

Brain Lateralization

When we talk about ‘Lateralization’ of the brain, we generally include the work/function that the hemispheres of the brain do. It means that the brain divides the work-load to each part of the brain and these works are carried out by the part of the brain.

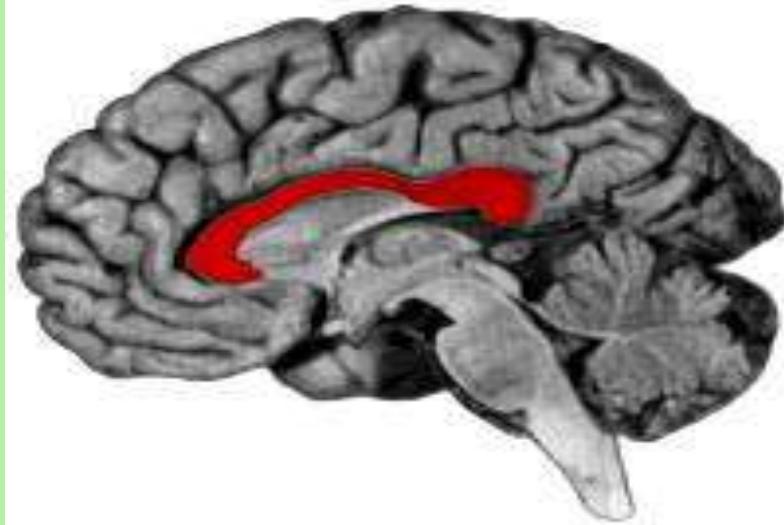
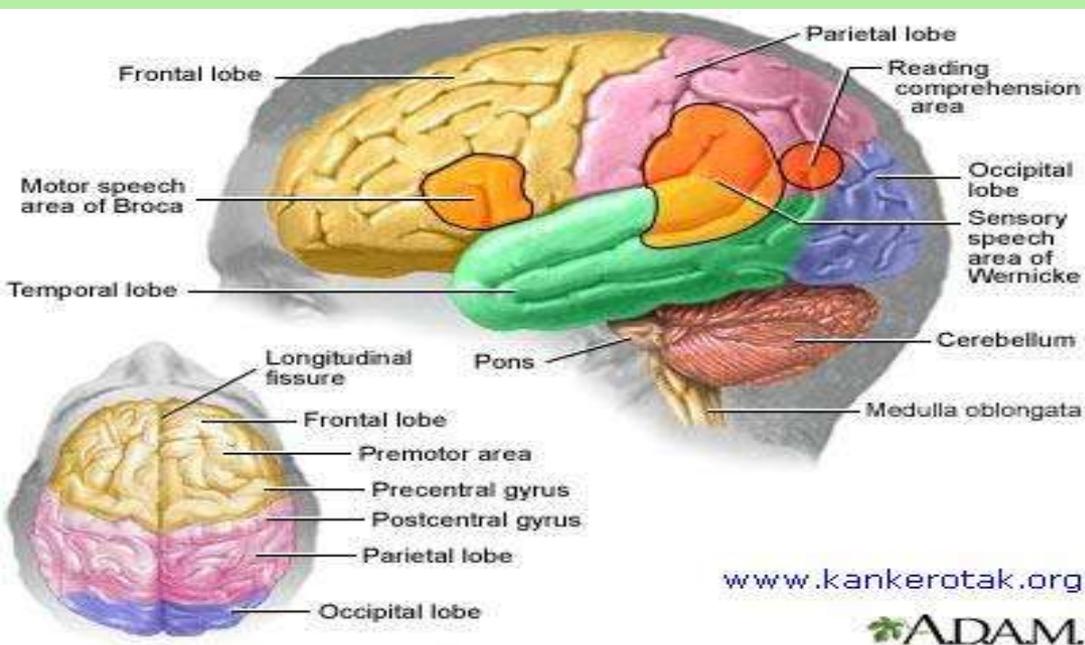
The corpus callosum helps the brain to transfer the information from one side to another side.

The corpus callosum is a thick band of nerve fibers that divides the cerebrum into left and right hemispheres.

It connects the left and right sides of the brain allowing for communication between both hemispheres.

The corpus callosum transfers motor, sensory, and cognitive information between the brain hemispheres.

A picture of brain with these information will help us too much at this stage.



The topics that we must discuss to understand ‘lateralization of brain’ are the following:

The Domination of Left Hemisphere

Tests of Cerebral Lateralization

The Split-Brain Experiment

Differences between the Left and Right Hemispheres

Broca’s Area

Wernicke’s Area

The Dominant Left Hemisphere

In 1836, **Marc Dax** (1771–1837), a French neurologist, reported that not one of his 40 patients with speech problems had displayed damage that could be located into the right hemisphere.

In other words, in all his findings, it was common that all the patients with speech problems had damage in the left hemisphere.

It took almost twenty five years for **Broca** to report the results of the postmortem examination of two **aphasic** patients.

These patients had deficits in the use of language and it was not attributable to general sensory, motor, or intellectual dysfunction.

Both the patients had problem/damage in the left hemisphere.

Both the patients seemed to have the problem that was centered in an area of the left prefrontal lobe, just in front of the primary motor face area.

Since this Broca reported this and was supported by other neurosurgical findings and practitioners, this part of the brain with neurological disorder is known as Broca's area.

Later this became synonymous with the term **Broca's Aphasia** that is associated with problem of language with regard to the grammar and speech production.

Another finding with regard to the lateralization of the brain was what we know as 'apraxia'.

Apraxia, in its simplest sense, means the difficulty in performing movements with either side of the body when asked to do so, but not when performing them spontaneously.

Liepmann discovered that **apraxia** was *almost* always associated with left-hemisphere damage.

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** hemisphere and **minor** hemisphere respectively.

The researchers found the evidence of language laterality when they compared the effects of left and right unilateral lesions due to the strokes to the brain.

In present, the **sodium amygdala test** and **dichotic listening test** are commonly used to assess language laterality.

The PET and fMRI techniques are also very useful in order to find out the evidence of brain laterality.

PET: A positron emission tomography (PET) scan is a unique type of imaging test that helps doctors to know how the organs and tissues inside your body/brain are actually functioning.

The PET test is done by injecting a very small dose of a radioactive chemical, called a radiotracer, into the vein of your arm.

The tracer travels through the body and is absorbed by the organs and tissues being studied.

Next, you will be asked to lie down on a flat examination table that is moved into the center of a PET scanner machine.

This machine detects and records the energy discharged by the tracer substance.

Next, with the aid of a computer, this energy is converted into three-dimensional pictures.

A physician can then look at cross-sectional images of the body organ from any angle in order to detect any functional problems.

In case of brain study, we follow the same procedure and study the function of various areas of human brain.

The other test called fMRI which is also known as **functional magnetic resonance imaging** is said to be one step ahead in scanning technology.

It not only can help us to diagnose diseases of the brain, but it might also enable doctors to get inside our mental processes to determine what we're thinking and feeling.

The fMRI technique, instead of creating images of organs and tissues like MRI, looks at blood flow in the brain to detect areas of activity.

These changes in blood flow, which are captured on a computer, help doctors understand more about how the brain works.

The above two techniques PET and fMRI have revealed that there is typically **more activity** in the **left hemisphere** than the right during **language-related activities**.

Many studies have reported a relation between **speech laterality** and **handedness**.

The following general conclusions have been reached:

- 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
- 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**

Two Hemispheres of the Brain

It has been reported by several studies that language is the most lateralized of all abilities

The **left-hemisphere** is better than the right one for almost all tasks that are related to **language**.

However, the **right hemisphere** proved to be able to understand single written and spoken words; also right-hemisphere detects **prosody** and **discourse**.

The **right hemisphere** proves to be better than the left at a variety of tasks with regard to the **spatial ability**, **emotional stimuli** and **musical tasks**.

The two hemispheres seem to engage different types of memory processing activities.

LH attempts to place its experience in a **larger context** (*relation* of parts that make up the whole).

RH, on the other hand, attends strictly to the Gestalt **perceptual characteristics** of the stimulus (parts or whole but not relation between)

The above mentioned difference is usually understood better by terms called **analytical** (LH) and **holistic** (RH).

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

We can go on listing the function of two different hemispheres such as verbal VS visual, responding to word meaning VS note of voice, sequential VS random, responds to logic VS responds to emotion and etc..

But the essence of the talk is that the two hemispheres are different in terms of their function and characteristics.

There are also **anatomical asymmetries** in the human brain; for example the planum temporale and frontal operculum (language related areas) are larger in LH.

Some other differences also include like the 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.

There are three famous and prevalent theories regarding the **cerebral asymmetry**:

- Analytic-synthetic theory
- Motor theory
- Linguistic theory

1. Analytic-synthetic theory: This suggests that there are two fundamentally different modes of thinking, an **analytic mode (LH)** and **synthetic mode (RH)**,

This is so because the NEURAL circuitry for each of these modes is fundamentally different.

The analytical mode operates in logical, sequential, analytic manner.

However, the synthetic mode makes immediate, overall synthetic judgments.

2. The motor theory: This hypothesizes that LH is specialized for many main and fine motor movement of which speech is just one example:

- There are other evidences for it that can be states as:
 - Lesions of the LH disrupt facial movements more than the lesions in the RH, even when they are not related to speech
 - Degree of disruption of nonverbal facial movements is positively correlated with the degree of aphasia

3. Linguistic theory: This is based on the view that the primary function of the LH is language.

On the basis of several studies of deaf people who communicate using ASL, it has been found that the signing ability is lost if a person suffers damage to the LH.

Moreover, the person can make use of other gestures and movements of his/her limbs as and when these movements of the limbs are required.

This aspect of sign language shows an important aspect of language, and that language is highly analytical.

To conclude the section on division of hemispheres and their work-load, we could say that barring the cases of '**brain plasticity**', the function of two hemispheres are different.

Whether, one is primary over other, or big over small are other issues.

Brain plasticity: It refers to the idea that the brain is constantly developing, growing and changing throughout the lifetime.

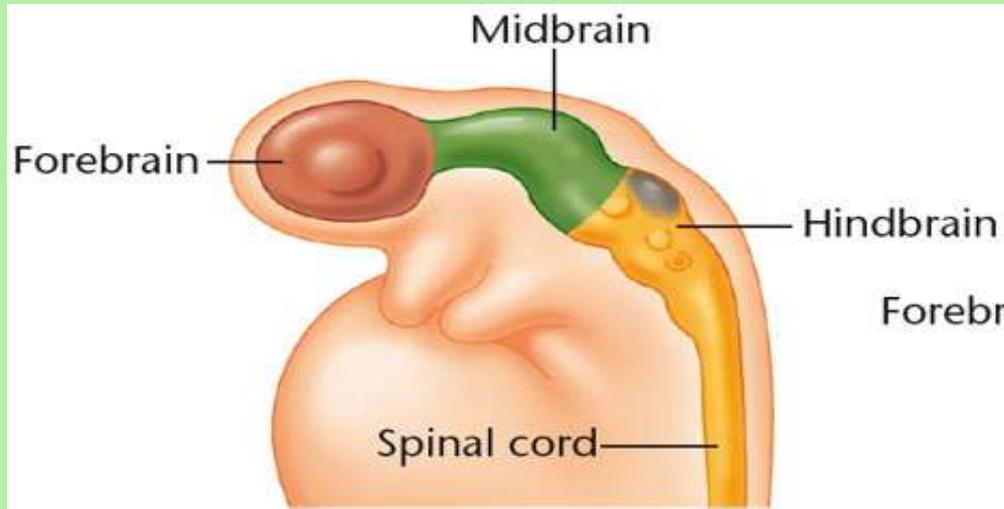
The Development of the brain is due to both experience and physical maturation.

The rapid development especially occurs early in life.

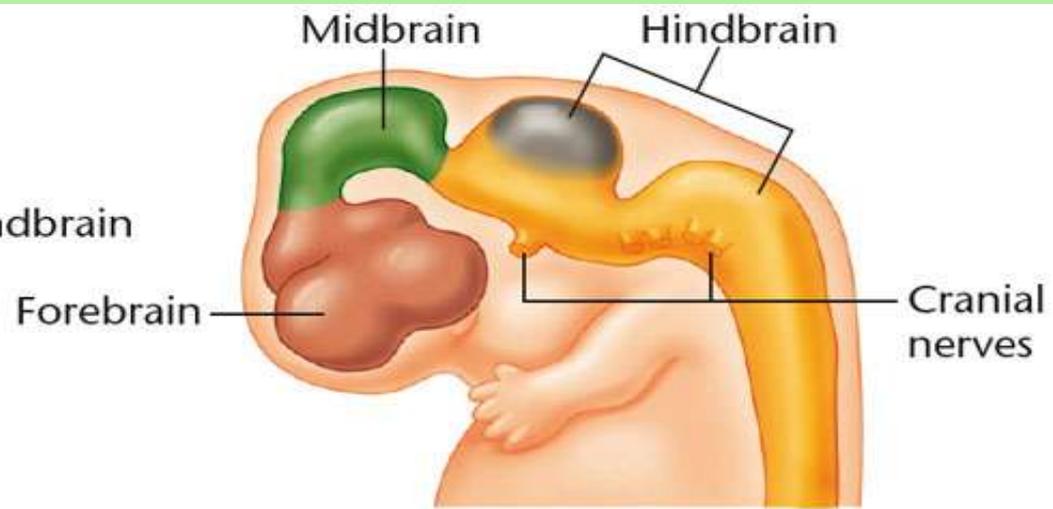
- The prefrontal cortex develops rapidly between 7 and 12 months.

The human central nervous system begins to form when the embryo is approximately 2 weeks old.

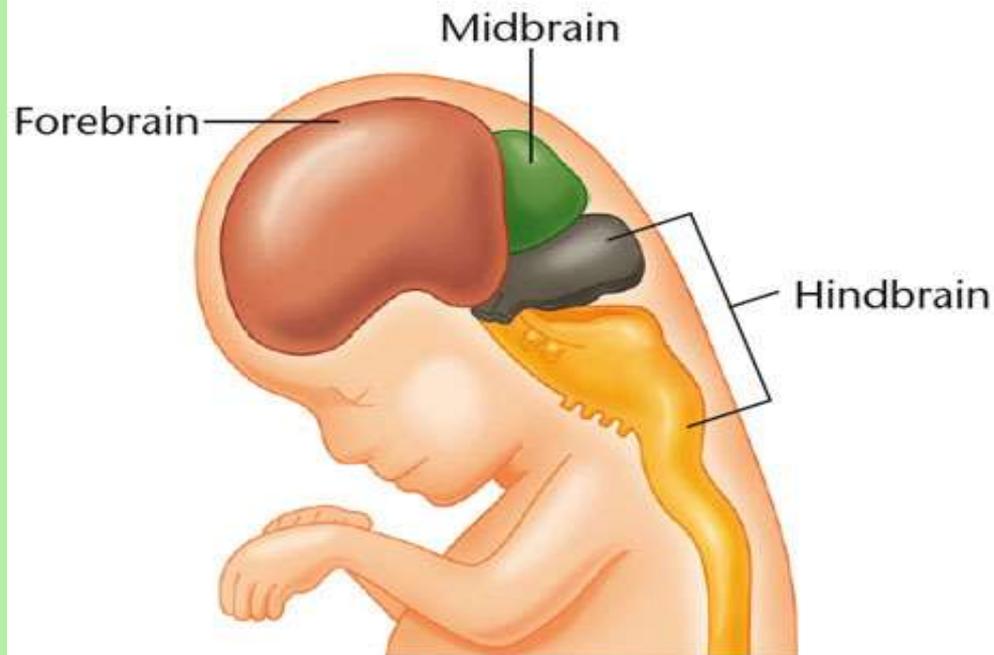
- The dorsal surface thickens forming a neural tube surrounding a fluid filled cavity.
- The forward end enlarges and differentiates into the hindbrain, midbrain and forebrain.
- The rest of the neural tube becomes the spinal cord.



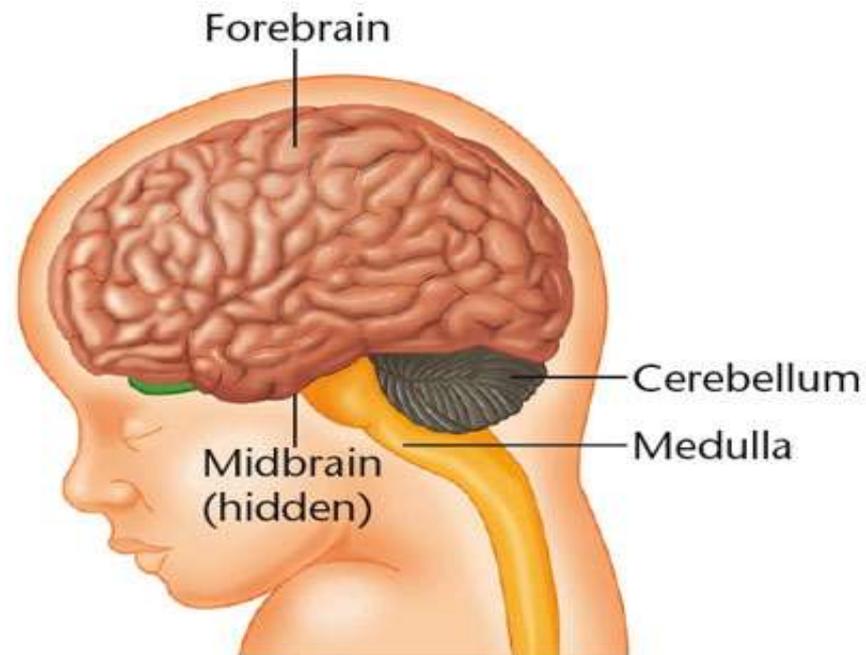
3 weeks



7 weeks



11 weeks



At birth

The term 'brain plasticity' is also used for a different kind of function of the brain when there is any injury or stroke in the brain.

The brain seems to act very smart when there is any injury to it.

If there is any case of neuron dead due to the stroke or lesion in the brain, the neurons surrounding the damaged area start functioning differently by trying to bear/share the load of the function of the damaged part.

This process changes the function of the neurons in certain area of the brain and in addition to their respective work-load, the neurons specialize in the other kind of functions which are not their characteristics or they are not known of such work.

This is the simplest view on 'brain plasticity' and we will get to know about it more in other courses.

Broca's area: As we saw earlier that the Inferior left prefrontal lobe in left hemisphere of the human brain is dedicated to and know as 'Broca's area'.

Any kind of damage in this area leads to deficits that are primarily related to speech production (problems with **expression**) and also to grammatical comprehension.

The area of the brain that is known as 'Broca area' is also a support to justify the lateralization of the brain.

We already have had lectures on 'Broca's area', we would move forward and bring the other discussions that help us to establish the notion of brain lateralization.

Wernicke's area: As we know that the left temporal lobe, just posterior to the primary auditory cortex is known as Wernicke's area.

Damage in this area leads to deficits to semantic comprehension of the language (problems with **reception**)

The speech is incomprehensible, despite having correct grammar.

One of the best example of ‘brain lateralization’ is what is know as ‘conduction or associative aphasia’.

If there is any damage to pathway that connects Broca’s and Wernicke’s areas is called the **arcuate fasciculus**.

The comprehension and spontaneous speech can be intact but patient suffering with arcuate fasciculus won’t **able to repeat words** they have just heard categorizing this as ‘conduction aphasia’.

Next is what is known as ‘alexia’. This is caused when there is a damage to the **left angular gyrus**.

This is an area of left temporal and parietal cortex and it is just posterior to Wernicke’s area.

This leads to the inability to **read** despite intact language comprehension and production for the subjects.

The other neurological disorder that helps us to strengthen the notion of 'brain lateralization is known as 'agraphia'.

This neural disorder takes place due to the damage to the **left angular gyrus**.

Person suffering with this disorder becomes incapable to **write** despite the fact that the language comprehension and production remain intact.

If we explain the process through which we 'respond to the head question', it will further support the notion of brain lateralization.

In order to respond what we hear, the concept is generated in Wernicke's area,

It then goes via arcuate fasciculus to Broca's area, then to primary motor cortex and articulatory areas (face, lip, and tongue etc.), all these justify the 'lateralization process.

If we examine the procedure through which we ‘read aloud’, we will get to know the specialized function of the brain.

In reading aloud, the primary visual cortex to left angular gyrus gets active and this transmits the visual code to auditory area where the code gets transformed.

After this, the signal goes to Wernicke’s area and it moves through arcuate fasciculus to Broca’s to primary motor cortex area where it gets the ingredients for articulation.

All these show the separate and specialized function of different parts of the brain, and thus its lateralization.

Last but not the least, the issues in **Dyslexia** also help us to strengthen the concept of ‘brain lateralization’.

In its most simplest sense, ‘dyslexia’ is pathological difficulty in reading and it does not result from general visual, motor, or intellectual deficits.

There are two kinds of dyslexia which is mentioned in the literature, and they are known as ‘developmental and acquired’ dyslexia.

1. Developmental dyslexia- This kind of dyslexia is apparent meaning we get to know about it right from the childhood age.

1. Differences between brains of dyslexic and non-dyslexic readers have been reported, however none seems to play a critical role

2. Several types of dyslexia and thus likely to have different causes and brain areas susceptible

3. Difficult to determine cause-and-effect of brain abnormalities

The question that remains unanswered is ‘..are these abnormalities the cause of dyslexia or the result of lack of reading experience (brain develops differently as a result of different experience)?

2. Acquired dyslexia – Acquired dyslexia is caused due to the damage in the brain in individuals who were capable of reading earlier.

Two strategies for reading aloud are suggested in the literature
Lexical procedure – This is based on specific stored information that has been acquired about written words.

The subjects look at it, recognize it and say it.

Phonetic procedure – This procedure asks the subjects to look at words, recognize *letters* and *sounds* and say the word

3. Surface Dyslexia – In this kind of dyslexia, the patient loses his/her ability to pronounce words based on the specific memories of the words (they lose their *lexical procedure*)

The subject can pronounce non-words – *wug, thug, gug etc.*

They can produce words that have some rules (*fish, river, or boat*) but can't pronounce unusual words (i.e. *have, lose* are like *cave, hose, and beak*)

4. Deep Dyslexia – In this category, the subjects lose their ability to apply common rules of pronunciation (they lose their *phonetic procedure*)

They also can't pronounce non-words

Example: They can produce phonetically unusual words like *aisle* and *yacht* but can not produce rule-governed words like *fish*, *river* or *glass*

So, the question that remains unanswered is where are lexical and phonetic processes in the brain?

There are two suggestions:

- Deep dyslexia (lose phonetic procedure) due to damage in LH
- Surface dyslexia (lose lexical) due to partial LH damage

Thus, 'Brain lateralization' is not a myth but a fact.

•That's all ☺