

Lateralization & The Split Brain

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- Tests of Cerebral Lateralization
- The Split-Brain Experiment
- Tests of Split-Brain Patients
- Differences Between the Left and Right Hemispheres
- Broca's Area
- Wernicke's Area

What is cerebral lateralization of brain?

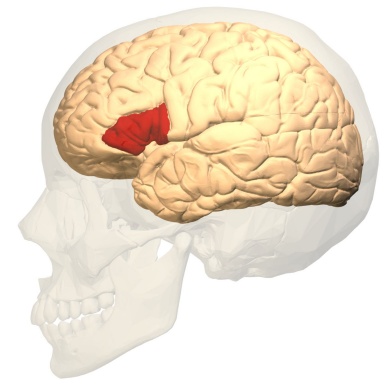
Aphasia and Apraxia:

The Dominant Left Hemisphere

- In 1836, Dax reported that not one of his 40 or so patients with speech problems had displayed damage restricted to the right hemisphere
- 25 yrs later, **Broca** reported the results of the postmortem examination of two **aphasic** patients (patients with deficits in the use of language that are not attributable to general sensory, motor, or intellectual dysfunction)...

Aphasia and Apraxia: The Dominant Left Hemisphere

- Both had diffuse left hemisphere damage that seemed to be centered in an area of the inferior left prefrontal lobe, just in front of the primary motor face area
- This became known as **Broca's area** that is associated with grammar and speech production



Aphasia and Apraxia: The Dominant Left Hemisphere

- Liepmann discovered that **apraxia** (difficulty performing movements with either side of the body when asked to do so, but not when performing them spontaneously) was *almost* always associated with left-hemisphere damage

Aphasia and Apraxia:

The Dominant Left Hemisphere

- This led to the view that all complex activities were performed by the left hemisphere; the left and right hemispheres thus became known as **dominant** and **minor** hemispheres, respectively

Tests of Cerebral Lateralization

- The first evidence of language laterality came from comparisons of the effects of left and right unilateral lesions; today, the **sodium amytal test** and **dichotic listening test** are commonly used to assess language laterality

Tests of Cerebral Lateralization

- PET of FMRI techniques have revealed that there is typically **more activity** in the **left hemisphere** than the right during **language-related activities**

Tests of Cerebral Lateralization

- Many studies have reported a relation between **speech laterality** and **handedness**; the following general conclusions have been reached:

Tests of Cerebral Lateralization

- Nearly all (about 95%) right-handed subjects are left-hemisphere dominant for speech;
- most left-handed or ambidextrous subjects (about 70%) are also left-hemisphere dominant for speech; and
- Early left-hemisphere damage can cause the right hemisphere to become dominant for speech and the left hand to be preferred

The Split-Brain Experiment

- In 1953, Myers and Sperry performed an experiment on cats that changed the way that we think about the brain; and it provided a means of comparing the function of the two hemispheres
- It was designed to reveal the function of the brain's largest commissure, the **corpus callosum**

The Split-Brain Experiment

- Earlier studies failed to reveal any deficits in laboratory animals following **callosal transection**, and people born without a corpus callosum had been reported to be perfectly normal

The Split-Brain Experiment

- In the Myers and Sperry experiment there were four groups of cats:
 - Corpus callosum severed
 - Optic chiasm severed
 - corpus callosum and optic chiasm severed
 - Intact controls

The Split-Brain Experiment

- In phase 1 of the experiment, all cats learned a lever-press pattern discrimination task with a patch over one eye; all four groups readily learned this simple task
- In phase 2, the patch was switched to the other eye...

The Split-Brain Experiment

- The cats in the optic-chiasm-severed group, corpus-callosum-severed group, and control kept performance same
- In contrast the optic-chiasm-and-corpus-callosum-severed group acted as if the task were completely new to them - they had to learn it again with no savings

The Split-Brain Experiment

- We can conclude:
 - The cat forebrain has the capacity to act as **two separate forebrains**, each capable of **independent** learning and of storing its own memories;
 - The function of the **corpus callosum** is to carry information between hemispheres
 - The best strategy for studying corpus callosum function is to use a method to limit information to a single hemisphere

Tests of Split-Brain Patients

- **Commissurotomy** is performed on patients with life-threatening cases of epilepsy to reduce the severity of convulsions by restricting epileptic discharges to half of the brain

Tests of Split-Brain Patients

- The operation is **remarkably effective**; many commissurotomy patients never experience another major convulsion; more remarkably they experience few obvious side effects in their daily lives

Tests of Split-Brain Patients

- The controlled neuropsychological testing of these split-brain patients has revealed some amazing things about the human brain
- To test split brain patients, visual stimuli are flashed to the right or left of a fixation point on a screen
- Also tactual information is presented to one hand under a ledge or in a bag

Tests of Split-Brain Patients

- These tests confirmed the conclusion that commissurotomy patients have **two independent streams of consciousness**

Evidence of Two Independent Streams of Consciousness

- When an object was presented to the **left hemisphere**, either by touching something with the right hand or viewing something in the right visual field, the subject could:

Evidence of Two Independent Streams of Consciousness

- Pick out the correct object with the right hand
- Could not pick out the correct object with the left hand
- Could name the correct object

Evidence of Two Independent Streams of Consciousness

- When an object was presented to the **right hemisphere**, either by touching something with the left hand or viewing something in the left visual field, the subject could:

Evidence of Two Independent Streams of Consciousness

- Could pick out the correct object with the left hand
- Could not pick out the correct object with the right hand
- Claimed nothing had been presented



Learning Two Things at Once

- Split-brain patients are capable of learning two things at once
- If a split-brain patient is visually presented two objects at the same time - let's say a pencil in the LVF and apple in the RVF - s/he can reach into two different bags at the same time, one with each hand, and pull out the two objects - a pencil in the left-hand and apple in the right

Helping-Hand Phenomenon

- Occurs when the two hemispheres are presented with different information about the correct choice and then are asked to reach out and pick up the correct object from a collection in full view
- Usually the right hand will reach out to pick out what the left hemisphere saw, but the right hemisphere seeing what it thinks is an error being made causes the left hand to grab the right hand and pull it over to the other object

Differences Between The Left and Right Hemispheres

- Language is the most lateralized of all abilities; the **left-hemisphere** is better than the right at **most language-related tasks**
- however, the **right hemisphere** proved to be able to understand single written and spoken words; also right-hemisphere detects **prosody** and **discourse**

Differences Between The Left and Right Hemispheres

- The **right hemisphere** proved better than the left at a variety of tasks involving **spatial ability, emotional stimuli** and **musical tasks**

Differences Between The Left and Right Hemispheres

- The two hemispheres seem to engage different types of memory processing; **LH** attempts to place its experience in a **larger context** (*relation* of parts that make up the whole), while the **RH** attends strictly to the Gestalt **perceptual characteristics** of the stimulus (parts or whole but not relation between)
- This is usually termed **analytical** (LH) versus **holistic** (RH)

Differences Between The Left and Right Hemispheres

- Thus the RH should not be regarded as the minor hemisphere; it has different abilities, not less important ones

Differences Between The Left and Right Hemispheres

- There are also **anatomical asymmetries** in the human brain; for example the planum temporale and frontal operculum (language related areas) are larger in LH
- However, Heschl's gyrus (also language related) is larger in RH

Differences Between The Left and Right Hemispheres

- left-handers seem to have symmetrical planum temporales, suffer less severely from LH aphasia, and suffer more severely from RH aphasia
- This suggests left-handers may have a more **diffuse representation of language** and is evident in differential grammatical strategies in sentence processing

RIGHT-BRAIN FUNCTIONS

Art awareness

Creativity

Imagination

Intuition

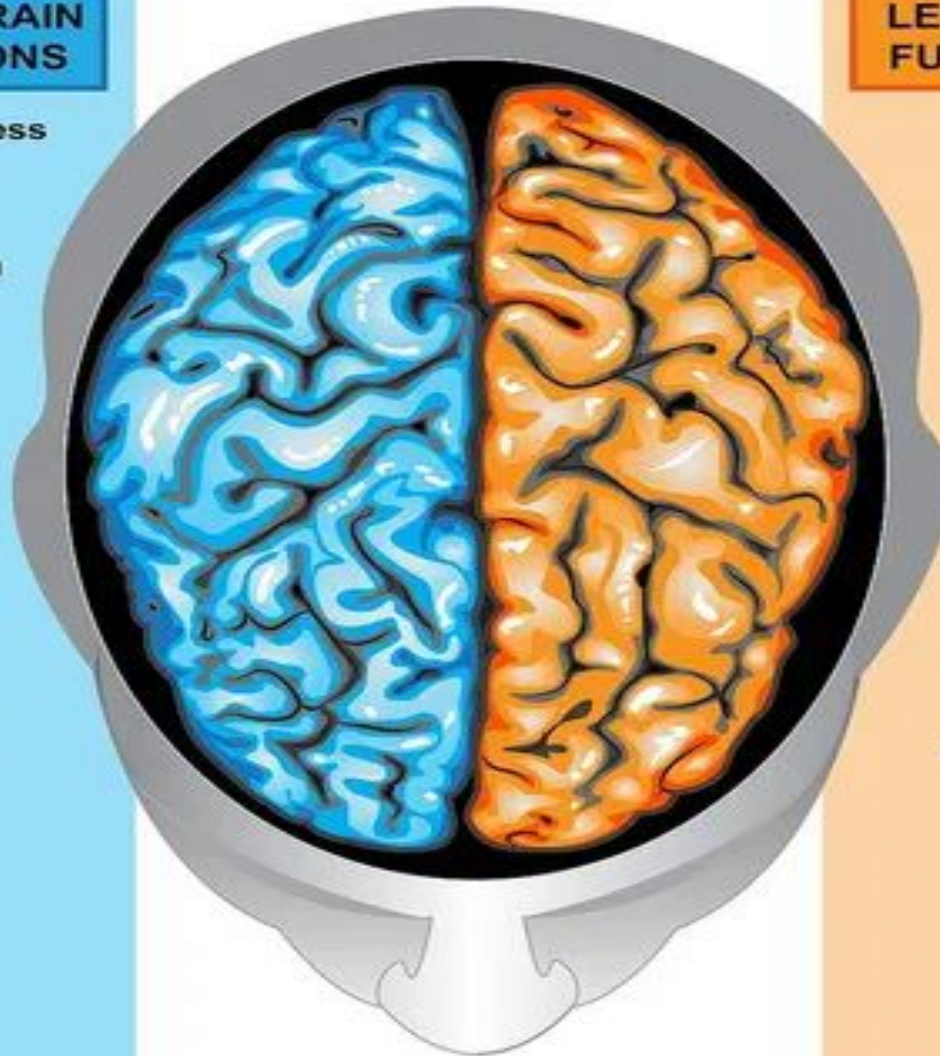
Insight

**Holistic
thought**

**Music
awareness**

3-D forms

**Left-hand
control**



LEFT-BRAIN FUNCTIONS

**Analytic
thought**

Logic

Language

Reasoning

**Science
and math**

Written

**Numbers
skills**

**Right - hand
control**

Three Theories of Cerebral Asymmetry

- Analytic-synthetic theory
- Motor theory
- Linguistic theory

Analytic-Synthetic Theory

- Suggests that there are two fundamentally different modes of thinking, an **analytic mode (LH)** and **synthetic mode (RH)**, and that the neural circuitry for each is fundamentally different
- LH (pieces of the whole) operates in logical, sequential, analytic fashion
- RH (the whole) makes immediate, overall synthetic judgments

Motor Theory

- Posits that LH is specialized for fine motor movement of which speech is but one example
- Two lines of evidence:
 - Lesions of the LH disrupt facial movements more than do RH lesions, even when they are not related to speech
 - Degree of disruption of nonverbal facial movements is positively correlated with the degree of aphasia

Linguistic Theory

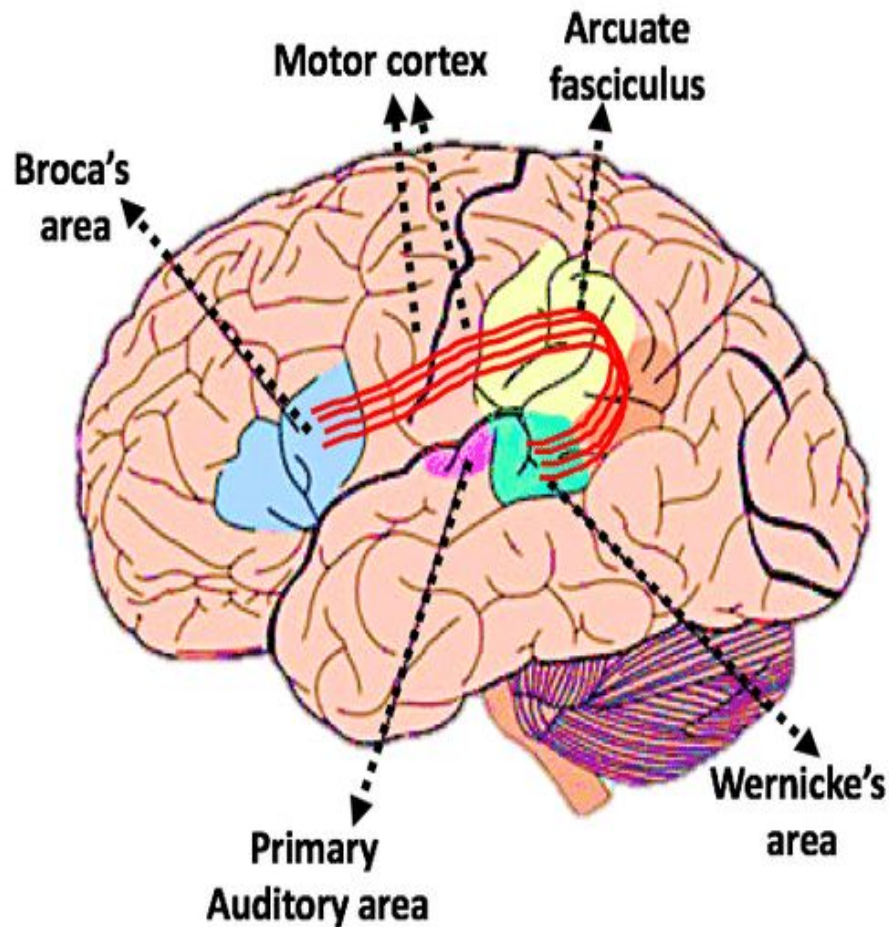
- Based on the view that the primary function of the LH is language

Broca's Area

- Inferior left prefrontal lobe in left hemisphere
- Damage leads to deficits primarily speech production (problems with **expression**) and also grammatical comprehension

Wernicke's Area

- Left temporal lobe, just posterior to the primary auditory cortex
- Damage leads to deficits to semantic language comprehension (problems with **reception**) and speech is incomprehensible, despite having correct grammar, rhythm and intonation (**word salad**)



Broca's area: involved in production of speech sound

Wernicke's area: involved in Understanding of speech

Motor cortex: controls the Movements of muscles

Arcuate fasciculus: connects Wernicke's area to Broca's area.

Parts of the Brain that controls Speech

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