Lateralization of Function

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Human Brain

- An extension of the spinal cord
Cortex

- Two millimeters thick and has area of 1.5 square meters
Cerebral Hemispheres
Corpus Callosum
Cerebral Lobes
Cartoon View: Frontal Lobe

- In front of central sulcus
- Motor control
- Decisions, judgments, emotions
- Language production
Cartoon View: Parietal Lobe

- Behind central sulcus
- Perception of stimuli related to touch, pressure, temperature, pain
- Spatial cognition
- Spatial attention
Cartoon View: Temporal Lobe

- Below lateral fissure
- Visual perception, object recognition, auditory processing
- Memory
- Language comprehension
Cartoon View: Occipital Lobe

- Located at back of brain, behind the parietal lobe and temporal lobe
- Vision
Lateralization of Function

• One side of the brain is more crucial for a given function and/or more efficient at the underlying computational tasks

• Typically a matter of degree
  – Strongly vs. Weakly Lateralized

• Motor control a good example of a lateralized function
Motor Control
Sensorimotor Cortex

Figure 4.21  Approximate representation of sensory and motor information in the cortex
(a) Each location in the somatosensory cortex represents sensation from a different body part. (b) Each location in the motor cortex regulates movement of a different body part. (Source: After Penfield & Rasmussen, 1950)
Figure 8.19  Within the modality of touch, in animals that are “feelers” the behaviorally most used and sensitive area of the body touch sense (upper panel) is much expanded in its representation on the somatic sensory area of the cerebral cortex (lower panel). The spider monkey explores with its tail, the raccoon with its forepaws, the rat with its whiskers, and the sheep with its lips and tongue.
Are there other lateralized functions?

• Speech is a paradigmatic example of a strongly lateralized cognitive phenomenon
Wada Test
Wada Test

Table A: Hemispheric Control of Speech in Relation to Handedness

<table>
<thead>
<tr>
<th>HANDEDNESS</th>
<th>NUMBER OF CASES</th>
<th>LEFT</th>
<th>BILATERAL</th>
<th>RIGHT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right</td>
<td>140</td>
<td>96</td>
<td>0</td>
<td>4</td>
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<tr>
<td>Left</td>
<td>122</td>
<td>70</td>
<td>15</td>
<td>15</td>
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</tbody>
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Lateralization of Function

• Historically, evidence of lateralized brain function has come from observing how brain damage affects behavior on various sorts of cognitive tasks
Paul Broca

- 19th century French neurologist
- Star patient: Leborgne
- Understood most of what was said to him
- Able to eat, drink (move mouth and tongue)
- Only utterance was “tan”
Broca’s Discovery

- Leborgne’s brain had damage to the lower rear portion of frontal lobe, lower front portion of parietal lobe, and upper part of the temporal lobe
- Broca deemed frontal lobe damage most important
- *Aphasia* – partial or total loss of ability to articulate ideas due to brain damage
- Broca’s Area – lower rear portion of frontal lobe, adjacent to motor cortex
  - Inferior frontal gyrus
  - Brodmann’s Areas 44/45
Brodmann’s Areas

• Korbinian Brodmann examined brain cells with various stains designed to detect chemical differences between areas
• Brain areas defined by cytoarchitectonic characteristics known as Brodmann’s Areas
  – 52 areas in the human brain (though some subdivided into a, b, etc)
Broca’s Aphasia

- *M.E.* Cinderella...poor...um 'dopted her...scrubbed floor, um, tidy...poor, um....'dopted...Si-sisters and mother...ball. Ball, prince um, shoe...
- *Examiner* Keep going.
- *M.E.* Scrubbed and uh washed and un...tidy, uh, sisters and mother, prince, no, prince, yes. Cinderella hooked prince. (Laughs.) Um, um, shoes, um, twelve o'clock ball, finished.
- *Examiner* So what happened in the end?
- *M.E.* Married.
- *Examiner* How does he find her?
- *M.E.* Um, Prince, um, happen to, um...Prince, and Cinderalla meet, um met um met.
- *Examiner* What happened at the ball? They didn't get married at the ball.
- *M.E.* No, um, no...I don't know. Shoe, um found shoe...
Broca’s Aphasic
Wernicke’s Aphasia

• 1871 Karl Wernicke reported a different sort of language disorder

• Symptoms
  – Talk fluently, excessively
  – Use made up words
  – Don’t understand, in spite of intact hearing
Wernicke’s Area
Wernicke’s Area
Wernicke’s Aphasic

• C.B. Uh, well this is the ... the /dodu/ of this. This and this and this and this. These things going in there like that. This is /sen/ things here. This one here, these two things here. And the other one here, back in this one, this one /gesh/ look at this one.
• Examiner: Yeah, what's happening there?
• C.B. I can't tell you what that is, but I know what it is, but I don't know where it is. But I don't know what's under. I know it's you couldn't say it's ... I couldn't say what it is. I couldn't say what that is. This shu-- that should be right in here. That's very bad in there. Anyway, this one here, and that, and that's it. This is the getting in here and that's the getting around here, and that, and that's it. This is getting in here and that's the getting around here, this one and one with this one. And this one, and that's it, isn't it? I don't know what else you'd want.

• Describing a picture of a child taking a cookie
Goodglass “cookie theft” picture
Pop Quiz

Wernicke’s Aphasia (Temporal Lobe Lesions)
Pop Quiz

Broca’s Aphasia (Frontal Lobe Lesions)
Wernicke-Geschwind Model

- Broca’s Area stores motor representation of speech
- Wernicke’s Area stores auditory representation of speech sounds
- Connected by fiber tract known as arcuate fasciculus
- Considered an oversimplified model
Broca’s Aphasia

Motor Word Comprehension

Speech motor output

Ventral prefrontal cortex

Concepts

Association Cortex

Auditory word Comprehension

Posterior Temporal Cortex

Auditory input

Arcuate Fasciculus

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Wernicke’s Aphasia

- Motor word comprehension
- Auditory word comprehension

Ventral prefrontal cortex

Speech motor output

Association Cortex

- Arcuate Fasciculus

Posterior Temporal Cortex

Auditory input

Concepts
Conduction Aphasia

- **Concepts**
  - Association Cortex
  - Posterior Temporal Cortex

- **Motor word Comprehension**
  - Ventral prefrontal cortex
  - Speech motor output

- **Auditory word Comprehension**
  - Arcuate Fasciculus
  - Auditory input

Conduction Aphasia

psychology.rutgers.edu/~rypma/
Reprise

• Wada Test
• Broca’s Aphasia
• Wernicke’s Aphasia
• Conduction Aphasia
• But remember, these models are cartoons…
TMS Demonstration
Language as a Social Activity

• Language is not the result of individual brains, but rather joint activity
  – Ballroom dancing
  – Salsa dancing
  – Tennis

• Conversation involves a lot of negotiation as speakers coordinate with one another

• Cooperative nature of communication through language even more evident in aphasia
Chil’s Semiotic Resources

Intonation

* * * * *

Lh dih dih dih dih:::

Three Words: Yes, No, And

12 Chil: °mmm Nih nih duh duh Da duh.
13 Pat: So *five* of us can fit there.
14 (0.2)
15 Pat: *Seven* a clock.

Pat

Chil

Gesture

Goodwin L
1 Pat: So we'll see if they have a table for five.
2 Chil: Ye(h)s. (0.7) Yes.
3 Helen: When? at six a clock?
4 Pat: mm hmm
5 Chil: Yes.
...
Da da:h.
When we went with Mack and June
We- we sat at a table
just as we came in the: fr-ont door.
*hh We sat with them. (.).
There. En then we-
mommm Nih nih duh duh Da duh.
So five of us can fit there.
(0.2)
Six a clock.
(1.0)
Five people.
Sure.
Its::
Seven?
Seven?
a’ clock?
(0.2)
No(h)
25 Pat: *Six* a clock.
26
27 Pat: *Seven?*
28 Helen: °Seven people Who *(‘d they be)* Five.
29 Pat: *(1.0)*
30 Helen; Seven people. Who are they.  That’s six.
32 Pat:
33 Julia: Two?
34 Pat: Seven?
35 Chil: Duh da *dah?* *(Chil turns and Points Toward Helen)* Yes.
36
37 Pat: Invite somebody?
38 Chil: Yes.
39 Chil: Yes.
40 Pat: Mack en June?
41 Chil: Yes.
42 Pat: *(0.2)*
43 Pat: Oh.
44 Pat: *(2.0)*
45 Pat: Oh.
46
Electrocortical Stimulation
Where does stimulation interrupt naming?
Representation of Language in Bilinguals

Naming objects in two languages:
- B: Bilingual naming sites
- E: English naming only
- S: Spanish naming only
- O: No naming disruption
If language is left, what is right?

- President Woodrow Wilson
- Suffered RH stroke during Versailles Peace Conference after WWI
- Participants noticed nothing wrong with him BUT his personality seemed to change overnight
- From friendly and conciliatory to unpleasant and vindictive
Woodrow Wilson

• Weeks later he suffered another stroke that resulted in paralysis of the left side of his body
  – Which side did this stroke affect?
• He denied there was anything wrong with him
  – Issued press release saying he hurt his left arm in a fall
  – Anosagnosia
• Wife & close advisors hid his medical problems from public and ran shadow government…
Right Hemisphere Damage

Large right brain stroke of the type suffered by Woodrow Wilson in 1919 producing "denial of illness" and defective body image.
Anosagnosia

Why can't you move your hand?
• “Somebody has ahold of it.”
• “I think it’s the weather. I could warm it up and it would be alright.”
• “I have a shirt on.”

Why can’t you walk?
• “I could walk at home, but not here. It’s slippery here.”
Abnormal Body Image

• Patients may deny that their left hand is their own hand and wonder why someone else is in bed with them
Hemineglect

- Inability to attend to objects (even one’s own body) on one side of space
  - Typically left side of space after right parietal damage

"Line cancellation task"
Unilateral (left) Neglect

- Right parietal lesion
- Neglect = Failure to report, respond, or even orient to stimuli on the contralateral side of the body
(A) "Draw a house"

Model

Patient's copy

(B) "Bisect the line"
“Draw the face of a clock, put in all of the numbers and set the hands for 10 after 11”
Neglect
Anton Radershcheidt
Neglect & Mental Imagery

- Asked to imagine the Piazza del Duomo in Milan from two different vantage points, a neglect patient describes different parts of the square -- Bisiach & Luzzatti (1978)
- Preserved visual knowledge and ability to visualize from different perspectives, but mental image lacks detail about the left half of space in each case!
Functional imaging: Right parietal neglect occurs because the left parietal lobe does not have a map of left visual field.

(A) Attending to the left visual field

(B) Attending to the right visual field

Only R side active

Posner and Raichle, 1994
Dressing Apraxia

- Patients with large RH stroke have trouble getting arms into sleeves and legs into pants
- Know what they’re supposed to do, but unable to do it due to defective body image
What about sign language?

- Language, but body image and spatial relationships very important for understanding
- Worse with LH or RH damage?
- LH damage results in aphasia in signers, while RH damage leads to visuo-spatial deficits but largely intact language
Visuospatial Ability in Aphasic & Non-Aphasic Signers

Fig. 2 Performance on spatial cognitive tasks by four aphasic LHD signers (top) and four non-aphasic RHD signers (bottom). The task in each case was to copy the model drawing in the centre panel. RHD signers show a greater impairment than LHD signers, indicating a dissociation between language and non-linguistic visuospatial functions. (Reproduced, with permission, from Ref. 15.)
fMRI: Spoken vs. Signed Language

Fig. 2 Group data showing cortical regions activated in language tasks. Areas activated (A) while hearing subjects read printed English sentences (versus non-word strings), and (B) while deaf subjects viewed a video of a signer producing ASL sentences (versus "non-sign" movements). (Reproduced, with permission, from Ref. 13.)
Summary

• LH damage
  – Communicative disorders
  – Frontal damage leads to expressive disorders, trouble with grammatical complexity
  – Posterior damage leads to receptive disorders, trouble with meaning

• RH damage
  – Anosagnosia
  – Body image disorder
  – Hemineglect

• Electro cortical Stimulation
  – Naming disruption w/stimulation in LH, not typically RH
  – Exact locale varies widely from individual to individual
  – Different languages disrupted at slightly different sites in cortex
Thanks

To contact Prof. Coulson:
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Neurons

- Brain composed of neurons
  - 100 billion
- Neurons both send and receive signals to other cells in form of pulses
- Important parts
  - Cell body
  - Axon
  - Synapse
Connectivity

- Each neuron connected to 10,000 other neurons
- Point of contact is the synapse
- Computing power of brain comes from connections
Sex Differences

- Women more vulnerable to aphasia after damage to *frontal* lobe
- Men more vulnerable to aphasia after damage to *parietal* and *temporal* lobe areas
- Similar sex differences in *apraxia*, impairment in voluntary motions