Chapter 16
Lateralization, Language, and the Split Brain

The Left Brain and the Right Brain of Language
Cerebral Lateralization of Function

- Major differences between the function of the left and right cerebral hemispheres
- Cerebral commissures connect the two halves of the brain
- Split-brain patients have been studied to understand what happens when these connections are severed

Discovery of the Specific Contributions of Left-Hemisphere Damage to Aphasia and Apraxia

- Aphasia – deficit in language comprehension or production due to brain damage, usually on the left
- Broca’s area – left inferior prefrontal cortex, damage leads to expressive aphasia
- Apraxia – difficulty performing movements when asked to do so out of context, also a consequence of damage on the left
Cerebral Lateralization of Function Continued

- Aphasia and apraxia – associated with damage to left hemisphere
- Language and voluntary movement seem to be controlled by one half of the brain, usually the left
- Suggests that one hemisphere is dominant, controlling these functions

Tests of Cerebral Lateralization

- Determining which hemisphere is dominant
  - Sodium amytal test
    - Anesthetize one hemisphere and check for language function
  - Dichotic listening
    - Report more digits heard by the dominant half
  - Functional brain imaging
    - MRI or PET used to see which half is active when performing a language test

Dichotic Listening Task

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Discovery of the Relation between Speech Laterality and Handedness

- Left hemisphere is speech dominant in almost all *dextrals* (right-handers) and most *sinestral* (left-handers)

Sex Differences in Brain Lateralization

- McGlone (1977, 1980) studies of unilateral stroke victims
- Females may use both hemispheres more often for language tasks than men do (females may be less lateralized)
- Mixed support for McGlone's hypothesis

The Split Brain
Corpus Callosum

- Largest cerebral commissure – 200 million axons
- Transfers learned information from one hemisphere to the other
  - When cut, each hemisphere functions independently
- Early research paradox
  - No apparent effect when cut in laboratory animals
  - No apparent effect when damaged in humans

Groundbreaking Experiment of Myers and Sperry

- Studied split-brain cats
  - Transected the corpus callosum and optic chiasm so that visual information could not cross to the contralateral hemisphere

Four Groups

1. Corpus callosum and optic chiasm severed (experimental group)
2. Corpus callosum severed control group
3. Optic chiasm severed control group
4. Intact control group
FIGURE 16.3 Restricting visual information to one hemisphere in cats. To restrict visual information to the hemisphere, Myers and Sperry (1) cut the corpus callosum, (2) cut the optic chiasm, and (3) blindfolded one eye. This restricted the visual information to the hemisphere ipsilateral to the uncovered eye.

FIGURE 16.4 Schematic illustration of Myers and Sperry’s (1953) groundbreaking split-brain experiment. There were four groups: (1) the key experimental group with both the optic chiasm and corpus callosum transected, (2) a control group with only the optic chiasm transected, (3) a control group with only the corpus callosum transected, and (4) an unlesioned control group. The performance of the three control groups did not differ, so they are illustrated together here.

Split-Brain Cats Continued

- Each hemisphere can learn independently
- Split-brain cats with one eye patched
  - Learn task as well as controls
  - No memory or savings demonstrated when the patch was transferred to other eye
- Intact cats or those with an intact corpus callosum or optic chiasm – learning transfers between hemispheres
- Similar findings with split-brain monkeys
Commissurotomy in Human Epileptics

- Commissurotomy limits convulsive activity
  - Many never have another major convulsion
- Sperry and Gazzaniga
  - Developed procedures to test split-brain patients
- Differ from split-brain animals in that the two hemispheres have very different abilities – most left hemispheres are capable of speech, while the right are not

Evidence that the Hemispheres of Split-Brain Patients Can Function Independently

- Left hemisphere can tell what it has seen, right hemisphere can only show it
  - Present a picture to the right visual field (left brain)
    - Left hemisphere can tell you what it was
    - Right hand can show you, left hand can’t
  - Present a picture to the left visual field (right brain)
    - Subject will report that they do not know what it was
    - Left hand can show you what it was, right can’t
Cross-Cuing

- Cross-cuing – facial feedback from the other hemisphere
  - For example, the right hemisphere might make the face frown when the left hemisphere gives an incorrect spoken answer

Doing Two Things at Once

- Each hemisphere of a split-brain can learn independently and simultaneously
  - Helping-hand phenomenon – presented with two different visual stimuli, the hand that “knows” may correct the other
  - Dual foci of attention – split-brain hemispheres can search for target item in array faster than intact controls
  - Chimeric figures task – only symmetrical version of right half of faces recognized
    - Indicates competition between hemispheres

Chimeric Figures Test

[Image of a chimeric figure]
The Z Lens

- Advancing the study of split-brains with a contact lens to restrict visual input to one hemisphere
- Previous studies had to limit viewing time to less than .1 second
- Can be used to assess each hemisphere’s understanding of spoken instructions by limiting essential visual information to one side of brain

FIGURE 16.7 The Z lens, which was developed by Zaidel to study functional asymmetry in split-brain patients. It is a contact lens that is opaque on one side (left or right) so that visual input reaches only one hemisphere.
Dual Mental Functioning and Conflict in Split-Brain Patients

- Usually in split-brain patients the left hemisphere is dominant in most everyday activities
- For some, the right is dominant and this can create conflict between hemispheres
  - For example, the case of Peter
  - Hemispheres often disagreed with each other

Independence of Split Hemispheres: Current Perspective

- Discussions of split-brain patients tend to focus on examples of hemispheric independence
- Still interactions between the hemispheres (via sub-cortical structures)
- Emotional information somehow passed between hemispheres
- Difficult tasks are more likely to enlist involvement of both hemispheres

Sperry, Zaidel, & Zaidel (1979)

Patient was shown an array of photos and asked if one was familiar. He pointed to the photo of his aunt.

Examiner: “Is this a neutral, a thumbs-up, or a thumbs-down person?”
Patient: With a smile, he made a thumbs-up sign and said, “This is a happy person.”
Examiner: “Do you know him personally?”
Patient: “Oh, it’s not a him, it’s a her.”
Examiner: “Is she an entertainment personality or an historical figure?”
Patient: “No, just …”
Examiner: “Someone you know personally?”
Patient: He traced something with his left index finger on the back of his right hand, and then he exclaimed, “My aunt, my Aunt Edie.”
Examiner: “How do you know?”
Patient: “By the E on the back of my hand.”
Task Difficulty

- Simple tasks best processed in one hemisphere
- Complex tasks generally require both hemispheres
- Important finding because:
  1. Complicates interpretation of functional-brain imaging studies of lateralization of function
  2. Explains why the elderly often display less lateralization of function

Differences between Left and Right Hemispheres

- For many functions there are no substantial differences between hemispheres
- When differences do exist, usually slight biases in favor of one hemisphere—not absolute differences
- Key point: Lateralization of function is statistical rather than absolute
- Media misrepresent or distort cerebral hemisphere differences – suggest there are absolute differences

Examples of Cerebral Lateralization of Function

- Left hemisphere: superior in controlling ipsilateral movement
- Left hemisphere: an “interpreter”
- Right hemisphere superiority:
  - Spatial ability
  - Emotion
  - Musical ability
  - Some memory tasks
What is Lateralized—Broad Clusters of Abilities or Individual Cognitive Processes?

- Broad categories are not lateralized – individual tasks may be
- Better to consider lateralization of constituent cognitive processes – individual cognitive elements
  - Example: two spatial tasks – left hemisphere is better at judging above or below, right at how close two things are

Anatomical Brain Asymmetries

- Frontal operculum (Broca’s area)
  - Near face area of primary motor cortex
  - Language production
- Planum temporale (Wernicke’s area)
  - Temporal lobe, posterior lateral fissure
  - Language comprehension
- Primary auditory cortex (Heschl’s gyrus)
Anatomical Brain Asymmetries Continued

- Although asymmetries are seen in language related areas, these regions are not all larger in the left
- Left planum temporale – larger in only 65% of human brains
- Heschl’s gyri – larger on the right
  - Two gyri in the right, only one in the left
- Frontal operculum – visible surface suggests right is larger, but left has greater volume

FIGURE 16.9 The anatomical asymmetry detected in the planum temporale of musicians by magnetic resonance imaging. In most people, the planum temporale is larger in the left hemisphere than in the right. The difference was found to be greater in musicians with perfect pitch than in other musicians without perfect pitch or controls. (Based on Bidelman et al., 1995.)