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1. Learning Outcomes

After studying the module, you shall be able to:

- Know what MRI is and why it is used.
- Know what CT scan is and why it is used.
- Know what is PET and why it is used.
- Know about the use of PET in studying 'memory'
- Know how we are controlled by two - brains.

2. Introduction

People worldwide suffer from physical and mental ailments ranging from arthritis to Alzheimer's. These kinds of diseases and disorders no doubt require a thorough and appropriate diagnosis. It's very common for us to face situations in life where proper diagnosis is not made. In many a case, this has even resulted in fatal consequences. For proper diagnosis, the various scans come to our rescue. These include MRI, X-rays, CT, and PET etc. Here, in this module we discuss about MRI, CT, PET scans, and the cases in which these are used by a doctor. We also discuss the procedures followed during these scans. Later, we will talk about studying memory with the help of PET scans. We will see how a PET scan can help us in predicting potential mental illnesses.
In the end, we will talk about the 2 brains we have – left and right brains. The area of governance of these two brains vary from each other. They together work to create our perception of this world!

3. MRI

MRI or Magnetic Resonance Imaging used in hospitals and clinical settings to examine the patients for any injuries and diagnosing the existing severities. It uses magnetic field and radio waves to create detailed images of the body. The most common reasons for an MRI are ankle sprain and back problems a special machine containing a strong magnet is used for an MRI test. The area of the body being studied is placed inside this special machine. The patient feels no pain in the procedure. MRI scans are digital images which can be saved and stored on a computer. This kind of data is easy to store and more durable facilitating future study, research and cross-analysis.

An MRI scan accurately detects disease and injury throughout the body and is often used when all other testing techniques and procedures fail to provide sufficient information about the patient's health or medical condition. Because of the use of magnet, patients with heart pacemakers, metal implants or metal chips or clips cannot be scanned with MRI to avoid the consequences. Neurosurgeons also use an MRI scan to evaluate the integrity of the spinal cord after trauma. It is also used with problems associated with the vertebrae or intervertebral discs of the spine. Important surgical decisions regarding the injury of the patient are much easier to take after the results of an MRI scan.

Picture 2: MRI scan of brains and skulls.

During the MRI, patients lie in a closed area inside the magnetic tube. Because of which some patients may feel claustrophobic during the procedure. Mild sedatives can be used to overcome this situation. There are chances of patients feeling dizzy and aching back due to lying on hard bed for long times. There are otherwise no major side effects of an MRI scan. An MRI scan takes 30-40 minutes. An easier way to diagnose is through a CT scan which takes around 5 minutes.

4. CAT scan

CAT stands for 'Computed Axial Tomography'. A Computed Tomography (CT) scan utilizes a computer that takes data gathered from many X-Ray images of bodily structures and transforms them into pictures on the monitor of the computer. Through CT scan we create a 2 dimensional images of a 3 dimensional object. A CT scanner emanates an array of minute beams right through the human body as it moves through an arc, in contrast to an X-ray machine which just sends one radiation beam. As a result, the concluding image is far more detailed than an X-ray image. A CT scan is generally used to diagnose problems of the chest, abdomen, urinary tract, liver, pancreas, gall bladder, adrenal glands, spleen, pelvis, arm or leg.

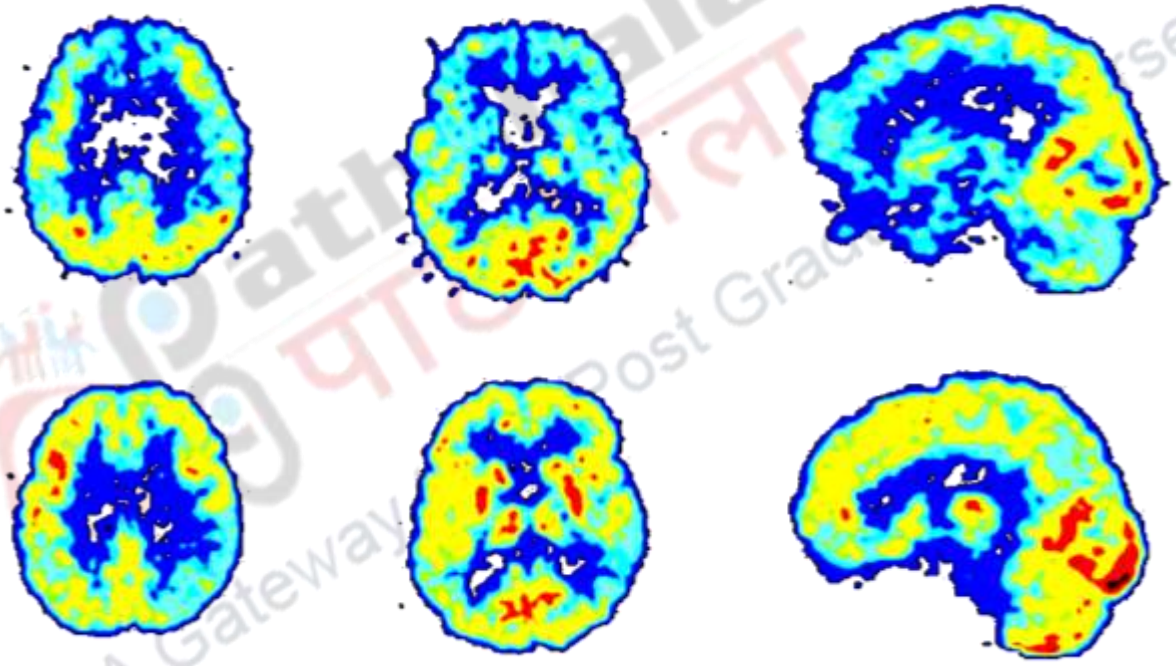
CT scanning is advantageous as it provides a very characteristic 3D image of even smallest parts of the body such as soft tissues, the pelvis, blood vessels, the lungs, the brain, abdomen and bones. It is most preferable in the cases of cancers as the image helps a doctor confirm the presence of a tumor, with respect to its size and location in the body or organ. Scanning of the head can provide the doctor with important information about the brain. However, Both MRI and CT scans do not give information regarding the activity level of the organ or tissue, hence PET comes to our rescue.

5. PET scan

PET is short for 'Positron emission tomography'. A PET scan uses a small amount of radioactive material (tracer). The tracer is injected through a vein, usually on the inside of the elbow. The tracer travels through the blood to the tissues and organs. The patient has to wait for an hour or so for the tracer

to travel throughout the body. Then the patient is made to lie down on a narrow table that slides into a large tunnel shaped scanner. The PET detects signals from the tracer. A computer changes the signals into 3D images which can be displayed on the computer screen. The patient must lie still during the test as movement can cause blur images. A PET scan detects the energy emitted by positively- charged particles (positrons).

Positron is produced by the breakdown of radiotracer inside the patient's body. This energy appears as a 3-dimensional image on the computer monitor. The image reveals how parts of the patient's body function as break down the radiotracer. A PET image will display different levels of positrons in keeping with the brightness and color. The accomplished image is then examined by a radiologist who reports his/her findings to a doctor. A radiologist is also specialized in interpreting these MRI scans, CT scans, ultrasound and X-ray images. According to doctors, PET scans are complementary to X-ray or MRI scans, As a result of which these are used in each other Doctors use PET scans as complementary to the main ones.



Picture 4: A PET scan of the brain.

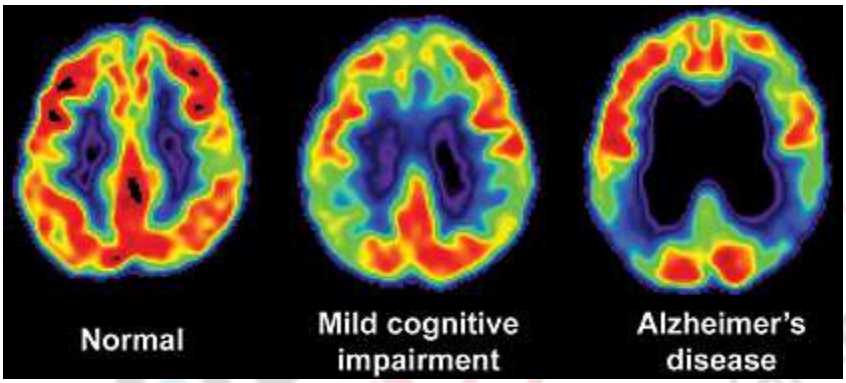
A PET scan unveils the size, shape, positions and function of organs. The test can be used to determine brain function, diagnosis of cancer, heart problems, brain disorders etc. The patient should be empty stomach for 4-6 hours prior the scan. Little amount of radiotracer is used in the testing hence it is to cause any trouble to the patients.

6. Memory and PET

PET is an excellent neuroimaging tool. Performance of any behavioral or cognitive task is marked by neuronal activity distributed throughout the brain. Changes in this neuronal activity are accompanied by changes in blood flow. Pet can measure these changes accurately and thus can identify brain areas that are

differentially active during the performance of different tasks. With respect to the domain of memory, this means that brain areas related to specific memory processes can be studied using PET. This can be done by making the subjects do 'memory tasks' within the PET scanner.

A study on patients with mild cognitive impairment reported that the patients can be warned of the development of Alzheimer's disease on the basis of results obtained from cognitive tests and brain scans. The PET scan on 85 participants with mild cognitive impairment demonstrated that those who scored low on a memory recall test and had low glucose metabolism in particular brain regions, had a 15-fold greater risk of developing Alzheimer's disease within 2 years, compared with others in the study. About half of the older people with memory loss who meet the criteria of mild cognitive impairment will develop Alzheimer's disease within 5 years.



Picture 5: PET scans showing a normal brain, brain with mild cognitive impairment and a brain with Alzeimer's disease (L to R)

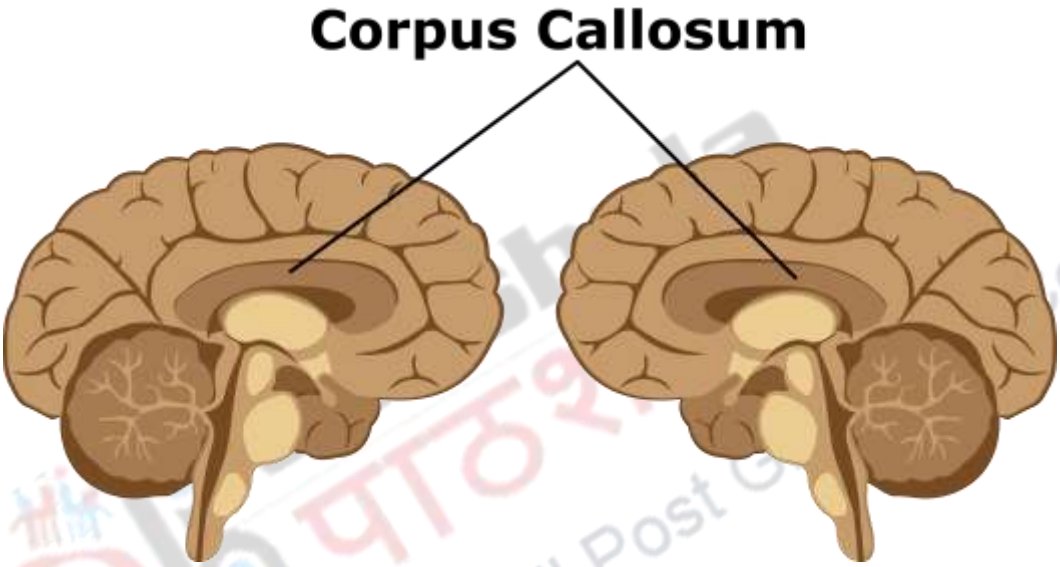
Source: http://www.berkeley.edu/news/media/releases/2009/07/images/alzheimer.jpg

As more and more PET data are collected (right now it is in nascent stages), commonalities across groups of studies will emerge and suggest models of neuroanatomical pathways that underlie memory processes. At the most global level, the PET studies have demonstrated how multiple forms of memory processes might interact. Verbal working memory tasks, elaborative semantic retrieval tasks, and episodic encoding tasks have all activated similar left prefrontal regions. 'Processing that requires verbal elaboration (deep processing) appears to activate left prefrontal cortex whereas well automatized language tasks (shallow tasks) do not'. (Petersen et al. 1998).

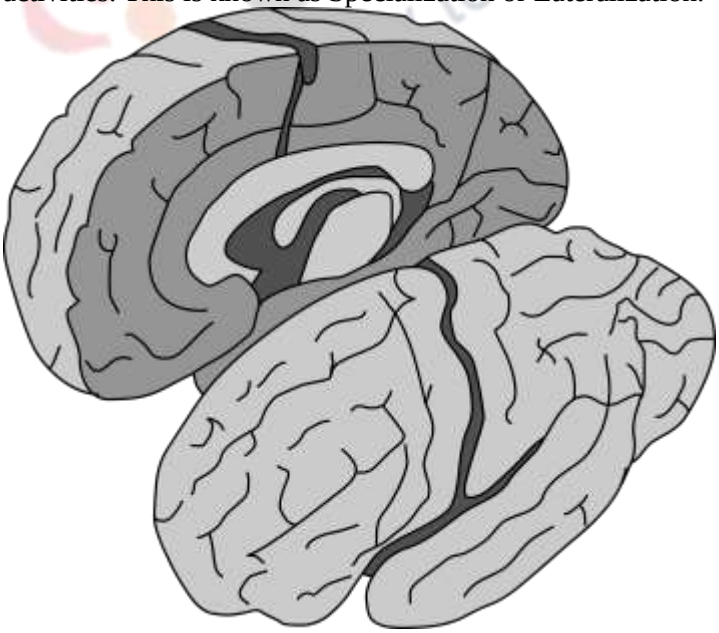
PET is very useful in studying different brain abnormalities. This can be done by comparing the activity patterns in healthy individuals with those of in patients. For example- the focus seizure in an epileptic patient is often associated with decreased activity, which can be observed through PET.
Altered PET activity can be seen in patients with psychiatric disorders such as schizophrenia and manic depression as it can be seen in patients suffering from Parkinson's disease, epilepsy, multiple sclerosis, cerebrovascular disorder, Alzheimer's disease etc.

7. Two Hemispheres.

Imagine looking down upon the top of your head onto the cortex of your brain. You would observe that it comprises of two halves called hemispheres: one on the left (the left brain) and one on the right (the right brain). The left and the right brains are connected by an intricate network of nerve fibers called the 'corpus callosum'. Ancient Egyptians were the first ones who noticed that the left brain tends to control the right side of the body while the right brain controls the left side of the body.



Despite being almost identical in structure, both hemispheres function quite differently with very different activities. This is known as Specialization or Lateralization.



- **Left Hemisphere**

The left brain is the 'Logical Brain' that looks after for words, logic, numbers, analyses, lists, linearity and sequence. It controls the right side of the body. People for whom the Left brain is dominant become scientists, lawyers, bureaucrats, accountants, architects, engineers etc.

- **Right Hemisphere**

The right brain is the 'Creative brain' that looks after rhythm, spatial awareness, color, imagination, day dreaming, holistic awareness and dimension. It controls the left side of the body. People in whom the right brain is dominant become writers, poets, musicians, dancers, painters, spiritual masters, directors, actors or dramatists, nurses etc.

Medical studies of patients suffering from different kinds of brain damage depicted that certain complex psychological functions were lateralized on either side of the brain. According to the deficits that occurred in patients after the damage, it was observed that for most people the left hemisphere is associated with, verbal abilities and speech, as well as mathematical and logical abilities. Therefore due to damage in the Broca's or Wernicke's speech areas in the left hemisphere the patient suffers from 'aphasia', the partial or total loss of the ability to communicate. Similarly, on the basis of the location where the damage has taken place, there might be problem in reorganization of the meaning of the words, in verbal communication with others or in both functions. On the other hand, when the right hemisphere suffers from an injury then the language functions are not ordinarily affected, but there is a disability in the perception of spatial relations due to which a patient might not recognize familiar faces or forget a well-traveled route.

Although the two hemispheres have distinct and specific functions, the brain works as an integrated whole as the two hemispheres constantly communicate with one another through the corpus callosum. Because of this persistent communication among the hemispheres, most of the revelation of lateralized functions in humans was gathered by studying people suffering from brain damage in any of the hemispheres.

The two hemispheres differ in terms of both, the cognitive functions and in their links with positive and negative emotions. EEG studies have demonstrated that the right hemisphere is certainly more active in experiencing negative emotions such as sadness and anger. On the contrary, the left hemisphere is responsible for experiencing positive emotions such as joy and happiness. This all started decades ago in Italy.

7.1 Emotion and Hemispheric Activation

Psychiatrists there were treating clinically depressed patients with electroshock treatments to either the right or the left hemisphere and they observed a striking phenomenon. The electric current temporarily disrupted neural activity in the targeted hemisphere. With the left hemisphere knocked out (forcing the right hemisphere to take charge), patients had what physicians termed a 'catastrophic' reaction, wailing and crying until the shock effects wore off. But, when they applied shock to the right hemisphere, allowing the left hemisphere to dominate, the patients reacted much differently; they seemed

unconcerned, happy and sometimes even euphoric. Researchers noted a similar pattern of emotions in patients in whom one hemisphere had been damaged but lesions or strokes.

These findings suggest that the left-hemisphere activation may underlie certain positive emotions and right- hemisphere functioning negative ones. To test this proposition, Richard Davidson and Nathan Fox (1988) obtained EEG measures of frontal-lobe activity as people experienced positive and negative emotions. They found that when people felt positive emotions by recalling pleasurable experiences or watching a happy film, the left hemisphere was relatively more active than the right. But, when sadness or other negative emotions were evoked by memories or watching a disgusting film, the right hemisphere became relatively more active. Moreover, the hemispheric pattern seems to be innate. Infants as young as 3 to 4 days old showed a similar pattern of hemispheric activation: left- hemispheric activation when given a sweet sucrose solution, which infants like, and right-hemisphere dominance in response to a citric acid solution which apparently disgusts them.

Davidson and Fox also found individual differences in typical, or resting, hemispheric activation when they recorded people's EEG responses under emotionally neutral conditions.
These resting differences predicted the tendency to experience positive or negative emotions. For example, human infants with resting right- hemisphere dominance were more likely to become upset or cry if their mothers later left the room than were those with resting left- hemisphere dominance. In adults, a higher resting level of right hemisphere EEG activity may be a risk factor for later development of adult depressive disorders.

8. Summary

- **MRI** or Magnetic Resonance Imaging through magnetic field and radio waves creates images of the body that helps the doctors in identifying injury with respect to location and severity.
- **CAT** or Computed Axial Tomography makes use of X-rays to form 2 or 3 dimensional images of body parts.
- **PET** or Position Emission Tomography uses radioactive material called 'tracer' (injected into the vein of the human body) to produce a colorful (depicting different activity levels) image of the organ.
- **PET** helps doctors in studying brain abnormalities and functioning.
- The left-hemisphere is called the 'logical brain' while the right- hemisphere is called the 'creative brain'.
- The two seemingly distinct (perform different functions) brains are connected to each other by the 'Corpus Callosum'.The brain cells within the hemispheres are connected through a thick band of nerve fibers, called Corpus Callosum.
- It is through this neural bridge that the two hemispheres remain in conversation with each other.
- Research shows that the left hemisphere governs positive emotions while the right governs negative ones.

PSYCHOLOGY	PAPER No. 1 Cognitive Science
	Module no. 5 Sensing Techniques