe of L hemisphere (Broca’s Area)

http://www.youtube.com/watch?v=f2liMEbMnPM
**BROCA’S APHASIA**


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**BROCA’S APHASIA (BA)**

- BA traditionally associated with impaired language **production** and relatively spared language **comprehension**
BROCA’S APHASIA (BA)

- Can’t read “To be or not to be.” But can read “Two bee oar knot two bee”
- Not just a pronunciation problem.
- Problem with word meanings
  - Little speech
  - Effortful, slow speech
  - Poor articulation
- Deaf person with BA find it difficult to sign, although they can use their hands for other purposes

WERNICKE’S AREA

Speech Production: Broca’s area

Wernicke’s area

Speech Comprehension
WERNICKE’S APHASIA

- 1874 discovered that damage to the left temporal cortex produced a different impairment in language than did damage to BA
- Person can speak smoothly – articulate speech
- Difficulty finding right word: anomia
- Problems arranging words properly
- Poor language comprehension – both written and spoken

PHOTO FROM THE WESTERN APHASIA BATTERY
WERNICKE’S APHASIA

- The boys and the girls are having a picnic. The son is flying the kase – the take. They all live in the garage. The keys are floating in the lake. The page of the flag. This is the home of the grass, the car – the home. This is the home of the home. See the oak in the creed. See the oak in the chair, the oak tree, the ocean – the animal – the trees are in the apple – in the sky in the apple. This is terrible. The trees live up in the mountain.
THOUGHT QUESTION

- Most people with Broca’s aphasia suffer from partial paralysis on the right side of the body.
- Most people with Wernicke’s aphasia do not.
- Why might this be?

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**EVOLUTION OF LANGUAGE CAPABILITIES**

- Why did our ancestors evolve the capacity for language?
- If language is so important, why has no other species evolved it?
- Is language present in some forms in other species?

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**HIERARCHICAL STRUCTURE OF LANGUAGE**

**DO ANIMALS HAVE SOME OF THESE?**

- **Phonological level**: speech sounds, phonemes (smallest units of language); e.g., “dog”
  - Some animals have these
- **Morphological level**: root words, suffixes and prefixes, e.g., “dogs”
  - Some animals may be taught these
- **Syntatic level**: rules governing phrases and sentences; e.g., “the dog”, “the red sports car”
- **Semantic level**: meanings combine to form different phrase and sentence meanings; “the rich man bought the red sports car but died soon thereafter”
CAN ANIMALS COMPREHEND LANGUAGE?

FAST MAPPING: CHASER AT WOFFORD

http://www.youtube.com/watch?v=mTTuiE1_Oe8&feature=related
ATTEMPTS AT TEACHING ANIMALS LANGUAGE

- Premack 1976: failed attempt to get chimps to speak
  - Dogs speaking: [http://www.youtube.com/watch?v=b9KL1F2nxqU](http://www.youtube.com/watch?v=b9KL1F2nxqU)
  - Chimp speaking: [http://www.youtube.com/watch?v=y4Z0xn4pYSY&NR=1](http://www.youtube.com/watch?v=y4Z0xn4pYSY&NR=1)
- Later attempts: Teaching chimps sign language (ASL) or symbol code:
  - “Please machine give me apple”
- But is this language like we have?

ATTEMPTS AT TEACHING CHIMPS LANGUAGE

- Just stringing together words to get reinforced?
- Chimps seldom combine symbols to make new “original” sentences—something any child can do
- Chimps use their symbols to request and almost never to describe
- If the experimenter varied the question a little the chimp seemed not to understand
- Conclusion: Chimps can’t learn syntax and rules for combining new words into meaning
DATA FROM BONOBO (PIGMY) CHIMPS - PAN PANICUS

- Chimp Matata (mid 1980s) made poor progress in learning symbol language
- Her infant son (Kanzi) never received formal training but learned a great deal by watching his mother.
- Understood some spoken language: “Go to the refrigerator and take out a tomato”
- Used symbols to speak of past: “Mantata bite” to explain cut on hand
- Do pigmy chimps have more-human-like language capacity?
- Do chimps need to learn at an early age?
- Is observational learning the optimal methods?

KANZI THE CHIMP

http://www.youtube.com/watch?v=wRM7vTrIIis
http://www.youtube.com/watch?v=kwm4FEB9LC8&NR=1
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WHAT DO SPLIT BRAIN PATIENTS TELL US ABOUT LANGUAGE AND HEMISPHERIC SPECIALIZATION?

- **Commissurotomy** - section of corpus callosum
  - Behave as if 2 brains
  - Used with humans to control spread of seizure
Split Brain Surgery

Route of visual input to the two hemispheres

Left hemisphere is connected to the left half of each retina and thus gets visual input from the right half of the world.
VISUAL STIMULATION OF ONE HEMISPHERE IN HUMANS

http://www.youtube.com/watch?v=ZMLzP1VCANo
The word *hatband* is flashed on a screen.

A woman with a split brain can report only what her left hemisphere saw, “band.” The left hemisphere controls the right hand.
However, with her left hand, she can point to a hat, which is what the right hemisphere saw. She can’t say it - but she can point.

SPLIT HEMISPHERES

- **Competition**
  - Soon after surgery - competition between activities on the two sides of the body

- **Hemispheric Specialization**
  - **Left**
    - Speech
    - Detail-oriented
  - **Right**
    - Emotional content of speech
    - Recognizes emotions in others
    - Expresses fear and anger
    - Spatial Relationships
    - Music perception
RIGHT-HEMISPHERE LANGUAGE FUNCTIONS

- It can understand the meaning of a word
  - Comprehend vocabulary at 13 yr level
  - Comprehend sentence structure at 5 yr level
- Provides an understanding of context of language
- Governs emotional expression of language
- Important with visual-spatial information

THOUGHT QUESTIONS

- Can a split brain person name an object after feeling it with the right hand? With the left hand? Explain.
- After a split-brain person sees something in the left visual field, how can he or she identify the object?
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GENERAL ATTENTION REGIONS

- Frontal Lobe - decision making, ST memory
- Posterior Parietal Lobe - focus of attention
- Reticular Formation – alertness, vigilance
NEGLIGENCE

Damage to right parietal lobe

“cross all the Os” – the patient only did this for the right side and “neglected” the left side