Lateralization of Function

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Human Brain

• An extension of the spinal cord

Cerebral Hemispheres

Corpus Callosum

Cartoon View of Brain

Cerebral Lobes
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

Cortex

- Two millimeters thick and has area of 1.5 square meters

Cartoon View: Frontal Lobe

- In front of central sulcus
- Decisions, judgments, emotions

Cartoon View: Parietal Lobe

- Behind central sulcus
- Perception of stimuli related to touch, pressure, temperature, pain

Cartoon View: Temporal Lobe

- Below lateral fissure
- Perception, recognition, auditory processing
Cartoon View: Occipital Lobe

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

Laterlization 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

Sensorimotor Cortex

Motor Control

What about language?

- Language is a paradigmatic example of a lateralized cognitive phenomenon
Wada Test

Lateralization of Function

• Most evidence of lateralized brain function comes 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...sisters and mother...ball. Ball, prince um, shoe...”
• Examiner Keep going.
• M.E. Scrubbed and uh washed and um... 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...”
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

Pop Quiz
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

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

Wernicke-Geschwind Model: Repeating a Spoken Word

Reading a Written Word

Broca’s Aphasia

Wernicke’s Aphasia
Conduction Aphasia

Reprise

- Wada Test
- Broca's Aphasia
- Wernicke's Aphasia
- Conduction Aphasia
- But remember, these models are cartoons…

Electrocortical Stimulation

Cheesy Demo

http://www.pbs.org/wgbh/aso/tryit/brain/

Where does stimulation interrupt naming?

Representation of Language in Bilinguals

psychology.rutgers.edu/~rypma/
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

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
Unilateral (left) Neglect

- Right parietal lesion
- Neglect = Failure to report, respond, or even orient to stimuli on the contralateral side of the body

“Draw the face of a clock, put in all of the numbers and set the hands for 10 after 11”

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.

Dressing Apraxia
- Patients w/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

fMRI: Spoken vs. Signed Language
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
- Electrocortical 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

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