UNIT 1 INTRODUCTION, DEFINITION AND DESCRIPTION OF NEUROPSYCHOLOGY

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1.0 INTRODUCTION

This unit deals with neuropsychology, its definition and descriptions. It starts with introduction to neuropsychology, followed by historical perspectives of neuropsychology, clinical neuropsychology, what it is and a description of theme, followed by a description of the central nervous system and its functioning. Then we move on to definitions of neuropsychology and its concepts. Then we differentiate it from other related disciplines, followed by the functions of neuropsychologists. Then we deal with the domains of neuropsychological functioning and the reasons for referrals to neuropsychologists for neuropsychological examination. Then we describe what the reports contain based on the neuropsychological examination, what are the applications of neuropsychological examination and the various limitations to neuropsychological test applications. Then we move on to neuropsychological test selection and the problems one faces in assessing executive functions and how to overcome the same.

1.1 OBJECTIVES

After completing this unit, you will be able to:

- Define neuropsychology;
- Conceptualise neuropsychology;
- Describe the various aspects related to neuropsychology;
- Explain historically how neuropsychology came about;
- Describe the central nervous system and its functioning;
- Explain the functions of neuropsychologists;
- Elucidate the major domains of neuropsychological functioning;
- Describe when a person is to be referred to neuropsychologist for testing; and
- Analyse the application of neuropsychology examination to different areas.

1.2 INTRODUCTION TO NEUROPSYCHOLOGY

A field that combines neurology and psychology and studies the relationship between brain and behaviour is called the field of neuropsychology. The behavioural neurobiology, neuropsychology, neurology and psychology are all combined together to study how brain functions and in what ways the various systems and organs work together to produce different types of behaviours. It studies the cognitive processes and tries to understand which part of the brain is associated with which type of cognitive processes etc. It aims to understand how the structure and function of the brain relates to specific psychological processes.

Neuropsychology is a structured, objective, and scientific discipline which delves into the brain and tries to associate various behaviours of the individuals to the changes that come about in the brain. The ultimate aim is to understand the *individual* mind and brain.

The methods that neuropsychology uses to study many of these aspects include both experimental and objective scientific methods. Neuropsychology compares the performance among persons with known differences in their biological brain structures and attempts to find out the various sources that cause the variations in the brain which all produce differences in individual behaviours. These sources include the following:

1) biological factors (e.g., genetic, diseases, and injuries)
2) psychological factors (e.g., learned behaviours and personality) and
3) social factors (e.g., economics, family structure, and cultural values).

Most persons may have come across people who are very old having tremors in their hands and unable to have proper motor coordination, and many would have also come across persons having tics and speech problems and quite a few would have come across persons lying in coma for days on in the hospital bed. All these conditions are related to neurological pathology. In other words these are related to certain neurological problems or brain related dysfunctions. At the same time there are also many behavioural aspects related to these dysfunctions. Many behaviours can be traced to certain areas of the brain and if those areas of the brain are attended to, then probably the person's behaviour could also be changed. However whether they will become normal or not depends on a large number of factors. All that one could state is that there would be a change and that too more towards the positive direction.

Thus one may state that Neuropsychology is the study of brain behaviour relationships. It makes assessment, understands the problem and suggests modifications to certain aspects, like for instance memory areas. Neuropsychology seeks to understand how the brain, through structure and neural networks, produces and controls behaviours and mental processes, including emotions, personality, thinking, learning and remembering, problem solving, and consciousness. The field is also concerned with how behaviour may influence the brain and related physiological processes, as in the emerging field of psycho neuro immunology (the study that seeks to understand the complex interactions between brain and immune systems, and the implications for physical health).

Neuropsychology is that branch of psychology which deals with the relationship between the nervous system, especially the brain, and the cerebral or mental functions such as language, memory, and perception. Neuropsychology as a science is concerned with the integration of psychological observations on behaviour with neurological observations on the central nervous system (CNS), including the brain.

Neuropsychology seeks to gain knowledge about brain and behaviour relationships through the study of both healthy and damaged brain systems. It seeks to identify the underlying biological causes of behaviours, from creative genius to mental illness, that account for intellectual processes and personality.

1.2.1 Historical Perspective of Neuropsychology

The First Anatomical Studies

Vesalius (1514-1564) was the first to conduct careful observations of brain anatomy and qualify the teachings of the cell doctrine in which he was trained. He represents the beginning of a period in which careful observations and empirical science began to triumph over the ideas that had been handed down since the time of Aristotle and Galen. Vesalius introduced the anatomical theater in which students and doctors could watch dissections from above. Vealius made careful diagrams of human anatomy.

Mind-Body Dualism

Descartes (1596-1650) introduced the concept of a separate mind and body. He believed that all mental functions were located in the pineal gland, a small centrally located brain structure which is now believed to play a role in sleep wake and dark light cycles. The dualist philosophy suggested a complete split between mental and bodily processes, and explained automatic bodily reflexes (body) while purposeful behaviours were a product of free will (mind).

Descartes subscribed to some of Galen's theories (that the brain was a reservoir of fluid, in which the fire displaces the skin, which pulls a tiny thread, which opens a pore in the ventricle allowing the "animal spirit" to flow through a hollow tube, which inflates the muscle of the leg, causing the foot to withdraw. This would now be described as a reflex, for which Descartes is credited.

Phrenology

Gall (1758-1828) introduced the idea that the brain was comprised of separate organs, each localised and responsible for a basic psychological trait. These traits controlled complex mental faculties, such as Cautiousness, Combativeness and Agreeableness, and simpler functions, such as Memory, Calculation Ability and Color Perception. Phrenology correlated the mental faculties described by philosophers with the development of specific brain areas. The development of these brain areas, called cerebral organs, resulted in skull prominences. These bumps could be analysed and a Phrenology practitioner could determine the subject's personality and intelligence from analysis of the skull, called cranioscopy.

Followers of phrenology categorised individuals on the basis of skull, and brain size. Men were believed to have larger "social regions" with more "pride, energy, and self-reliance", as compared to female skulls which were thought to possess more inhabitivness, that is love of home, a lack of firmness and self esteem.

However research has shown that there is no relationship between the bumps on the skull and the underlying brain tissue, nor is there a relationship between the size of an area of brain and the size of the function that it supports. Although he was almost completely incorrect, Gall's Phrenology represents the beginning of the strong modern day localisationist doctrine.

19th Century Localisation

Broca (1824-1880) described most famous case, "Tan", a patient who suffered a stroke of the left hemisphere who could only utter the phrase "Tan". The patient could accurately comprehend language. Broca then used this case and a number of others to show that the expression of language was localised to the left frontal lobe. If you look carefully at the brain, you can detect a soft, fluid filled area in the frontal lobe. This represents the empty space, or infarction that is caused by the drop in blood supply to that brain area (stroke). The third convolution of the inferior posterior frontal lobe has since become known as "Broca's area", and patients with damage to Broca's area are referred to as having Broca's aphasia.

Several years after Broca presented his cases of frontal lobe lesions, Wernicke (1848-1904) presented cases in which patients had lesions of the superior posterior part of the left hemisphere and had trouble comprehending language. This resulted in the idea that component processes of language were localised. On the basis of Wernicke's observations, the modern doctrine of component process localisation and disconnection syndromes began. This doctrine states that complex mental functions, such as language, represent the combined processing of a number of subcomponent processes represented in widely different areas of the brain. A mental faculty like "Combativeness" described by the Phrenologists was not discreetly localised in the brain. Such faculties, if they have validity at all, are the result of a number of primary cognitive operations.

1.2.2 Clinical Neuropsychology

Clinical neuropsychology seeks such understanding, particularly, in the case of how damaged or diseased brain structures alter behaviours and interfere with mental and cognitive functions.

To understand fully the functions of neuropsychology it is imperative to have an idea of the structure and functions of the brain and the nervous system.

1.2.3 Central Nervous System (CNS)

The central nervous system is that part of the nervous system that consists of the brain and spinal cord. It is one of the two major divisions of the nervous system. The other is the peripheral nervous system (PNS) which is outside the brain and spinal cord.

The peripheral nervous system (PNS) connects the central nervous system (CNS) to sensory organs such as the eye and ear, other organs of the body, muscles, blood vessels and glands. The peripheral nerves include the 12 cranial nerves, the spinal nerves and roots, and what are called the autonomic nerves that are concerned specifically with the regulation of the heart muscle, the muscles in blood vessel walls, and glands.

We can consider the brain as a central computer that controls all bodily functions. The nervous system can be likened to a network that relays messages back and forth from the brain to different parts of the body. It does this via the spinal cord. The spinal cord runs through the back and has threadlike nerves which branch out to every organ and body part. These transmit all messages to the body from the brain and vice versa.

Imagine yourself touching a hot iron, immediately you wince and pull your hand back.

What happened, let us see. The moment you touched the hot iron, the nerves in your skin sent a message of pain to the brain. The brain immediately sends back a message asking the muscles in your hands to pull back. All this happens in a split second before you even realise what is going on.

Though so much of work is accomplished the human brain is only 3 pounds in weight. It has many folds and grooves which can store a large amount of information received by the brain. This brain is protected by the bones of the skull. The brain is made up of 3 parts, namely forebrain, midbrain and the hindbrain.

The forebrain is the largest and contains the cerebrum that is the area with folds and grooves and a certain other structures beneath it.

The spinal cord, on the other hand, is a long bundle of nerve tissue about 18 inches long and ¾ inch thick. It extends from the lower part of the brain down through spine. Along the way, various nerves branch out to the entire body. These are called the peripheral nervous system.

Both the brain and the spinal cord are protected by bone: the brain by the bones of the skull, and the spinal cord by a set of ring-shaped bones called vertebrae. They’re both cushioned by layers of membranes called meninges as well as a special fluid called cerebrospinal fluid. This fluid helps protect the nerve tissue, keep it healthy, and remove waste products.

The brain is made up of three main sections: the forebrain, the midbrain, and the hindbrain.

The cerebrum contains all information about us, that is our intelligence, memory, personality, emotion, speech, and ability to feel and move.

The cerebrum also contains four lobes, that is frontal, parietal, temporal and occipital lobes. The cerebrum is also divided into two halves, the right and the left hemispheres. These hemispheres are connected by a band of nerve fibres, called as corpus collosum. This helps in the two hemispheres communicating with each other.

It must be kept in mind that the two hemispheres have different functions to perform, that is while the left hemisphere is considered to be logical, analytical and objective, the right side is considered to be more intuitive, creative and subjective. For example, when you are doing maths, you are using your left hemisphere, and when you listen to music you are using the right hemisphere.

Until now we were discussing the inner parts of the cerebrum. Now let us see what its outer parts are like. The outer layer of the cerebrum is called the cortex.

You know we have five senses, vision, hearing, touch, taste and smell. Information collected by these 5 senses are sent by the spinal cord to the cortex. Cortex is also known as the gray matter. The information then is directed to other parts of the nervous system for further processing. For example in the case of touching the hot iron, not only the hand is withdrawn, but the information is sent to the memory to make sure that you don't do it again.

The messages received from the sensory organs like eyes, nose, tongue, skin and ears are carried to the cortex by the thalamus which is in the inner part of the forebrain.

Another organ within the forebrain is called the hypothalamus which controls the pulse, thirst, appetite and sleep which are automatic processes. It also controls the pituitary gland associated with growth of the body, metabolism etc.

The *midbrain* is located underneath the middle of the forebrain, acts as a master coordinator for all the messages going in and out of the brain to the spinal cord.

The *hindbrain* sits underneath the back end of the cerebrum, and it consists of the cerebellum, pons, and medulla.

The cerebellum is also called as the "little brain" because it looks like a small version of the cerebrum. The cerebellum is responsible for balance, movement, and coordination.

The pons and the medulla, along with the midbrain, are often called the brainstem. The brainstem takes in, sends out, and coordinates all of the brain's messages. It also controls many of the body's automatic functions, like breathing, heart rate, blood pressure, swallowing, digestion, and blinking.

1.2.4 Functioning of the Nervous System

The basic functioning of the nervous system depends a lot on tiny cells called neurons. The brain has billions of them, and they have many specialised jobs. For example, sensory neurons take information from the eyes, ears, nose, tongue, and skin to the brain. Motor neurons carry messages away from the brain and back to the rest of the body.

The nervous system is the System of specialised cells (neurons, or nerve cells) which conduct stimuli from a sensory receptor through a network to the site. A neuron consists of many of the impulse-conducting cells that constitute the brain, spinal column, and nerves. It consists of a nucleated cell body with one or more dendrites and a single axon.

It is also called as the *nerve cell*. (e.g., a gland or muscle) where the response occurs. The cranial nerves handle head and neck sensory and motor activities, except the vagus nerve, which conducts signals to visceral organs. Each spinal nerve is attached to the spinal cord by a sensory and a motor root.

All neurons, however, relay information to each other through a complex electrochemical process, making connections that affect the way we think, learn, move, and behave.

At birth, the nervous system contains all the neurons you will ever have, but many of them are not connected to each other. As you grow and learn, messages travel from one neuron to another over and over, creating connections, or pathways, in the brain.

To take an example, when you learnt to drive the cycle it was so difficult and took time but once you leant you do not have to think to cycle, but cycling comes automatically to you. That means a pathway has been established.

In young children, the brain is highly adaptable; in fact, when one part of a young child's brain is injured, another part can often learn to take over some of the lost function. But as we age, the brain has to work harder to make new neural pathways, making it more difficult to master new tasks or change established behaviour patterns. That's why many scientists believe it's important to keep challenging your brain to learn new things and make new connections. It helps keep the brain active over the course of a lifetime.

Memory is another complex function of the brain. The things we have learned, seen are first processed in the cortex, and then, if we sense that this information is important enough to remember permanently, it is passed inward to other regions of the brain (such as the hippocampus and amygdala) for long-term storage and retrieval. As these messages travel through the brain, they too create pathways that serve as the basis of our memory.

Different parts of the cerebrum are responsible for moving different body parts. The left side of the brain controls the movements of the right side of the body, and the right side of the brain controls the movements of the left side of the body. When you press the accelerator with your right foot, for example, it's the left side of your brain that sends the message allowing you to do it.

A part of the peripheral nervous system called the autonomic nervous system is responsible for controlling many of the body processes we almost never need to think about, like breathing, digestion, sweating, and shivering. The autonomic nervous system has two parts: the sympathetic and the parasympathetic nervous systems.

The sympathetic nervous system prepares the body for sudden stress, like if you see a robbery taking place. When something frightening happens, the sympathetic nervous system makes the heart beat faster so that it sends blood more quickly to the different body parts that might need it. It also causes the adrenal glands at the top of the kidneys to release adrenaline, a hormone that helps give extra power to the muscles for a quick getaway. This process is known as the body's "fight or flight" response.

The parasympathetic nervous system does the exact opposite: It prepares the body for rest. It also helps the digestive tract move along so our bodies can efficiently take in nutrients from the food we eat.

Because the brain controls just about everything, when something goes wrong with it, it is often serious and can affect many different parts of the body. Inherited diseases, brain disorders associated with mental illness, and head injuries can all affect the way the brain works and upset the daily activities of the rest of the body.

Problems that can affect the brain include brain tumours, cerebral palsy, epilepsy meningitis and encephalitis, migraine headaches, and mental illnesses. Another important problem is head injury which may be caused by many factors including accidents.

Self Assessment Questions

1) Define Neuropsychology and state its characteristic features.

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2) Trace the history of neuropsychology.

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3) What is clinical neuropsychology? Discuss

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4) Describe the Central nervous system and elucidate its functions.

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1.3 DEFINITION AND CONCEPT OF NEUROPSYCHOLOGY

Neuropsychology, as mentioned earlier is the study of (and the assessment, understanding, and modification of) brain-behaviour relationships. Neuropsychology seeks to understand how the brain, through structure and neural networks, produces and controls behaviour and mental processes, including emotions, personality, thinking, learning and remembering, problem solving, and consciousness. The field is also concerned with how behaviour may influence the brain and related physiological processes, as in the emerging field of psychoneuroimmunology (the study that seeks to understand the complex interactions between brain and immune systems, and the implications for physical health).

The neuropsychologist uses objective tools, such as the neuropsychological tests to find out the association between biological and behavioural aspects together. Through the use of tests, the clinical neuropsychologist is able to differentiate whether or not a behavioural abnormality is more likely caused by a biological abnormality in the brain or by an emotional or learned process.

1.4 NEUROPSYCHOLOGY AND OTHER DISCIPLINES

If we presume that the brain is the starting point for why and how we process *all* mental information and not just cognitive, but interpersonal communications, self-concept, emotional reactivity, personality, learned responses, etc., then in some aspect, all psychology is *neuro*psychology. Neurolinguistics, for example, is the study of how language shapes our self concepts and our interpersonal communications.

Neurodevelopmental psychology is the study of how behavioural and mental characteristics change with nervous system growth. Even psychological concepts of dreaming (and dream content), level of attention, and conscious experience are subserved by brain processes.

Neuropsychology is the basic scientific discipline that studies the structure and function of the brain related to specific psychological processes and overt behaviours. The term neuropsychology has been applied to lesion studies in humans and animals.

It has also been applied to efforts to record electrical activity from individual cells (or groups of cells) in higher primates (including some studies of human patients).

Neuropsychology is scientific in its approach.

- It is closely related to cognitive psychology in that it also considers the mind as information processing system
- It is closely related to cognitive science.
- It is considered eclectic
- It overlaps with some areas of neuroscience

- It is also closely associated to philosophy of mind
- It ofcourse is associated closely with neurology
- Psychiatry draws a lot from neurology
- By using artificial neural networks it is considered close to computer science also.

Neuropsychology seeks to gain knowledge about brain and behaviour relationships through the study of both healthy and damaged brain systems. It seeks to identify the underlying biological causes of behaviours, from creative genius to mental illness, that account for intellectual processes and personality. *Clinical* neuropsychology seeks such understanding, particularly, in the case of how damaged or diseased brain structures alter behaviours and interfere with mental and cognitive functions.

Cognitive Neuropsychology aims to promote the investigation of human cognition that is based on neuropsychological methods including brain pathology, recording, stimulation or imaging. The research can involve brain lesioned or neurologically intact adults, children or non human animals as long as it makes an explicit contribution to our understanding of normal human cognitive processes and representations. Cognition is understood broadly to include the domains of perception, attention, planning, language, thinking, memory and action.

1.5 FUNCTIONS OF NEUROPSYCHOLOGISTS

Neuropsychologists are not medical doctors, but doctors of psychology whose field of study is concentrated on the brain and its functions. Neuropsychological testing is designed to determine the brain's capacity with respect to short and long term memory, abstract reasoning, attention, concentration, executive functioning, motor skills and other cognitive and psychological factors. By comparing the pattern of these results, against the patients pre-morbid capabilities, and correlating these results with the nature of the trauma suffered by the patient, neuropsychologists can, to a reasonable degree of certainty, opine that individuals without an acute diagnosis of brain injury, have permanent deficits as a result of brain trauma.

Neuropsychologists use batteries of tests to triangulate the brain's functioning and through that triangulation, determine whether the brain is functioning as it should. Just like tapping a knee to check the reflexes is an objective test of how the nervous system operates, neuropsychological tests are an objective measure of how the brain is functioning.

If a neuropsychologist is using what is called a "fixed battery" they will be using one of two such batteries, the Halstead-Reitan or the Luria-Nebraska battery. The advantage of using such batteries is that decades of study and thousands of test results have created an accurate profile of the pattern of deficits which correlate to specific types of brain injury.

The Halstead-Reitan Battery consists of the Category Test, Tactual Performance Test, Seashore Rhythm Tests, Speech Sounds Perception Tests, Finger Tapping Test, and Trail Making. Neuropsychologists often administer Full Scale IQ, Verbal IQ, and Performance IQ.

The most commonly employed intelligence test is the Wechsler Adult Intelligence Scale-Revised (WAIS-R). The three summary IQ measures are derived from averaging individual subtest scores.

An Aphasia Screening Test, a Sensory-Perceptual Examination, are also typically administered, and many neuropsychologists will also administer the MMPI as well.

A normal IQ score, or even high test scores in specific areas, do not rule out brain injury. First, if a person has a 130 IQ before the injury and a 100 IQ after, this would clearly establish injury. More significantly, many profoundly brain injured survivors, maintain an average IQ near their pre-morbid levels. It is not their average scores that are significant, but the pattern of such scores. The IQ only measures certain brain functions, those primarily cognitive in nature. The neuropsychological examination is designed to evaluate a comprehensive cross section of brain function.

Self Assessment Questions

1) Define Neuropsychology.

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2) How would you conceptualise neuropsychology?

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3) How is neuropsychology related to other disciplines? Explain

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4) What are the functions of neuropsychologists? Elucidate.

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1.6 MAJOR DOMAINS OF NEUROPSYCHOLOGICAL FUNCTIONING

Neuropsychological examination is useful in measuring many categories of functioning, including the following:

- Intellectual functioning
- Academic achievement
- Language processing
- Visuospatial processing
- Attention/concentration
- Verbal learning and memory
- Visual learning and memory
- Executive functions
- Speed of processing
- Sensory-perceptual functions
- Motor speed and strength
- Motivation/symptom validity
- Personality assessment

1.6.1 Referrals to Neuropsychologists for Neuropsychological Examination

Neuropsychological testing provides diagnostic clarification and grading of clinical severity for patients with obvious or supposed cognitive deficits. Often these include patients with a history of any of the following problems:

- Head injury
- Failure to achieve developmental milestones
- Learning or attention deficits
- Exposure to drugs, alcohol, or maternal illness in utero
- Exposure to chemicals, toxins, or heavy metals
- Parkinson's disease
- Seizure disorders
- Substance abuse
- Strokes
- Dementia
- Psychiatric Disorders

1.6.2 Information Obtained From Neuropsychological Reports

Neuropsychological tests are a series of measures that identify cognitive impairment and functioning in individuals. They provide quantifiable data about the following aspects of cognition:

- Reasoning and problem solving ability
- Ability to understand and express language

- Working memory and attention
- Short-term and long-term memory
- Processing speed
- Visual-spatial organisation
- Visual-motor coordination
- Planning, synthesising, and organising abilities

1.6.3 Applications of Neuropsychological Examinations

This includes the following:

- Differential diagnosis of organic and functional pathologies
- Assessment for dementia versus pseudodementia.
- Determination of the presence of epilepsy versus somatoform disorder (that is, nonepileptic seizures or pseudoseizures)
- Determination of the presence of traumatic brain injury (TBI) versus malingering or
  - unconscious highlighting
- Guidance for rehabilitation programs and monitor patient progress
- Guidance for referring to specialists
- Providing of data to guide decisions about the patient's condition, such as the following:
  - Competency to manage legal and financial affairs
  - Capacity to participate in medical and legal decision making
  - Ability to live independently or with supervision
  - Ability to return to work and school affairs
  - Candidacy for transplants
- Providing data to guide the following assessments and procedures:
  - Evaluation of the cognitive effects of various medical disorders and associated interventions
  - Assessment of tests for diabetes mellitus, chronic obstructive pulmonary disease (COPD), hypertension, human immunodeficiency virus (HIV) infection, coronary artery bypass graft (CABG), and clinical drug trials
  - Assessment of CNS lesions and/or seizure disorders before and after surgical interventions, including corpus callosotomy, focal resection (e.g., topectomy, lobectomy), and multiple subpial transection
- Monitoring the effects of pharmacologic interventions
- Documentation of the cognitive effects of exposure to neurotoxins
- Documentation of the adverse effects of whole brain irradiation in children
- Issuance of Standard protocols for assessment of specific disorders, such as dementia (e.g. Alzhimer Disease)

In addition to the above, developmental disorders (e.g. specific learning disabilities) require detailed assessment of cognition, academic achievement, and psychosocial adjustment for proper identification and neuropsychological tests help in these assessments. It acts as a guide to their management including academic placement in special education and resource classrooms.

Neuropsychological examination is however of limited value in the following areas and these are given below.

- In cases where the patient is severely compromised, as in the case of advanced dementia
- Where patient is suffering from serious brain injury (e.g., TBI, stroke, anoxia, infection),
- Where the patient has other serious medical complications or psychiatric disorders.

1.6.4 Technical Limitations and Issues in Neuropsychological Evaluation

Results of an NPE must be considered in the context of the patient's age, education, sex, and cultural background. These factors can affect test performance and limit the conclusions that can be drawn from the evaluation. In addition, issues such as reliability, validity, sensitivity, and specificity need to be considered.

- Large, population based norms are available for relatively fewer measures.
- Those measures that do boast such norms, such as major intellectual and academic instruments, are of limited usefulness within a neuropsychological test battery.
- Ideally, patients should be compared with population based norms, as well as with local norms and subgroup norms so as to examine strengths and weaknesses in the individual who is being tested.
- Significant gaps can be found in the normative data for all age, educational, and intellectual ranges.
- Also there are major deficiencies in the development of appropriate measures and norms for minority populations.

Self Assessment Questions

1) What are the major domains of neuropsychological functioning?

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2) When and whom we refer to neuropsychologists for examinations?

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3) Describe the information available in a neuropsychological report.

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4) Discuss the application of neuropsychological examination to different areas.

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5) What are the limitations to neuropsychological test examination?

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1.7 NEUROPSYCHOLOGICAL TEST SELECTION

1) **Reliability, Validity, Sensitivity and Specificity**

Generally, findings suggest that performance on tests of motor functioning, speed of cognitive processing, cognitive flexibility, complex attention, and memory are related positively to real-world success. The amount of variance accounted for by cognitive factors alone, however, is typically quite small. Exceptions occur when comparisons made between results of formal Neuropsychological examination and real world criteria are limited to very simple, very circumscribed, and very well defined functions.

Consequently, situational assessment is seen as a critical adjunct to neuropsychological assessment, especially at higher levels of cognitive functioning.

Neuropsychological tests, with very few exceptions, were not developed with an eye toward ecologic validity. They were developed as indicators of brain function or dysfunction and generally were validated against neurosurgical, neurologic, and neuroradiologic data. Nevertheless, many tests have proven to be good predictors of future behaviour and, therefore, have demonstrated ecologic validity.

A qualitative process approach may improve the ecologic validity of the neuropsychological test battery. For example, testing the limits with measures of memory and executive functioning allows the examiner to understand better what a person can do under relatively ideal circumstances. The test itself may have little demonstrable ecologic validity, but an accurate analysis and insightful interpretation of findings can be highly valid from an ecologic perspective.

2) **Sensitivity and Specificity**

Sensitivity refers to a test's ability to detect the slightest abnormalities in CNS function and is a reflection of the test's true positive rate, that is, its ability to identify persons with a disorder. Specificity refers to the ability to differentiate patients with a certain abnormality from those with other abnormalities or with no abnormality, as indicated by the true negative rate.

A score on any test can be a true positive, false positive, true negative, or false negative.

True positive means it rquires high sensitivity to dysfunction, allowing dysfunctions to be detected.

False positive means it indicates sensitivity to dysfunction, though lacks specificity to a particular dysfunction.

True negative refers to the high specificity, allowing negative to be distinguished from others.

False negative on the other hand refers to the lack of sensitivity, without regard to specificity of the test.

Therefore for any evaluation, it is important to understand the rates of each of the above aspects in the results.

The Stroop Test, for example, shows a relatively high level of specificity, with a high true negative rate (95.7%) and low false positive rate (4.3%). However, its sensitivity is questionable, as it has a relatively low true positive rate (30.8%) and high false negative rate (69.2%).

It must be kept in mind that each test has strengths and weaknesses in its ability to detect a minimal CNS dysfunction (sensitivity) while being able to indicate a specific CNS dysfunction (specificity).

Timed measures of cognitive and/or motor processing are generally sensitive to diffuse cerebral dysfunctions, although the specificity of these tests is generally poor to moderate.

Measures of cognitive and motor processing that are not timed are generally less sensitive to diffuse dysfunctions but are very useful in identifying specific brain lesions.

1.7.1 Problems in Assessing Executive Functions

One of the major drawbacks of the neuropsychological tests can be stated to be the lack of ecologic validity when assessing executive functioning.

As is known, the neuropsychological examination is generally conducted within calm and quiet testing rooms where the subject is clearly presented with the task to be completed, is informed of time restrictions, and is prompted to start and stop behaviours. Under these conditions, a subject may achieve a score that indicates no executive dysfunctions, although the individual may be particularly drained from the mental exertion.

Completing tasks in the real world, however, requires several executive functions that are not tested in traditional neuropsychological examination, including recognising that a task must be completed, starting the task, switching tasks, adapting to changes, and stopping a task.

However, changes in executive tests have dramatically increased the environmental validity of executive neuropsychological examination. These changes include a growing emphasis on subject self reporting of premorbid and postmorbid functioning, as well as premorbid and postmorbid reports from relatives and significant others in the subject's life. Oftentimes, the self report is not sufficient, for executive dysfunctions may be unknown to the subject, or else they may be ego syntonic.

A dramatic approach to overcoming the problem of ecologic validity appears in the Multiple Errands Test (MET). The test takes place in a shopping mall and requires the subject to conduct 3 tasks simultaneously, such as buying an item, meeting at a certain location at a certain time, and acquiring available information (such as a foreign currency exchange rate). This evaluation tests the subject's abilities in planning, task initiation, and task switching, and even requires the subject to interact with other individuals in an effective manner. The test has shown considerable sensitivity and specificity, and subjects with neurologic deficits have performed considerably worse than controls. A version of this test has also been created for the hospital setting.

1.8 LET US SUM UP

Neuropsychology is that branch of psychology which deals with the relationship between the nervous system, especially the brain, and the cerebral or mental functions such as language, memory, and perception.

The field emerged through the work of Paul Broca and Carl Wernicke , both of whom identified sites on the cerebral cortex involved in the production or comprehension of language.

The nervous system is the System of specialised cells (neurons, or nerve cells) which conduct stimuli from a sensory receptor through a network to the site. A neuron consists of any of the impulse-conducting cells that constitute the brain, spinal column, and nerves, consisting of a nucleated cell body with one or more dendrites and a single axon.

The field is also concerned with how behaviour may influence the brain and related physiological processes, as in the emerging field of psychoneuro-immunology (the study that seeks to understand the complex interactions between brain and immune systems, and the implications for physical health).

The neuropsychologist uses objective tools -neuropsychological tests to tie the biological and behavioural aspects together. Through the use of tests, the clinical neuropsychologist is able to differentiate whether or not a behavioural abnormality is more likely caused by a biological abnormality in the brain or by an emotional or learned process.

Cognitive Neuropsychology aims to promote the investigation of human cognition that is based on neuropsychological methods including brain pathology, recording, stimulation or imaging.

Neuropsychological examination is used to quantitatively measure the cognitive and behavioural capabilities of a patient. The data from neuropsychological tests can then be compared to normative data based on a number of different demographic criteria, including (but not limited to) age, race, gender, and socio-economic status. NPE can include testing of intelligence, attention, memory, and personality, as well as of problem solving, language, perceptual, motor, academic, and learning abilities.

1.9 UNIT END QUESTIONS

1) Discuss the functions of neuropsychologists.
2) Define Neuropsychology and bring out its characteristic features.
3) Discuss the important aspects related to the major domain of neuropsychological functioning
4) What are the important aspects to be kept in mind in applying neuropsychological battery to patients? (discuss the reliability, validity, specificity etc.).
5) What are the various problems encountered in testing executive functions with neuropsychological test?

1.10 SUGGESTED READINGS

John A.Kiernan (2008). 9th edition. *Barr's The Human Nervous System: An Anatomical Viewpoint*, Lippincott Williams Wilkins.

Kolb Bryan and Ian Q.Whishaw (2008). *Fundamental of Human Neuropsychology*. Worth publishers, NY

Todd E. Feinberg and Martha J.Farah (2003). (2nd edition). *Behavioural Neurology and Neuropsychology.* McGraw Hill Medical Publishing Division, New York.

Warren H Lewis (editor) (2000). (2oth edition) *Gray's Anatomy of the Human Body Anatomy of the Human Body* New York: Bartleby.com

UNIT 2 NEUROPSYCHOLOGY AND OTHER DISCIPLINES

Structure

2.0 Introduction

2.1 Objectives

2.2 Concept and Definition of Neuropsychology

2.2.1 Historical Perspective

2.2.2 Approaches to Neuropsychology

2.3 Neuropsychology and Neuroscience

2.4 Cognitive Neuropsychology and Neuroscience

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2.6 Cognitive Psychology and Neuropsychology

2.7 Neurobiology and Neuropsychology

2.8 Neuropsychology and Neurophysiology

2.9 Neurology and Neuropsychology

2.10 Comparative Neuropsychology and Neuropsychology

2.11 Scientific Study of the Nervous System

2.12 Cognitive Neuroscience and Neuropsychology

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2.14 Behavioural Neuroscience

2.14.1 Broca's and Wernicke's Areas

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2.16 Unit End Questions

2.17 Suggested Readings

2.0 INTRODUCTION

In this unit we are going to deal with neuropsychology as related to other disciplines like neurosciences, neurobiology and so on. We start with concept and definition of neuropsychology providing certain historical aspects as to how neuropsychology came about. Then we deal with the various approaches to neuropsychology. We then present the relationship of neuropsychology to various other disciplines. In this we start with neuroscience as related to neuropsychology, followed by cognitive neuropsychology, and then cognitive psychology as related to neuropsychology. Then we turn on to biological psychology, neurobiology, neurology etc. and bring their relatedness to neuropsychology. Then we take up behavioural neuroscience and point out how neuropsychology explains behaviour in terms of the various parts of the brain and its functions.

2.1 OBJECTIVES

After completing this unit, you will be able to:

- Define neuropsychology;

- Describe neuropsychology in terms of its characteristic features;
- Explain historically the emergence of neuropsychology;
- Describe the methods used in neuropsychology; and
- Elucidate the relationship between neuropsychology and other disciplines.

2.2 CONCEPT AND DEFINITION OF NEUROPSYCHOLOGY

Neuropsychology is that branch of psychology that deals with the relationship between the nervous system, especially the brain, and cerebral or mental functions such as language, memory, and perception. It is a science concerned with the integration of psychological observations on behaviour with neurological observations on the Central Nervous System including the brain. The two areas in the brain identified by Paul Broca and Carl Wernicke, involved in the production or comprehension of language. Actually set the tone for neuropsychology research and practice. Since then much work has been carried out in describing the neuroanatomical systems and their relation to higher mental processes. The developments which led up to the emergence of an autonomous discipline of neuropsychology have a long and chequered history and provide insights into the perennial issues which still occupy neuropsychologists.

2.2.1 Historical Perspective

The study of the nervous system dates back to ancient Egypt. Evidence of trepanation, the surgical practice of either drilling or scraping a hole into the skull with the aim of curing headaches or mental disorders or relieving cranial pressure, being performed on patients dates back to Neolithic times and has been found in various cultures throughout the world. Manuscripts dating back to 1700BC indicated that the Egyptians had some knowledge about symptoms of brain damage.

In parallel with this research, work with brain damaged patients by Paul Broca suggested that certain regions of the brain were responsible for certain functions. At the time Broca's findings were seen as a confirmation of Franz Joseph Gall's theory that language was localised and certain psychological functions were localised in the cerebral cortex. The localisation of function hypothesis was supported by observations of epileptic patients conducted by John Hughlings Jackson, who correctly deduced the organisation of motor cortex by watching the progression of seizures through the body.

Wernicke further developed the theory of the specialisation of specific brain structures in language comprehension and production. Modern research still uses the Brodmann cytoarchitectonic (referring to study of cell structure) anatomical definitions from this era in continuing to show that distinct areas of the cortex are activated in the execution of specific tasks.

2.2.2 Approaches to Neuropsychology

Today there are several different approaches to the study of the brain behaviour relationships. It is important to note that the results of carefully controlled animal studies have been very important in the development of neuropsychology. While one cannot study the brain behaviour relationships in the humans with the same precision one could use in animal studies, yet with the neuroimaging techniques etc., presently much breakthrough in understanding the brain behaviour relationship has come about in regard to humans too. In human studies, experimental psychologists have contributed significantly by devising ingenious techniques to be used under controlled conditions and by proposing theoretical concepts to account for the deficits in behaviour observed in brain damaged patients the distinction between short-term memory and long-term memory and models of their interrelationships. Neuropsychologists study our awareness of the world in which we move. What we see, hear, and touch are dependent upon the proper functioning of the intact central nervous system. Likewise, how we respond by taking action is dependent on the intactness of those parts of the nervous system concerned with initiating and sustaining coordinated motor activity. But it is not only sensory and motor processes that may be altered by changes in the nervous system but the higher functions such as language, thought, and memory may also be changed.

To state briefly neuropsychology studies the structure and function of the brain related to specific psychological processes and behaviours. The term neuropsychology has been applied to lesion studies in humans and animals. It is scientific in its approach and like cognitive psychology and cognitive science considers the mind from a information sharing point of view.

In practice neuropsychologists tend to work in clinical settings (involved in assessing or treating patients with neuropsychological problems in forensic settings or industry as consultants where neuropsychological knowledge is applied. It is also interdisciplinary in nature to an extent and has in someway or the other related to certain other fields. These are being discussed below.

Self Assessment Questions

1) Define neuropsychology.

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2) Trace historically the emergence of neuropsychology.

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3) What are the various functions of neuropsychologists?

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4) Describe Broaca's and Wernicke's work on the brain that led to the emergence of neuropsychology.

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2.3 NEUROPSYCHOLOGY AND NEUROSCIENCE

Rapid advances in technology combined with knowledge about how the brain and nervous system work have ushered in progress once considered purely science fiction, but today falling under a growing area of scientific study called "neuroscience."

Take, for example, the case of implanting a sensor into a paralysed individual's brain. The sensor detects thoughts that the individual has about moving an arm, for example. These "thoughts" are then sent to a plug on the individual's scalp, which sends signals to a computer that translates the signals into motor movements.

The field of Neuroscience, an area of specialty that was not formalised into its own field until 1971. Since then, the amount of investigation and research completed by those working in the field has grown faster than most other scientific areas of thought and empirical study.

Individuals with devastating brain and spinal cord injuries, brain diseases and disorders, are the main beneficiaries of these once unimaginable scientific advancements.

Neuroscience is a field that studies of the nervous system, including the brain, spinal cord, and networks of sensory nerve cells called neurons. It is an interdisciplinary field, meaning that it integrates several disciplines, including psychology, biology, chemistry, and physics.

In studying the nervous system, the field adds to a body of knowledge about human thought, emotion, and behaviour that is the main area of expertise for those working in psychology, especially the field of Neuropsychology

Both neuropsychologists and neuroscientists focus their research on the understanding of "brain" disorders, injuries, and deficits. For this reason, these scientists must have a solid understanding of how psychological processes relate to the brain's structures and systems, or on the interrelated and inseparable connections between cognition and brain physiology.

2.4 COGNITIVE NEUROPSYCHOLOGY AND NEUROSCIENCE

Cognitive neuropsychology and neuroscience methods are used to elucidate the nature of mental representation and processing and its neural substrates. Specific methods include the analysis of the performance of adults who have suffered neural injury (as a result or stroke, trauma, degenerative disease), the study of individuals who suffer from developmental deficits including developmental dyslexia , dysgraphia etc., through functional magnetic resonance imaging (fMRI), eye tracking and cortical stimulation. These methods are used to investigate, among others, topics such as: the relationship between language and spatial processes, the neural substrates that support recovery of function in acquired language deficits, the relationship between and among language processes etc.

2.5 BIOLOGICAL PSYCHOLOGY AND NEUROPSYCHOLOGY

Biological psychology, also called physiological psychology or behavioural neuroscience, is the study of the physiological bases of behaviour. Biological psychology is concerned primarily with the relationship between psychological processes and the underlying physiological events. In other words, the mind body phenomenon. Its focus is the function of the brain and the rest of the nervous system in activities (e.g., thinking, learning, feeling, sensing, and perceiving) recognised as characteristic of humans and other animals. Biological psychology has continually been involved in studying the physical basis for the reception of internal and external stimuli by the nervous system, particularly the visual and the auditory system.

2.6 COGNITIVE PSYCHOLOGY AND NEUROPSYCHOLOGY

Cognitive psychology is the branch of psychology that studies mental processes including how people think, perceive, remember and learn. As part of the larger field of cognitive science, this branch of psychology is related to other disciplines including neuroscience, philosophy, and linguistics.

The core focus of cognitive psychology is on how people acquire, process and store information. There are numerous practical applications for cognitive research, such as ways to improve memory, how to increase decision making accuracy, and how to structure educational curricula to enhance learning.

Self Assessment Questions

1) Discuss the relationship between neuropsychology and neuroscience.

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2) Describe cognitive neuropsychology and bring out the relationship between neuropsychology and cognitive neuropsychology.

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3) Describe the field of biological psychology. How do we use this knowledge in neuropsychology?

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4) What close relationship Cognitive psychology and neuropsychology have? Elucidate.

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2.7 NEUROBIOLOGY AND NEUROPSYCHOLOGY

Neurobiology brings together persons who do research and instruction with the mission of understanding how nervous systems work. This task requires scientific approaches on different physical scales, from the level of single molecules to the level of the entire nervous system, and of different temporal scales from fractions of a millisecond to years. There is an analysis of the brain circuits and neural networks. The researchers use genetics to understand sensory receptor function. They sort out the molecular mechanisms of neurotransmitter release and neurotransmitter receptor regulation. They make computational models of processes from the movement of molecules in membranes to the control of behaviours.

They use Molecular and cell biological techniques and use biophysical recordings using a variety of electrophysiological and optical techniques. Computerised analysis are providing great insights into the functioning of single nerve cells, as well as complicated networks of neurons. This multidisciplinary approach is yielding insights into the rich complexity of mechanisms that influence how we think, feel, and act.

Research also focuses on information processing in vertebrate retina; structure, function, and development of auditory and visual systems; development and regeneration in the central and peripheral nervous system; neural mechanisms mediating higher nervous system functions, including perception, learning, attention and decision making.

2.8 NEUROPSYCHOLOGY AND NEUROPHYSIOLOGY

Neuropsychology is that branch of psychology which deals with the relationship between the nervous system, especially the brain, and the cerebral or mental functions such as language, memory, and perception. The nervous system is composed of a network of neurons and other supportive cells (such as glial cells). Neurons form functional circuits, each responsible for specific tasks to the behaviours at the organism level. While neurophysiology is the study of the chemical and physical changes which take place in the nervous system, Neuroscience is the study of all aspects of nerves and the nervous system, in health and in disease. It includes the anatomy, physiology, chemistry, pharmacology, and pathology of nerve cells; the behavioural and psychological features that depend on the function of the nervous system; and the clinical disciplines that deal with them, such as neurology, neurosurgery, and psychiatry

The term neurobiology is usually used interchangeably with neuroscience, although the former refers specifically to the biology of the nervous system, the latter refers to the entire science of the nervous system.

2.9 NEUROOLOGY AND NEUROPSYCHOLOGY

Neurology deals with diseases of the central and peripheral nervous systems such as amyotrophic lateral sclerosis (ALS) and stroke, while psychiatry focuses on behavioural, cognitive, and emotional disorders. It uses neuropsychology for understanding the disorders in terms of the brain dysfunctions. It uses neuropsychology for testing and other purposes including rehabilitation of the patients suffering from neurological disorders.

Neurology is part of medical science that deals with the nervous system and disorders affecting it. It is a Medical specialty concerned with nervous system function and disorders.

Clinical neurology began in the mid-19th century, when mapping of the functional areas of the brain first began and understanding of the causes of conditions such as epilepsy improved.

Neuropsychiatry is the medical study of disorders with both neurological and psychiatric features. It is the branch of medicine dealing with mental disorders attributable to diseases of the nervous system. It preceded the current disciplines of psychiatry and neurology. However, neurology and psychiatry subsequently split apart and are typically practiced separately.

Mind/brain monism: Neurologists have focused objectively on organic nervous system pathology, especially of the brain, whereas psychiatrists have laid claim to illnesses of the mind. This antipodal distinction between brain and mind as two different entities has characterised many of the differences between the two specialties. However, it is argued that this division is simply not veridical; a plethora of evidence from the last century of research has shown that our mental life has its roots in the brain and that the brain and mind are not discrete entities but function differently and look at the same phenomenon from a different perspective.

It has been argued that embracing this mind/brain monism is important for several reasons. Firstly, rejecting dualism logically implies that all mental activities are biological and so immediately there is a common research framework in which understanding of and the treatment of mental suffering can be advanced. Secondly, it removes the widespread confusion about the legitimacy of mental illness: all disorders should have a footprint in the brain-mind system.

In sum, one reason for the division between psychiatry and neurology was the difference between mind or first-person experience and brain. That this difference is artificial is taken as good support for a merge between these specialties.

Neuropathology focuses upon the classification and underlying pathogenic mechanisms of central and peripheral nervous system and muscle diseases, with an emphasis on morphologic, microscopic and chemically observable alterations.

Behavioural neurology is a subspecialty of neurology that studies the neurological basis of behaviour, memory, and cognition, the impact of neurological damage and disease upon these functions, and the treatment thereof.

Causal pluralism

Another broad reason for the divide is that neurology traditionally looks at the causes of disorders from an 'inside-the-skin' perspective (neuropathology, genetics) whereas psychiatry looks at 'outside-the-skin' causation (personal, interpersonal, cultural). This dichotomy is argued not to be instructive and authors have argued that it is better conceptualised as two ends of a causal continuum.

The benefits of this position are:

1) Firstly, understanding of etiology will be enriched, in particular between brain and environment. One example is eating disorders, which have been found to have some neuropathology, but also show increased incidence in rural Fijian school girls after exposure to television. Another example is schizophrenia, the risk for which may be considerably reduced in a healthy family environment.

2) Secondly, it is argued that this augmented understanding of aetiology will lead to better remediation and rehabilitation strategies through an understanding of the different levels in the causal process where one can intervene. Indeed, it may be that non-organic interventions, like cognitive behavioural therapy (CBT), soothe disorders alone or in conjunction with drugs.

To sum up, the argument is that an understanding of the mental disorders must not only have a specific knowledge of brain constituents and genetics but also the context in which these parts operate. Only by joining neurology and psychiatry, it is argued, can this combination or interaction be used to reduce human suffering.

2.10 COMPARATIVE NEUROPSYCHOLOGY AND NEUROPSYCHOLOGY

Comparative neuropsychology refers to an approach used for understanding human brain functions. It involves the direct evaluation of clinical neurological populations by employing experimental methods originally developed for use with nonhuman animals.

The principles of cognitive neuropsychology have recently been applied to mental illness, with a view to understanding, for example, what the study of delusions indicate about the function of normal belief. This relatively young field known as cognitive neuropsychiatry refers to an approach used for understanding human brain functions. It involves the direct evaluation of clinical neurological populations by employing experimental methods originally developed for use with nonhuman animals.

Over many decades of animal research, methods were perfected to study the effects of well-defined brain lesions on specific behaviours, and later the tasks were modified for human use. Generally the modifications involve changing the reward from food to money, but standard administration of the tasks in humans still involves minimal instructions, thus necessitating a degree of procedural learning in human and nonhuman animals alike.

Currently, comparative neuropsychology is used with neurological patients to link specific deficits with localised areas of the brain. This approach employs simple tasks that can be mastered without relying upon language skills. Precisely because these simple paradigms do not require linguistic strategies for solution, they are especially useful for working with patients whose language skills are compromised, or whose cognitive skills may be minimal.

Comparative neuropsychology contrasts with the traditional approach of using tasks that rely upon linguistic skills, and that were designed to study human cognition. Because important ambiguities about its heuristic value had not been addressed empirically, only recently has comparative neuropsychology become popular for implementation with brain-damaged patients.

Within the past decade, comparative neuropsychology has had prevalent use as a framework for comparing and contrasting the performances of disparate neurobehavioural populations on similar tasks.

Self Assessment Questions

1) What are the characteristic features of neurobiology? How is it related to neuropsychology?

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2) Describe molecular and cellular technology in the functions of neuropsychology.

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3) What is neurobiology? How is it different from neuroscience?

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4) Describe Clinical neuropsychology and its functions.

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5) What is neuropathology?

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6) What is meant by causal pluralism? What are its benefits?

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7) How is the experiments conducted on animal brains are of use in the understading of human brain functioning?

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2.11 SCIENTIFIC STUDY OF NERVOUS SYSTEM

The scientific study of the nervous systems underwent a significant increase in the second half of the twentieth century, principally due to revolutions in molecular biology, electrophysiology, and computational neuroscience. It has become possible to understand, in much detail, the complex processes occurring within a single neuron. However, to understand as to how the networks of neurons produce intellectual behaviour, cognition, emotion, and physiological responses is rather difficult even today.

The task of neural science is to explain behaviour in terms of the activities of the brain. It is indeed a marvel to find that the brain controls and manipulates millions of individual nerve cells to bring about a behaviour. These cells are also influenced by the environment and it is important to know how this happens. It is important to understand the biological basis of consciousness and the mental processes by which we perceive, act, learn and remember Neuroscience can be studied at different levels from molecular to cellular level to systems level to cognitive level.

The nervous system is composed of a network of neurons and other supportive cells (such as glial cells).

Neurons form functional circuits, each responsible for specific tasks to the behaviours at the organism level.

At the molecular level, the basic questions addressed in molecular neuroscience include the mechanisms by which neurons express and respond to molecular signals and how axons form complex connectivity patterns.

At this level, tools from molecular biology and genetics are used to understand how neurons develop and die, and how genetic changes affect biological functions.

The morphology, molecular identity and physiological characteristics of neurons and how they relate to different types of behaviour are also of considerable interest. (The ways in which neurons and their connections are modified by experience are addressed at the physiological and cognitive levels.)

At the cellular level, the fundamental questions addressed in cellular neuroscience are the mechanisms of how neurons process signals physiologically and electrochemically. They address how signals are processed by the dendrites, somas and axons, and how neurotransmitters and electrical signals are used to process signals in a neuron.

Another major area of neuroscience is directed at investigations of the development of the nervous system. These questions of neural development include the patterning and regionalisation of the nervous system, neural stem cells, differentiation of neurons and glia, neuronal migration, axonal and dendritic development, trophic interactions, and synapse formation.

At the systems level, the questions addressed in systems neuroscience include how the circuits are formed and used anatomically and physiologically to produce the physiological functions, such as reflexes, sensory integration, motor coordination, circadian rhythms, emotional responses, learning and memory.

In other words, they address how these neural circuits function and the mechanisms through which behaviours are generated.

For example, systems level analysis addresses questions concerning specific sensory and motor modalities: how does vision work? How do songbirds learn new songs and bats localise with ultrasound? How does the somatosensory system process tactile information? The related field of neuroethology, in particular, addresses the complex question of how neural substrates underlie specific animal behaviour.

2.12 COGNITIVE NEUROSCIENCE AND NEUROPSYCHOLOGY

At the cognitive level, cognitive neuroscience addresses the questions of how psychological/cognitive functions are produced by the neural circuitry. The emergence of powerful new measurement techniques such as neuroimaging (e.g., fMRI, PET, SPECT), electrophysiology and human genetic analysis combined with sophisticated experimental techniques from cognitive psychology allows neuroscientists and psychologists to address abstract questions such as how human cognition and emotion are mapped to specific neural circuitries.

Neurocognitive is a term used to describe cognitive functions closely linked to the function of particular areas, neural pathways, or cortical networks in the brain.

Neuroscience is the scientific study of the nervous system. Traditionally, neuroscience has been seen as a branch of biology. Nevertheless, it is currently an interdisciplinary science that involves other disciplines such as cognitive and neuro-psychology, computer science, statistics, physics, philosophy, and medicine. As a result, the scope of neuroscience has broadened to include different approaches used to study the structure, function, evolutionary history, development, genetics, biochemistry, physiology, pharmacology, informatics, computational neuroscience and pathology of the nervous system.

The techniques used by neuroscientists have also expanded enormously, from biophysical and molecular studies of individual nerve cells to imaging of perceptual and motor tasks in the brain. Recent theoretical advances in neuroscience have also been aided by the use of computational modeling of neural networks.

Given the ever increasing number of neuroscientists that study the nervous system, several prominent neuroscience organisations have been formed to provide a forum to all neuroscientists and educators. For example, the International Brain Research Organisation was founded in 1960, the European Brain and Behaviour Society in 1968, and the Society for Neuroscience in 1969.

Neuroscience is also beginning to become allied with social sciences, and burgeoning interdisciplinary fields of neuroeconomics, decision theory, social neuroscience are starting to address some of the most complex questions involving interactions of brain with environment. Neuroscience generally includes all scientific studies involving the nervous system.

Psychology, as the scientific study of mental processes, is closely related to neuroscience, although the two disciplines are distinct, with such subjects as behaviourism and traditional cognitive psychology studied independently of the underlying neural processes.

The term neurobiology is usually used interchangeably with neuroscience, although the former refers specifically to the biology of the nervous system, the latter refers to the entire science of the nervous system.

Neurology, psychiatry, and neuropathology are medical specialties that specifically address the diseases of the nervous system. These terms also refer to clinical disciplines involving diagnosis and treatment of these diseases.

Neurology deals with diseases of the central and peripheral nervous systems such as amyotrophic lateral sclerosis (ALS) and stroke, while psychiatry focuses on behavioural, cognitive, and emotional disorders.

Neuropathology focuses upon the classification and underlying pathogenic mechanisms of central and peripheral nervous system and muscle diseases, with an emphasis on morphologic, microscopic and chemically observable alterations. The boundaries between these specialties have been blurring recently, and they are all influenced by basic research in neuroscience.

Integrative neuroscience makes connections across these specialised areas of focus.

Current neuroscience education and research activities can be very roughly categorised into the following major branches, based on the subject and scale of the system in examination as well as distinct experimental or curricular approaches. Individual neuroscientists, however, often work on questions that span several distinct subfields.

Self Assessment Questions

1) Describe the central nervous system and its functioning briefly.

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2) What is meant by cognitive neuroscience? How is it related to neuropsychology?

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3) Describe neuropathology, neurology and psychiatry and their relationship.

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2.13 BEHAVIOURAL NEUROLOGY

Behavioural neurology is a subspecialty of neurology that studies the neurological basis of behaviour, memory, and cognition, the impact of neurological damage and disease upon these functions, and the treatment thereof. Two fields associated with behavioural neurology are neuropsychiatry and neuropsychology.

Behavioural neurology is that speciality which deals with the study of neurological basis of behaviour, memory, and cognition, and their impact of damage and disease and treatment.

Syndromes and diseases commonly studied by behavioural neurology include but are not limited to:

Agraphia	Aprosodias
Agnosias	Dementias
Agraphesthesia	Dyslexias
Alexia_(disorder)	Epilepsy
Amnesias	Hemispatial Neglect
Anosognosia	Stroke
Aphasias	Traumatic Brain Injury
Apraxias	

Relationship behavioural neuroscience to other fields of psychology and biology.

In many cases, humans may serve as experimental subjects in behavioural neuroscience experiments; however, a great deal of the experimental literature in behavioural neuroscience comes from the study of non-human species, most frequently rats, mice, and monkeys. As a result, a critical assumption in behavioural neuroscience is that organisms share biological and behavioural similarities, enough to permit extrapolations across species. This links behavioural neuroscience closely with comparative psychology, evolutionary psychology, evolutionary biology, and neurobiology.

Behavioural neuroscience also has paradigmatic and methodological similarities to neuropsychology, which relies heavily on the study of the behaviour of humans with nervous system dysfunction.

Synonyms for behavioural neuroscience include biopsychology, behavioural neuroscience, and psychobiology. Physiological psychology is another term often used synonymously with behavioural neuroscience, though some authors would make physiological psychology a subfield of behavioural neuroscience, with an appropriately more narrow definition.

The distinguishing characteristic of a behavioural neuroscience experiment is that either the independent variable of the experiment is biological, or some dependent variable is biological. In other words, the nervous system of the organism under study is permanently or temporarily altered, or some aspect of the nervous system is measured (usually to be related to a behavioural variable).

Disabling or decreasing neural function. These include the following, viz., lesions, electrolytic lesions, chemical lesions, temporary lesions, transcranial magnetic stimulation, psychopharmacological manipulations, etc.

Areas in behavioural neuroscience

In general, behavioural neuroscientists study similar themes and issues as academic psychologists, though limited by the need to use nonhuman animals. As a result, the bulk of literature in behavioural neuroscience deals with mental processes and behaviours that are shared across different animal models such as:

- Sensation and perception
- Motivated behaviour (hunger, thirst, sex)
- Control of movement
- Learning and memory
- Sleep and biological rhythms
- Emotion

However, with increasing technical sophistication and with the development of more precise noninvasive methods that can be applied to human subjects, behavioural neuroscientists are beginning to contribute to other classical topic areas of psychology, philosophy, and linguistics, such as:

- Language
- Reasoning and decision making
- Consciousness

Behavioural neuroscience has also had a strong history of contributing to the understanding of medical disorders, including those that fall under the purview of clinical psychology and biological psychopathology (also known as abnormal psychology).

Although animal models for all mental illnesses do not exist, the field has contributed important therapeutic data on a variety of conditions, including the following:

- Parkinson's disease, a degenerative disorder of the central nervous system that often impairs the sufferer's motor skills and speech.

- Huntington's disease, a rare inherited neurological disorder whose most obvious symptoms are abnormal body movements and a lack of coordination. It also affects a number of mental abilities and some aspects of personality.

- Alzheimer's Disease, a neurodegenerative disease that, in its most common form, is found in people over the age of 65 and is characterised by progressive cognitive deterioration, together with declining activities of daily living and by neuropsychiatric symptoms or behavioural changes.
- Clinical depression, a common psychiatric disorder, characterised by a persistent lowering of mood, loss of interest in usual activities and diminished ability to experience pleasure.
- Schizophrenia, a psychiatric diagnosis that describes a mental illness characterised by impairments in the perception or expression of reality, most commonly manifesting as auditory hallucinations, paranoid or bizarre delusions or disorganised speech and thinking in the context of significant social or occupational dysfunction.
- Autism, a brain development disorder that impairs social interaction and communication, and causes restricted and repetitive behaviour, all starting before a child is three years old.
- Anxiety, a physiological state characterised by cognitive, somatic, emotional, and behavioural components. These components combine to create the feelings that are typically recognised as fear, apprehension, or worry.

2.14 BEHAVIOURAL NEUROSCIENCE

Behavioural neuroscience is also known as biological psychology, biopsychology, or psychobiology. It is the application of the principles of biology, in particular neurobiology, to the study of mental processes and behaviour in human and non-human animals.

A psycho-biologist, for instance, may compare the unfamiliar imprinting behaviour in goslings to the early attachment behaviour in human infants and construct theory around these two phenomena. Behavioural Neuroscientists may often be interested in measuring some biological variable, e.g. an anatomical, physiological, or genetic variable, in an attempt to relate it quantitatively or qualitatively to a psychological or behavioural variable, and thus contribute to evidence based practice.

2.14.1 Broca's Area and Wernicke's Area

Similarly, Paul Broca's 1861 post mortem study of an aphasic patient, known as 'Tan' after the only word which he could speak, showed that an area of the left frontal lobe (now known as Broca's area) was damaged. As Tan was unable to produce speech but could still understand it, Broca argued that this area might be specialised for speech production and that language skills might be localised to this cortical area.

Clues about the role of the occipital lobes in the visual system were provided by soldiers returning from World War I. The small bore ammunition often used in this conflict occasionally caused focal brain injuries. Studies of soldiers with such wounds to the back of their head showed that areas of blindness in the visual field were dependent on which part of the occipital lobe had been damaged, suggesting that specific areas of the brain were responsible for sensation in specific visual areas, known as retinotopy.

Studies on Patient HM are commonly cited as some of the precursors, if not the beginning of modern cognitive neuropsychology. Henry Gustav Molaison (February 26, 1926 – December 2, 2008), famously known as HM or H.M., was an American memory disorder patient who was widely studied from late 1957 until his death. His case played a very important role in the development of theories that explain the link between brain function and memory, and in the development of cognitive neuropsychology, a branch of psychology that aims to understand how the structure and function of the brain relates to specific psychological processes. Before his death, he resided in a care institute located in Windsor Locks, Connecticut, where he was the subject of ongoing investigation.

His brain now resides at UC San Diego where it was sliced into histological sections on December 4, 2009. HM had parts of his medial temporal lobes surgically removed to treat intractable epilepsy in 1953. The treatment proved successful in reducing his dangerous seizures, but left him with a profound but selective amnesia.

Because HM's impairment was caused by surgery, the damaged parts of his brain were precisely known, information which was usually not possible to know in a time before accurate neuroimaging became widespread. This allowed detailed connections to be made between theories of memory formation and the brain structures removed in HM.

These and similar studies had a number of important implications.

1) The first is that certain cognitive processes (such as language) could be damaged separately from others, and so might be handled by distinct and independent cognitive and neural processes.
2) The second is that such processes might be localised to specific areas of the brain. Whilst both of these claims are still controversial to some degree,
3) The influence led to a focus on brain injury as a potentially fruitful way of understanding the relationship between psychology and neuroscience.

During the 1960s, information processing became the dominant model in psychology for understanding mental processes. This provided an important theoretical basis for cognitive neuropsychology, as it allowed an explanation of what areas of the brain might be doing and also allowed brain injury to be understood in abstract terms as impairment in the information processing abilities of larger cognitive system.

Self Assessment Questions

1) Discuss behavioural neurology. What are the syndrome and diseases seen in behavioural neurology?

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2) Discuss the relationship of behavioural neuroscience with the field of psychology and biology.

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3) Enumerate the areas of behaviour neuroscience.

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4) What do you understand by Broca's and Wernicke's area?

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Neurocognitive is a term used to describe cognitive functions closely linked to the function of particular areas, neural pathways, or cortical networks in the brain. Therefore, their understanding is closely linked to the practice of neuropsychology and cognitive neuroscience, two disciplines that broadly seek to understand how the structure and function of the brain relates to thought and behaviour.

A *neurocognitive deficit* is a reduction or impairment of cognitive function in one of these areas, but particularly when physical changes can be seen to have occurred in the brain, such as after neurological illness, mental illness, drug use, or brain injury.

2.15 LET US SUM UP

Neuropsychology is that branch of psychology which deals with the relationship between the nervous system, especially the brain, and the cerebral or mental functions such as language, memory, and perception.

While neurophysiology is the study of the chemical and physical changes which take place in the nervous system, Neuroscience is the study of all aspects of nerves and the nervous system, in health and in disease. It includes the anatomy, physiology, chemistry, pharmacology, and pathology of nerve cells; the behavioural and psychological features that depend on the function of the nervous system; and the clinical disciplines that deal with them, such as neurology, neurosurgery, and psychiatry. Neuroscience is the scientific study of the nervous system. Traditionally, neuroscience has been seen as a branch of biology.

The nervous system is composed of a network of neurons and other supportive cells (such as glial cells). Neurons form functional circuits, each responsible for specific tasks to the behaviours at the organism level.

The term neurobiology is usually used interchangeably with neuroscience, although the former refers specifically to the biology of the nervous system, the latter refers to the entire science of the nervous system.

Neurology, psychiatry, and neuropathology are medical specialties that specifically address the diseases of the nervous system. These terms also refer to clinical disciplines involving diagnosis and treatment of these diseases.

Neurology deals with diseases of the central and peripheral nervous systems such as amyotrophic lateral sclerosis (ALS) and stroke, while psychiatry focuses on behavioural, cognitive, and emotional disorders.

Neuropathology focuses upon the classification and underlying pathogenic mechanisms of central and peripheral nervous system and muscle diseases, with an emphasis on morphologic, microscopic and chemically observable alterations.

Behavioural neurology is a subspecialty of neurology that studies the neurological basis of behaviour, memory, and cognition, the impact of neurological damage and disease upon these functions, and the treatment thereof.

Behavioural neuroscience also has paradigmatic and methodological similarities to neuropsychology, which relies heavily on the study of the behaviour of humans with nervous system dysfunction.

Behavioural neuroscience is also known as biological psychology, biopsychology, or psychobiology. It is the application of the principles of biology, in particular neurobiology, to the study of mental processes and behaviour in human and non-human animals.

Comparative neuropsychology refers to an approach used for understanding human brain functions. It involves the direct evaluation of clinical neurological populations by employing experimental methods originally developed for use with nonhuman animals.

Neurocognitive is a term used to describe cognitive functions closely linked to the function of particular areas, neural pathways, or cortical networks in the brain.

2.16 UNIT END QUESTIONS

1) Define neuropsychology and bring out its features.
2) Trace historically the emergence of neuropsychology discipline
3) Why is it neuropsychology called an interdisciplinary approach?

4) Bring out the relationship between neuropsychology and all other disciplines and related fields.

5) Describe the scientific study of nervous system. How is it helpful to neuropsychiology?

6) What is neuropathology? Describe some of the pathological syndromes related to the brain.

7) What are the functions of neuropsychologist?

2.17 SUGGESTED READINGS

M. W. Eysenck, and M. T. Keane (2005). *Cognitive Psychology: A Student's Handbook* (5th ed.). Hove, UK: Psychology Press.

E. E. Smith and S. M. Kosslyn (2007). *Cognitive Psychology: Mind and Brain* (1st ed.). Upper Saddle River, NJ: Pearson/Prentice Hall.

B. Kolb and I. Q. Whishaw, I. Q. (1996). *Fundamentals of Human Neuropsychology* (4th ed.). New York, NY: W. H. Freeman.

UNIT 3 HISTORICAL PERSPECTIVE OF NEUROPSYCHOLOGY

Structure

3.0 Introduction

3.1 Objectives

3.2 History of Neuropsychology

- 3.2.1 Trephanation
- 3.2.2 Ancient Egyptian
- 3.2.3 Ancient Greek
- 3.2.4 The Cell Doctrine
- 3.2.5 Phrenology
- 3.2.6 Localisation

3.3 Brain and Behaviour

3.4 Let Us Sum Up

3.5 Unit End Questions

3.6 Suggested Readings

3.0 INTRODUCTION

In this unit we will be discussing the historical perspective of neuropsychology. We start with history of neuropsychology within which we will be presenting trephanation, ancient Egyptian methods, Ancient Greek methods and then follow it up with cell doctrine. We then discuss phrenology and how this helped in understanding the functions of the brain. Then we take up localisation in which we present some of the disorders arising due to pathology in certain localised areas. Then we have a discussion about the relationship between brain and behaviour.

3.1 OBJECTIVES

After going through this unit, you will be able to:

- understand the evidence of neuropsychology;
- know various studies which got neuropsychology into existence;
- discuss the relation between the brain and behaviour; and
- understand the current developments in neuropsychology.

3.2 HISTORY OF NEUROPSYCHOLOGY

Neuropsychology is the basic scientific discipline that studies the structure and function of the brain related to specific psychological processes and overt behaviours. The term neuropsychology has been applied to studying lesions in humans and animals. It has also been applied to efforts to record electrical activity from individual cells (or groups of cells) in higher primates (including some studies of human patients).

Neuropsychology and neuroscience in general have a history that is quite a bit older than one would think. Written records of the nervous system date back as far as 1700 B.C. But the bulk of knowledge about the brain and its functions did not become known until the 17th century. This is when men like Rene Descartes and Thomas Willis began studying the human nervous system and how it worked. The brain has really only recently been linked to the behaviours of individuals. This was begun in the 1900's when scientists started to look at how the mind affected people's behaviours.

Neuropsychology is the study of the relationships between brain function and behaviour. It observes changes in thoughts and behaviours that relate to the structural or cognitive integrity of the brain. It is a method of studying the brain by examining its behavioural product.

The developments which led up to the emergence of an autonomous discipline of neuropsychology have a long and chequered history and provide insights into the perennial issues which still occupy neuropsychologists.

3.2.1 Trephanation

Trephanation is the ancient surgical procedure of operating on the human skull by scraping, chiseling, or cutting bone from the skull. This method was discovered by archaeologists. It is reported that at that time when this method was used many who underwent trephanations survived which showed that this method was very effective in healing some of the brain disorders. Those disorders for which trephanation was used included Traumatic Brain disorders, psychiatric disorders etc. This method was rather a crude method and many also died and never got alright. Some even underwent multiple trephanations. Many had their skulls damaged due to trephanation. Trephanation was also carried out for religious purposes that is to release and drive away the evil spirits etc. perhaps a religious rite - to release evil spirits.

In a study conducted by Verona & Williams (1992), they examined 750 skulls from Peru and measured trephinated skulls for technique, location, size, healing, and presence of fractures. Results suggest that most trephinations were performed in the frontal and upper parietal regions following injury to the skull from clubs and other weapons of the pre-Columbian era. Scraping and circular grooving had the highest success rates as opposed to straight cutting and drilling. Techniques used were similar to modern day methods of drilling burr holes to relieve pressure and release trapped blood.

In one process, the practitioner had even produced ring of small holes. The next step in the procedure is to cut the bone between each hole and pry off the bone piece in the center. The patient probably would die before the trephination is completed. There is no evidence of healing. There is also a large linear skull fracture besides the trephination opening. It is clear that this trephination was used to treat the associated skull fracture. Perhaps the practitioner believed that a blood clot was underneath the skull, near the fracture. Such blood clots are a frequent result of this type of traumatic skull injury.

This skull on the right shows evidence of multiple head injuries and trephinations. There is a well-healed trephination and a fresh one. The patient probably died soon after receiving this recent head injury and fresh trephination. This one demonstrates the great survival rate associated with the procedure. This person lived for many years after the first trephination. There is considerable healing. This trephination was done with the scraping method.

In another process, the practitioner begins with cuts that surround the central area. They began cutting the outer perimeter in order to create a larger opening. This trephination shows no signs of healing because the patient dies.

3.2.3 Ancient Greek

The knowledge of brain function at that time was limited by the strong aversion to dissecting the brain. They had a number of mistaken beliefs, including *Aristotle's* localisation of mental functions in the heart. This theory explained that people with heavy upper bodies were intellectually dull due to the extra weight bearing on the heart. The view that the heart is the organ of the human mind or consciousness is called the "cardiac or cardio centric hypothesis". Aristotle identified the heart as "the most important organ of the body," and the first to form according to his observations of chick embryos. It was the seat of intelligence, motion, and sensation - a hot, dry organ. Aristotle described it as a three-chambered organ that was the center of vitality in the body. Other organs surrounding it (e.g. brain and lungs) simply existed to cool the heart.

Why? After death, the heart was weighed to see if one would enter into eternal afterlife, but the brain was usually discarded. Aristotle believed in "dualism" which divides the world into two spheres: mind and matter. The mind (or soul) is a nonphysical entity, which somehow interacts with the material body. In particular, mind-body dualism claims that neither the mind nor matter can be reduced to each other in any way, and is sometimes referred to as "mind and body" and stands in contrast to philosophical monism, which views mind and matter as being ultimately the same kind of thing. According to Aristotle, the mind and body interacted through a "point of interaction" which he identified as the heart. To this day, we continue to perpetuate this belief by giving cards with hearts on Valentine's day, and by using terms such as "heartbroken" or "cold-blooded."

Pythagoras (circa 550 BC, best known for the Pythagorean theorem) was one of the first to propose that the thought processes and the soul were located in the brain and not the heart. This belief is the "brain or cephalocentric hypothesis", stating that the brain is the source of reasoning and all human behaviour. Pytharoras also claimed to have lived four lives that he could remember in detail, and heard the cry of his dead friend in the bark of a dog.

Hippocrates (circa 400 BC, influenced by Socrates) was considered one of the most outstanding figures in the history of medicine, is referred to as the "father of medicine", and was the founder of the Hippocratic school of medicine. The Hippocratic school held that all illness was the result of an imbalance in the body of the four humours, fluids which in health were naturally equal in proportion (pepsis). When the four humours, blood, black bile, yellow bile and phlegm, were not in balance (dyscrasia, meaning "bad mixture"), a person would become sick and remain that way until the balance was somehow restored. Hippocratic therapy was directed towards restoring this balance.

However, Hippocrates also believed the brain to be the seat of intelligence, and the controller of the senses, emotions, and movement, and was the first to recognise that paralysis occurred on the side of the body *opposite* the side of a head injury.

History of cognitive neuropsychology

Cognitive neuropsychology first began to flourish in the second half of the Nineteenth Century, initially in relation to disorders in the comprehension and production of spoken language (aphasia). Continental neurologists such as Broca (1861), Lichtheim (1873) and Wernicke (1874) studied patients with aphasia and inferred information-processing models of the normal language-processing system from the patterns of preserved and impaired language abilities they saw in their patients. They even expressed these models as box-and-arrow flowcharts of information processing, which is the universal notation in modern cognitive neuropsychology. This cognitive-neuropsychological approach was also applied to the understanding of disorders of written language, both reading and spelling (Bastian, 1869; Dejerine, 1891), and soon spread to other cognitive domains such as object recognition (Lissauer, 1890), calculation (Lewandowsky & Stadelmann, 1908) and many others.

Cognitive neuropsychology was thus flourishing by the early Twentieth Century. But then it rapidly lost favour. This happened for two reasons, one to do with psychology and the other to do with neurology.

Re psychology: the whole idea that it is possible to study the structure and nature of mental information processing systems that is, the idea that it is possible to do cognitive psychology was directly attacked by John B Watson in 1913 argued that mental processes were not directly observable and therefore could not be studied scientifically. All that should be studied by psychologists is what could be objectively observed. Stimuli and an organism's responses to them. This doctrine is known as behaviourism. It became very strong in the psychology of the first half of the twentieth century, and since it was completely incompatible with an interest in developing models of mental processing systems, it provided a hostile climate for cognitive psychology and hence for cognitive neuropsychology.

Regarding neurology, the nineteenth century cognitive neuropsychologists were also neurologists. So they were not satisfied just with developing modular models of cognitive processes. They also wanted to localise these modules in the brain. This was a hopelessly premature endeavour which was bound to fail, and when it failed this left them highly vulnerable to criticism.

The endeavour was premature for two reasons. Firstly, the only way they could acquire information about the location in the brain of any patient's lesion was extremely crude by autopsy after the patient's death. Secondly, even if the information about lesion location could have been obtained by less crude methods, the models themselves were not sufficiently detailed for questions to be sensibly asked about where the modules were located in the brain. That may even still be true even today; cognitive neuroscientists believe that it isn't.

Early in the twentieth century, a number of anti modular and anti localisationist neurologists attacked the work of Broca, Wernicke and others, and their attacks made highly effective use of the unconvincingness of the attempts by the nineteenth century cognitive neuropsychologists to demonstrate relationships between particular lesion sites and particular cognitive impairments.

Particularly effective were the attack on Broca by Pierre Marie in 1906 and, especially, the attack on the whole field of cognitive neuropsychology by Henry Head in 1926, which was expressed in the most brutal of terms: "Wernicke failed to recognise the wide-spread nature of the difficulty owing to the preconceptions with which it was approached: in the solemn discussion which follows that report we can only wonder at his clinical obtuseness and want of clinical insight . . We are astonished at the serene dogmatism with which the writers assume a knowledge of the working of the mind and its dependence on hypothetical groups of cells and fibres. Most of the observers mentioned in this chapter failed to contribute anything of permanent value to the solution of the problem."

The "Cognitive Revolution" the abandonment of behaviourism and the acknowledgement that there are scientifically acceptable ways of investigating the structure and nature of mental information-processing systems even if these are no more directly observable than neutrons and electrons - occurred in Britain and North America in the mid-1950s. New and more detailed modular models of various forms of cognitive processing, initially language and also selective attention, were developed and applied to the explanation of data collected from experiments on normal subjects.

Then there developed certain research collaborations between cognitive psychologists who had been doing this kind of work and clinical neuropsychologists who saw in the clinic various kinds of breakdowns of cognition caused by brain damage. The clinicians were interested in understanding these breakdowns in more detail. The cognitive psychologists were interested in learning more about normal systems by studying how they could break down.

The 1960s saw two such seminal collaborative papers, which marked the rebirth of cognitive neuropsychology: Marshall and Newcombe (1966) on reading and Warrington & Shallice (1969) on memory. A decade later, cognitive neuropsychology had been fully reestablished, according to Selnes (2001), who notes that in 1977 "a meeting to discuss deep dyslexia was convened in Oxford, and this is often considered by many to be a convenient marker for the early beginnings of cognitive neuropsychology (E. Saffran, personal communication, 2000). The book *Deep Dyslexia* (Coltheart, Patterson & Marshall, 1980) which resulted from the conference is considered by many to be the first major book that deals with the cognitive approach to neuropsychology. The journal *Cognitive Neuropsychology* was first published in 1984." (Selnes, 2001, p. 38). Not long afterwards, in 1988, the field's first textbook, *Human Cognitive Neuropsychology*, was published (Ellis & Young, 1988), and so was the first book critically reviewing the field (Shallice, 1988).

Cognitive neuropsychology has two major domains of application: assessment and rehabilitation.

Cognitive-neuropsychological assessment is assessment that is based on an explicit modular information-processing model of the relevant cognitive domain. The existence of the model permits the construction of tests specific to the individual modules of the model, so that a comprehensive analysis can be made of which of these cognitive modules is operating normally and which have been perturbed by brain damage (in the case of acquired disorders of cognition) or have not been acquired to age-appropriate levels (in the case of developmental disorders of cognition). The best-developed cognitive-neuropsychological assessment batteries are the PALPA battery for the assessment of disorders of spoken and written language (Kay, Lesser & Coltheart, 1992) and the BORB battery for the assessment of disorders of visual perception and visual object recognition (Riddoch and Humphreys, 1993).

Cognitive-neuropsychological rehabilitation (Coltheart, Brunsdon & Nickels, 2005) is similarly model-based: it is treatment that is specifically directed at improving the functioning of the particular cognitive modules or pathways that have been identified, via cognitive-neuropsychological assessment methods, as specifically impaired. Other approaches to neuropsychological rehabilitation differ from this in typically being rather generally aimed at the entire cognitive domain within which the patient shows some or other symptoms. Numerous examples of the cognitive-neuropsychological approach to rehabilitation can be found in Humphreys & Riddoch (1994) and Whitworth, Webster & Howard (2005).

The volume by Coltheart and Caramazza (2006) is a recent review of the field which contains state-of-the-art accounts of contributions of cognitive neuropsychology to our understanding of a variety of domains of cognition, showcasing in particular what we have learned so far from cognitive neuropsychology about conceptual representation, speech production, sentence comprehension, reading and spelling, short-term memory, visual object recognition, spatial attention and skilled action.

Self Assessment Questions

1) Match the Following:

1)	Trephenation	a)	Aristolte
2)	Ancient Egyptian	b)	Vermona & Williams
3)	Localisation	c)	Edwin Smith

2) Give one word for each of the following statement:

a) Relationship between brain function and behaviour. ....

b) Ancient surgical procedure of operating on the human skull is ....

c) Weaknmess on the one side of the body is ....

d) Thought processes and soul were located in the brain and not the heart ....

e) The brain is the seat of intelligence, and the controller of senses, emotion and movement. ....

3.2.4 The Cell Doctrine

This theory postulated that mental and spiritual processes/functions were localised in the ventricles (called Cells) of the brain. The theory was proposed by *Nemesius* and *Saint Augustine* in approximately 130-200 A.D. It was strongly influenced by the anatomical studies of *Galen* in the second century, in which he described the ventricles in detail and developed his own theory of “psychic gases and humours” that flowed through the body and ventricles (thus, the ventricular localisation hypothesis”), giving rise to mental functions. (He also characterised the brain as a “large clot of phlegm”.)

The idea that the ventricles were merely a sewer system through which passed bodily fluids, led to the theory of the importance of "humors" which has persisted for 1000 years. Mental functions derived from the descriptions of Aristotle, such as memory, attention, fantasy and reason, were assigned locations within the ventricles. These images depict the connections between the senses (vision, hearing etc.) and the "Common Sense", located in the first ventricle. Cognitive functions were then arrayed from front to back in the ventricles. This Doctrine was proven to be totally false, as we now know that the ventricles are the site through which cerebrospinal fluid passes.

From this period, many important discoveries and theories were noted. Dissections of condemned criminals (who, at that time, were at the disposal of scientists and physicians) led to the knowledge that specific parts of the brain control specific behaviours (discussed later as localisation). As well, the discovery of ascending (sensory) and descending (motor) nerves occurred.

Galen (circa 200 BC) was a prominent ancient Greek physician, who also served as a physician in a gladiator school. During this time he gained much experience with treating trauma and especially wounds, which he later called "windows into the body". He performed many operations, including brain and eye surgeries, and also "vivisections" of numerous animals to study the function of the kidneys and the spinal cord. From these studies, Galen hypothesised that the mind controlled fluids known as pneuma (animal spirits): the brain was the reservoir of pneuma, which were stored in the ventricles.

Pneuma traveled through nerves, which Galen believed were tubes, throughout the body - sent out from the brain to the muscles (i.e., controlled by the mind, causing the body to move) and sent back to the brain due to sensory stimulation. Physical functioning was dictated by the balance of four bodily fluids or humors: Blood, Mucus, Yellow bile, Black bile, which were related to the four elements - air, water, fire, and earth. Galen also showed that pressing on the heart in human subjects did not lead to loss of consciousness or loss of sensation but severing the spinal cord in animals abolished sensory responses after brain stimulation.

The First Anatomical Studies: *Vesalius* (1514-1564) was the first to conduct careful observations of brain anatomy and qualify the teachings of the cell doctrine in which he was trained. He represents the beginning of a period in which careful observations and empirical science began to triumph over the ideas that had been handed down since the time of Aristotle and Galen. Vesalius introduced the anatomical theater in which students and doctors could watch dissections from above. Vesalius made careful diagrams of human anatomy.

Mind-Body Dualism: *Descartes* (1596-1650) introduced the concept of a separate mind and body. He believed that all mental functions were located in the pineal gland, a small centrally-located brain structure which is now believed to play a role in sleep/wake and dark/light cycles. The dualist philosophy suggested a complete split between mental and bodily processed, and explained automatic bodily reflexes (body) while purposeful behaviours were a product of free-will (mind).

Descartes did subscribe to some of Galen's theories (that the brain was a reservoir of fluid), as demonstrated by one of his illustrations, in which the fire displaces the skin, which pulls a tiny thread, which opens a pore in the ventricle (F) allowing the "animal spirit" to flow through a hollow tube, which inflates the muscle of the leg, causing the foot to withdraw. This would now be described as a reflex, for which Descartes is credited. Popular culture has many references to dualism.

3.2.5 Phrenology

Phrenology is a hypothesis stating that the personality traits of a person can be derived from the shape of the skull. It is now considered a pseudoscience. Developed by German physician Franz Joseph Gall in 1796, the discipline was very popular in the 19th century.

Phrenology is based on the concept that the brain is the organ of the mind, and that certain brain areas have localised, specific functions or modules. Phrenologists believed that the mind has a set of different mental faculties, with each particular faculty represented in a different area of the brain.

These areas were said to be proportional to a person's propensities, and the importance of the given mental faculty. It was believed that the cranial bone conformed in order to accommodate the different sizes of these particular areas of the brain in different individuals, so that a person's capacity for a given personality trait could be determined simply by measuring the area of the skull that overlies the corresponding area of the brain.

Gall (1758-1828) introduced the idea that the brain was comprised of separate organs, each localised and responsible for a basic psychological trait. These traits controlled complex mental faculties, such as Cautiousness, Combativeness and Agreeableness, and simpler functions, such as Memory, Calculation Ability and Color Perception. Phrenology correlated the mental faculties described by philosophers with the development of specific brain areas. The development of these brain areas, called cerebral organs, resulted in skull prominences. These bumps could be analysed and a Phrenology practitioner could determine the subject's personality and intelligence from analysis of the skull, called cranioscopy.

Followers of phrenology categorised individuals on the basis of skull, and thus, brain size. Men were believed to have larger "social regions" with more "pride, energy, and self-reliance", as compared to female skulls which were thought to possess more "inhabitivness (love of home), a lack of firmness and self esteem." Many studies have refuted the notion that skulls of different races reflect superiority, and it is impossible to distinguish between murders and geniuses on the basis of skull size or shape.

Phrenology was a complex process that involved feeling the bumps in the skull to determine an individual's psychological attributes. Franz Joseph Gall first believed that the brain was made up of 27 individual 'organs' that created one's personality, with the first 19 of these 'organs' believed to exist in other animal species.

Phrenologists would run their fingertips and palms over the skulls of their patients to feel for enlargements or indentations. The phrenologist would usually take measurements of the overall head size using a caliper. With this information, the phrenologist would assess the character and temperament of the patient and address each of the 27 "brain organs".

Gall's list of the "brain organs" was lengthy and specific, as he believed that each bump or indentation in a patient's skull corresponded to his "brain map". An enlarged bump meant that the patient utilised that particular organ extensively. The 27 areas were varied in function, from sense of colour, to the likelihood of religiosity, to the potential to commit murder.

Each of the 27 "brain organs" was located in a specific area of the skull. As a phrenologist felt the skull, he could refer to a numbered diagram showing where each functional area was believed to be located.

There is no relationship between the bumps on the skull and the underlying brain tissue, nor is there a relationship between the size of an area of brain and the size of the function that it supports (skulls are hard, brains are not). Although he was almost completely incorrect, Gall's Phrenology represents the beginning of the strong modern day localisationist doctrine.

3.2.6 Localisation

Broca (1824-1880) described most famous case, "Tan", and a patient who suffered a stroke of the left hemisphere who could only utter the phrase "Tan". The patient could accurately comprehend language. Broca then used this case and a number of others to show that the expression of language was localised to the left frontal lobe. If you look carefully at the brain, you can detect a soft, fluid-filled area in the frontal lobe. This represents the empty space, or infarction that is caused by the drop in blood supply to that brain area (stroke). The third convolution of the inferior posterior frontal lobe has since become known as "Broca's area", and patients with damage to Broca's area are referred to as having "Broca's aphasia".

Several years after Broca presented his cases of frontal lobe lesions, **Wernicke** (1848-1904) presented cases in which patients had lesions of the superior posterior part of the left hemisphere and had trouble comprehending language. This resulted in the idea that component processes of language were localised. On the basis of Wernicke's observations, the modern doctrine of component process localisation and disconnection syndromes was begun. This doctrine states that complex mental functions, such as language, represent the combined processing of a number of subcomponent processes represented in widely different areas of the brain. A mental faculty like "Combativeness" described by the Phrenologists was not discreetly localised in the brain. Such faculties, if they have validity at all, are the result of a number of primary cognitive operations.

Responses to Localisation: *Freud* described several types of language disorders wich could not be explained by lesions to Broca's or Wernike's areas. He postulated that lesions in the subcortical areas would produce similar behavioural disorders. Similar anti-localisation concepts were presented by *Flourens* (1794-1867). He asserted that while sensory input was localised, to an extent, at an elementary level, the more compels process of perception was dependent on the entire brain (Luria later explained this in terms of primary, secondary and tertiary zones). Based on ablation studies of hens and pigeons, he concluded that loss of function is more a product of the amount of damage rather than the location of that damage. Flourens also offered the notion of equipotentiality of brain tissue, or that if there is enough intact tissue following brain damage, the remaining tissue will compensate and take over the function of the missing area. By utilising dependent measures such as wing-flapping and eating behaviours in pigeons, Flourens erroneously suggested that only 10 percent of brain tissue of used.

Munk (1839-1912) produced temporary "mind-blindness" in dogs following lesions in their association cortex. This notion that an animal will recognise an object (i.e., see the object) but fail to recall the conditioned significance is similar to the concept of "anosognosia." Following lesions to the association cortex of the right hemisphere, *Babinski* (1857-1932) described a similar unawareness of deficit.

Lashley supported Flourens' notion of equipotentiality based on his own research on rats. While the specific area of the lesion had no effect on subsequent performance, Lashley found that the amount of brain tissue removed from rat brains effected the ability to negotiate previously learned mazes. From his studies, Lashley offered the theories of "mass action" and "multipotentiality"; the amount of damaged brain tissue influences subsequent behaviour and each part of the brain participates in multiple functions.

3.3 BRAIN AND BEHAVIOUR

Brain and behaviour is concerned with determining the neural and chemical correlates of motivation, development, and cognition. This includes reward, feeding, maternal behaviour, biological rhythms, drugs, and psychiatric disorders; the anatomy, physiology, and chemistry of brain change associated with learning, aging, retardation, and epilepsy; and cognitive changes in brain-injured human patients.

The brain has really only recently been linked to the behaviours of individuals, this was begun in the 1900's when scientists started to look at how the mind affected people's behaviours.

1913 John Watson presented his theory that human behaviour is based upon conditioned responses to stimuli. His theory was somewhat against the eugenics theory which had reached its height at this time. This marked the beginning of the behaviour of the behaviourist school of psychology.

Eugenics According to this, human behaviour is said to be an inherited trait. In 1930's scientists try to affect the workings of the brain in order to treat mental illnesses such as anxiety, depression and schizophrenia.

Lobotomy This method was developed by Monis,. This involved was the surgical sieving of connections in the frontal lobe of the patients. This actually resulted in adverse side effects such as mood problems and changes in personality.

Electric Shock Therapy. This was developed by Cerletti and Boni. Used electric shocks to induce positive chemical changes in the brain. This like lobotomy had detrimental side effects.

The use of both these techniques declined in the 1950's after the development of the medicine Thorazine.

1950's and 60's. Wilder Penfield identified specific areas of the brain that control motor impulses, sensory inputs and memories.

1970's and 80's. New scanning devices like the CT scanner and MRI allow for detailed mapping of the brains functions.

1975 The roles of brain chemicals such as endorphins are discovered. Behaviour is now thought of as biochemical events.

1990. With new knowledge more effective drugs are developed for the treatment of mental illnesses.

Genes also are beginning to be studied in order to see if there are ties to behaviours. This could lead to evidence supporting eugenics or knowledge that could link eugenics and behaviourism together.

Today there are several different approaches to the study of the brain behaviour relationships, but the method which has figured most prominently is the one that is the natural successor or complement to the work of the early neurologists, namely study of the effects of lesions in specific areas of the brain by carefully observing associated changes in behaviour.

Self Assessment Questions

1) What do you understand by cell doctrine?

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2) Discuss phrenology and localisation.

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3) Discuss the relation between the brain and behaviour.

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3.4 LET US SUM UP

The developments which led up to the emergence of an autonomous discipline of neuropsychology have a long and chequered history

Attempts to localise mental processes to particular bodily structures can be traced back at least to the 5th century BC, when Hippocrates identified the brain as the organ of intellect, and the heart as the organ of the senses.

Recent research (Bruce 1985) suggests that the term 'neuropsychology' was first used in 1913 by Sir William Osler in an address he gave at the opening of the Phipps Clinic at the Johns Hopkins Hospital.

Hans-Lukas Teuber, one of the early pioneers in neuropsychology, argued that the task of neuropsychology is twofold.

To help the patient with the damaged brain to understand his disease and to provide essential insights into the physiological basis of normal brain function.

Today there are several different approaches to the study of the brain–behaviour relationships, but the method which has figured most prominently is the one that is the natural successor or complement to the work of the early neurologists, namely study of the effects of lesions in specific areas of the brain by carefully observing associated changes in behaviour.

Neuropsychologists study the individual's awareness of the world in which one moves. But it is not only sensory and motor processes that may be altered by changes in the nervous system: higher functions such as language, thought, and memory may also be changed.

Another approach to the study of brain function arises at times in the course of major brain surgery when a neurosurgeon may briefly stimulate the exposed surface of the brain electrically in order to ascertain which part of the brain he is treating, and also to establish with as much certainty as possible on which side of the brain speech is lateralised.

The flow of blood to the neocortex increases in areas where the neurons are particularly active. In some cases batteries of tests have been applied to large groups of patients in an attempt to analyse quantitatively the patterns of deficits that emerge between the different brain-damaged groups.

Each of these distinctive approaches to neuropsychology has contributed significantly to its development and will continue to do so.

3.5 UNIT END QUESTIONS

1) Trace the history of Neuropsychology.
2) What is meant by localisation?
3) Discuss the relationship between brain and behaviour.

3.6 SUGGESTED READINGS

Kolb, B.& Wishaw,I.Q. (1990). *Fundamentals of Human Neuropsychology*. W.H.Freeman and Company. New York

Rao,S.L.,Subbakrishna,D.K.,Gopukumar,K.(2004). *Nimhans Neuropsychology Battery*. Nimhans Publication. Bangalore.

Snyder,P.J.,Nussbaum,P.D.,Robins,D.L.(2006). *Clinical Neuropsychology A Pocket Handbook for Assessment*. American Psychological Association , Washington.

Spreen,O. & Strauss,E.(1991). *A Compendium of Neuropsychological Tests*. Oxford University Press. New York.

UNIT 4 DOMAINS OF NEUROPSYCHOLOGY

Structure

4.0 Introduction

4.1 Objectives

4.2 Areas of Neuropsychology

- 4.2.1 Clinical Neuropsychology
- 4.2.2 Expérimental Neuropsychology

4.3 Cognitive Functions

- 4.3.1 Attention
- 4.3.2 Motor Function
- 4.3.3 Language
- 4.3.4 Learning and Memory
- 4.3.5 Visual Perception and Constructional Ability
- 4.3.6 Executive Functions

4.4 Neuropsychological Assessment

4.5 Approaches of Neuropsychological Assessment

- 4.5.1 Fixed Battery Approach
- 4.5.2 Flexible Battery Approach

4.6 Goals of Neuropsychological Assessment

4.7 Assessment Process

4.8 Other Assessments

4.9 Let Us Sum Up

4.10 Unit End Questions

4.11 Suggested Readings

4.0 INTRODUCTION

The brain is a fascinating and enigmatic machine. It has the ability to monitor and control our basic life support systems, to maintain our posture and direct our movements, to receive and interpret information about the world around us, and to store information in a readily accessible form throughout our lives. It allows us to solve problems which range from the strictly practical to the highly abstract, to communicate with our fellows through language, to create new ideas and imagine things that have never existed, to feel love and happiness and disappointment and to experience an awareness of ourselves as individuals.

Neuropsychology as one of the neurosciences has grown to be a separate field of specialisation within psychology. Neuropsychology seeks to understand the relationship between the brain and behaviour i.e. it attempts to explain the way in which the activity of the brain is expressed in observable behaviour.

4.1 OBJECTIVES

After completing this unit, you will be able to:

- Define neuropsychology;

- Describe neuropsychological functions;
- Explain the different neuropsychological functions;
- Explain the different approaches to neuropsychological assessment;
- Elucidate the goals of neuropsychological assessment; and
- Describe the various tests used for assessment.

4.2 AREAS OF NEUROPSYCHOLOGY

Neuropsychology is often divided into two main areas: clinical neuropsychology and experimental neuropsychology.

4.2.1 Clinical Neuropsychology

This deals with patients who have lesions of the brain. These lesions may be the effect of disease or tumours, may result from damage or trauma (such as accident) to the brain, or be the result of some biochemical changes caused by toxic substances.

4.2.2 Experimental Neuropsychology

The experimental neuropsychologist works with normal subjects with intact brains. A variety of techniques are employed in the laboratory to study higher functions in the brain. Subjects are generally required to undertake performance tasks while their accuracy or speed of response is recorded, from which inferences about brain organisation are made.

4.3 COGNITIVE FUNCTIONS

Neuropsychological functioning covers a wide variety of cognitive domains subserved by different parts of the brain. In order to establish the relationship between brain and behaviour a neuropsychologist should have a thorough knowledge of these cognitive functions and the brain Ares responsible for these functions. The following section briefly describes the cognitive domains.

4.3.1 Attention

Attention can be defined as “the concentration of mental effort on sensory or mental events. Attentional processes facilitate, enhance, or inhibit other cognitive processes. Attentional problems may manifest as either distractibility or difficulty remaining focused on a task. Individuals with attentional dysfunction are usually unable to allocate cognitive resources effectively to the task at hand and fails to perform at optimal levels even though primary cognitive resources, such as sensory registration, perception, memory, and associative functions, are intact.

There are three subsystems of attention – *selective attention*, *sustained attention* and *divided attention*.

Selective or Focussed attention

This requires a capacity to focus and ‘close’ on one stimulus stream or feature, while attenuating the distracting effect of competing information. Orbitofrontol area (OFC) in the prefrontal cortex mediates the capacity to inhibit responding to stimuli irrelevant to the task at hand. Lesion studies have shown that damage to this area results in distractibility.

Sustained attention

This requires 'holding' attention over relatively long periods of time and has features of vigilance. Right fronto parietal network mediates sustained attention. Imaging studies have depicted that vigilance tasks that require sustained attention activate a network of structures in the right frontal and parietal cortices.

Divided attention

This refers to the ability to perform two or more tasks simultaneously and may be considered as requiring the opposite operations to selective attention. For example a subject may be presented with stimuli which vary with respect to colour, motion and shape and monitor changes in all three dimensions. Dorsolateral prefrontal cortex is implicated in divided attention. Overall it can be said that frontal lobe plays an important role in all aspects of attention.

4.3.2 Motor Function

Motor function requires integration among multiple structures. The prefrontal cortex mediates motor planning, the supplementary motor area mediates initiation of motor acts while the premotor cortex , basal ganglia and cerebellum mediate fine motor control

4.3.3 Language

Language functions include expressive language (e.g. naming, vocabulary, storytelling), verbal fluency (fluency of speech, writing, reading), and receptive language (following directions, attending to spoken language, comprehension of information). Disorder of language occurs as aphasia.

Aphasia is a primary disturbance in the comprehension or production of speech caused by brain damage. Mainly there are two types of aphasia:

Expressive aphasia characterised by difficulty in producing words. Patients has difficulty using grammatical constructions, a nomia (word finding difficulty) and articulation difficulty (mispronounce words).It is caused by lesion in the left frontal lobe.

Receptive Aphasia is characterised by poor speech comprehension and production of meaningless speech.

4.3.4 Learning and Memory

These are the capacities by which an individual gains experience and retain it. Learning is the means of acquisition of new information about the environment and memory refers to the processes that are used to acquire, store, retain and later retrieve information. There are three major processes involved in memory: encoding, storage and retrieval. Both are interdependent processes. Memory can be broadly divided into explicit memory and implicit memory.

Explicit memory

This is the conscious recollection of information such as specific facts or events and at least in humans that can be verbally communicated. There are two subtypes of explicit memory.

Episodic memory

It is the retention of information about the where and when of life's happening.

Semantic Memory

Semantic means meanings. It is a person's knowledge about the world. It includes general knowledge, knowledge about meanings of words famous individuals, important places etc.

Procedural memory

It is related to unconsciously remembering skills and perceptions rather than consciously remembering facts. Examples include skills of driving a car or typing. Once learnt the individuals do not have to remember consciously how to drive a car or type. The subsystems of implicit memory are:

Studies have shown the acquisition of new information is meditated by a wide network of structures including anterior temporal cortex amygdala hippocampus prefrontal cortex.

The left prefrontal cortex is involved in encoding episodic memory and retrieval for semantic memory.

The right prefrontal lobe is implicated in retrieval from episodic memory. Left temporal lobe mediates verbal memory and of the right temporal lobe mediates visuo- spatial memory.

Memory deficits may take the form of amnesia in which there is a partial or total loss of memory. Amnesic patients are unable to encode and consolidate verbal and nonverbal information regardless of the modality of presentation (auditory or visual) or the nature of the material (verbal or nonverbal). In contrast, attention span, language functions, and reasoning are relatively preserved. Amnesic patients show the greatest deficits on tasks of declarative memory in that they are unable to demonstrate awareness of prior learning experiences, whereas procedural memory (skills, habits, and classically conditioned responses) remains intact. Amnesia may be of two types.

Anterograde amnesia (AA) refers to an inability to learn new information after the onset of amnesia. AA is present inmost cases of amnesia. Retrograde amnesia (RA) refers to deficient recall of events preceding the onset of amnesia.

4.3.5 Visual Perception and Constructional Ability

The evaluation of visual perception and constructional ability is a necessary component of the comprehensive neuropsychological examination. A focal lesion or incipient dementia may cause a profound deficit of visuoperceptual discrimination, visuospatia judgment, or constructional ability in an otherwise articulate patient with normal verbal functioning and normal visual acuity.

Visual perception

It is the process through which sensory information derived from light is interpreted for object recognition or spatial orientation. Visual perception consists of visuoperceptual and visuospatial ability, two functionally independent processes that have separate neuroanatomical substrates.This functional distinction is commonly referred to as “what” (visuoperceptual) verses “where” (visuospatial).

Visuoperceptual ability

This subsumes form or pattern discrimination. Colour, shape, and other intrinsic features are processed by the visuoperceptual system, regardless of the spatial dimensions of an object or environment. Visuo-perceptual deficit may manifest in the form of

a) *Visual agnosia* I

It is a deficit in recognition of common objects or familiar faces. Bilateral temporo-occipital lesions damaging the visual association cortices of both hemispheres usually leads to the manifestation of visual agnosia.

b) *Deficits of form discrimination*

This may be found on a variety of tasks, including the following:

i) discrimination of unfamiliar human faces;

ii) visual analysis, which involves the identification of overlapping or hidden figures;

iii) visual synthesis, which involves the ability to mentally combine disparate parts into an integrated whole; and

iv) identification or matching of objects obscured by excessive shadowing or by presentation at unusual angles.

The typical neuroanatomical substrate for these deficits is a lesion in the right temporo-occipital area. .

Visuospatial ability

It is the processing of visual orientation or location in space, regardless of the intrinsic features of that object or environment. Depth and motion are subsumed by this system. Visuospatial deficit may appear as

a) *Balint-Holmes syndrome* in which the spatial disturbance is so severe that despite adequate visual acuity, the patients may collide with large objects in their path and may be unable to grasp objects placed within their reach. Balint-Holmes syndrome is associated with bilateral lesions of the superior parietal lobule.

b) *Visual neglect* is pathological inattention to objects or events in the visual space contralateral to a brain lesion. Visual neglect is due to unilateral lesions of the parietal lobe, dorsolateral frontal lobe, putamen, cingulate gyrus and thalamus.

c) *Deficit in visuospatial judgment* – In this there is deficits in judging the position and orientation of objects due to posterior right-hemisphere disease.

Constructional ability

Constructional ability is the capacity to draw or assemble an object from component parts, either on command or to copy a model. The concept measures the integrative aspect of construction. Visuo constructive ability requires attention, visuo spatial perception, visuomotor coordination, planning and error correction abilities. It is mediated by bilateral parietal structures predominantly right parietal structure. The prefrontal structures mediate the planning and error correction capacity.

4.3.6 Executive Functions

Executive functions are the capacities that enable a person to control their behaviour and engage successfully in independent, purposive, goal-directed activities. (Lezak, 1995). Lezak describes four components of executive functions, each of which relies on its own set of behaviours:

a) volitional activity, which relies on self-awareness, initiation, and motivation;

b) planning and organisation;

c) carrying out purposive action; and

d) self-regulation, which relies on monitoring, shifting, inhibiting; and selfcorrecting.

Executive functions include: planning, set shifting and response inhibition

Planning

It is the ability to set goals, to monitor performance so as to reach the goals and to make corrections in the steps adopted, in order to ensure that the goal is attained. Goal setting involves identification of both final goals and intermediate goals that needs to be achieved in order to attain the final goal. Left frontal lobe is associated with planning ability.

Cognitive flexibility/ Set Shifting

It refers to a person's ability to switch from one topic to another. In this an individual needs to inhibit or curtail the current behaviour and spontaneously commence another. Test that measure these characteristics typically set up an automatic expectancy or routine of behaviour in the patient and then require the patient to shift from that expectancy or routine in an independent manner. It requires strategic planning, organised searching utilising environmental feedback to shift cognitive set directing behaviour towards the goal and modulating impulsive response. Lesions of the dorsolateral prefrontal cortex impair set shifting ability and increases perseverative responses.

Response inhibition

The concept refers to the suppression of actions that are inappropriate in a given context and that interfere with goal-driven behaviour. Prefrontal areas are essential for response inhibition.

Problems with executive function may present in many ways, such as impulsivity, disorganisation, poor judgment, dysregulated behaviour, and amotivation.

4.4 NEUROPSYCHOLOGICAL ASSESSMENT

A neuropsychological assessment is the systematic administration of clearly defined procedures (i.e., "tests") to assess the neurocognitive, behavioural, and emotional functioning of an individual in order to form hypotheses regarding his/her central nervous system functioning. Neuropsychological assessment precisely identifies which functional system is impaired or to what extent it is impaired.

4.5 APPROACHES OF NEUROPSYCHOLOGICAL ASSESSMENT

Despite shared goals, neuropsychologists differ widely with respect to their approach to assessment. There are two different approaches (i) Fixed battery approach and (ii) Flexible battery approach. These two approaches are discussed below.

4.5.1 Fixed Battery Approach

Proponents of this approach typically recommend the use of a standard or fixed battery of tests, in which the same set of instruments is used for each individual tested, regardless of the referral question. These batteries include tests of a wide range of cognitive functions by utilising a standard test battery, practitioners ensure that all significant domains are addressed, thus avoiding the possibility of overlooking deficits that may better account for or contribute to the patient's presenting problem. The disadvantages of battery approach are: 1) excessive time (fatigues patient, requires several visits); 2) include assessment measures that might not be necessary for a given patient.

4.5.2 Flexible Battery Approach

On the other hand flexible approach emphasises the need to tailor the assessment to the nature of particular patient's difficulties. In this approach tests are chosen depending on the presenting issues or suspected pathologies and are sometimes based on a short screening battery. The disadvantages of this approach are that it relies heavily on the skills and insights of the individual clinician. There is a risk that certain areas of function might get neglected or that complex patterns of functional interaction may be missed.

4.6 GOALS OF NEUROPSYCHOLOGICAL ASSESSMENT

Neuropsychological assessment can be useful in achieving several clinical goals with a variety of patient populations.

First the neuropsychological assessment aims to diagnose the presence of cortical damage or dysfunction and localise (which part of the brain is damaged) it.

Second neuropsychological assessment helps to conceptualise an individual's overall functional abilities and his/her specific cognitive strengths and weaknesses.

Third Neuropsychological assessment can identify the presence of mild disturbances in cases in which other diagnostic studies have produced equivocal results.

Fourth, it determines the baseline functioning of the individual following traumatic exposure which serves as a means of devising a rehabilitation programme or offering advice as to an individual's ability to carry out certain tasks (for example, fitness to drive, or returning to work).

Finally serial assessments over time helps to monitor treatment effects and provide information regarding the rate of recovery and the potential for resuming previous lifestyle.

4.7 ASSESSMENT PROCESS

Neuropsychological assessment usually starts with a detailed history of the pateient followed by the evaluation of general intellectual functioning as intelligence test provide an overview of cognitive function integrity. Thereafter assessment of specific cognitive domains is done by either using fixed of flexible battery approach.

Intelligence Tests

Usually Wechsler Tests of Intelligence is administered.WAIS-IV, (current version) is composed of 10 core subtests and five supplemental subtests, with the 10 core subtests comprising the Full Scale IQ. It provides four index scores representing major components of intelligence:

Verbal Comprehension Index (VCI)

Perceptual Reasoning Index (PRI)

Working Memory Index (WMI)

Processing Speed Index (PSI)

Subtests

The Verbal Comprehension Index includes four tests:

i) Similarities: Abstract verbal reasoning (e.g., "In what way are an apple and a pear alike?")

ii) Vocabulary: The degree to which one has learned, been able to comprehend and verbally express vocabulary (e.g., "What is a guitar?")

iii) Information : Degree of general information acquired from culture (e.g., "Who is the president of Russia?")

iv) Comprehension [Supplemental]: Ability to deal with abstract social conventions, rules and expressions (e.g., "What does *Kill 2 birds with 1 stone* metaphorically mean?")

The Perceptual Reasoning Index comprises five tests:

i) Block Design: Spatial perception, visual abstract processing and problem solving.

ii) Matrix Reasoning: Nonverbal abstract problem solving, inductive reasoning, spatial reasoning.

iii) Visual Puzzles: non-verbal reasoning.

iv) Picture Completion [Supplemental]: Ability to quickly perceive visual details.

v) Figure Weights [Supplemental]: quantitative and analogical reasoning.

The Working Memory Index is obtained from three tests:

i) Digit span: attention, concentration, mental control (e.g., Repeat the numbers 1-2-3 in reverse sequence)

ii) Arithmetic: Concentration while manipulating mental mathematical problems (e.g., "How many 45-cent stamps can you buy for a dollar?")

iii) Letter-Number Sequencing [Supplemental]: attention and working memory (e.g., Repeat the sequence Q-1-B-3-J-2, but place the numbers in numerical order and then the letters in alphabetical order)

The Processing Speed Index includes three tests:

i) Symbol Search: Visual perception, speed

ii) Coding: Visual-motor coordination, motor and mental speed

iii) Cancellation [Supplemental]: visual-perceptual speed

Two broad scores are also generated, which can be used to summarise general intellectual abilities:

Full Scale IQ (FSIQ), is obtained from the combined performance of the VCI, PRI, WMI, and PSI

General Ability Index (GAI), based only on the six subtests that comprise the VCI and PRI

The WAIS-IV measure is appropriate for use with individuals aged 16–90 years. For individuals under 16 years, the Wechsler Intelligence Scale for Children (WISC, 6-16 years) and the Wechsler Preschool and Primary Scale of Intelligence (WPPSI, 2½–7 years, 3 months) are used.

Fixed Approach of Assessment

The two most widely known batteries are Halstead-Reitan Battery and Luria Nebraska Neuropsychological Battery.

The Halstead-Reitan Battery includes:

Trails A and B (which see how quickly a patient can connect a sequence of numbers (trail A) or numbers and letters (trail B).

Controlled Oral Word Association Test (COWAT, or Verbal Fluency) - a measure of a person's ability to make verbal associations to specified letters.

Halstead Category Test is a measure of abstract ability, including seven subtests which form three factors:

i) a Counting factor (subtests I and II),

ii) a Spatial Positional Reasoning factor (subtests III, IV, and VII), and

iii) a Proportional Reasoning factor (subtests V, VI, and VII).)

Tactual Performance Test A form board containing ten cut-out shapes, and ten wooden blocks matching those shapes are placed in front of a blindfolded individual. Individuals are then instructed to use only their dominant hand to place the blocks in their appropriate space on the form board. The same procedure is repeated using only the non-dominant hand, and then using both hands.

Rhythm Test: discrimination of like and unlike pairs of musical beats is required.

Speech Sounds Perception Test: It is a test of auditory acuity.

Finger Oscillation Test. In this, the subjects finger tapping speed is measured.

Luria-Nebraska Neuropsychological Battery

The Luria-Nebraska is a standardised test appropriate for people aged 13 and older and takes between 90 and 150 minutes to complete. It consists of 269 items in the following 11 clinical scales:

Reading, writing, arithmetic, visual memory, expressive language, receptive language, motor function, rhythm, tactile, intellectual.

Scores for three summary scales can also be calculated: pathognomonic, right hemisphere, and left hemisphere.

A children's version of the battery, called the Luria- Nebraska Neuropsychological Battery for Children (LNNB-C), appropriate for children aged eight to 12, is also available.

Flexible Approach of Assessment

As already stated in flexible approach of assessment neuropsychologist uses pertinent patient information to guide test selection and chooses tests (either from existing batteries or tests designed to assess specific deficits) that assess cognitive functions relevant to a given patient. More than 700 tests of cognitive functioning are available. A brief overview of few of the tests assessing various cognitive functions is described below:

Tests for Attention

Measures of Sustained Attention

i) *Colour Cancellation Test*: This test Comprises of a sheet having 150 circles in five different colours i.e. red, yellow, blue, black and gray. Subject is required to cancel only red and yellow circles as quickly as possible. Time taken to complete the test is recorded and error of commission (circles other than red and yellow cancelled) and error of omission (red and yellow circles not cancelled) is noted.

ii) *Digit Span Test*: Subject listen to random sequences of numbers presented in increasing length, and immediately repeat each sequence (two trials at each span length are presented) - maximum span is number of digits patient can correctly repeat on at least one trial (normal 5-9 digits).

iii) *Corsi Block Test*: Subject is presented with nine blocks array arranged in random order; examiner touches blocks in sequences of increasing length; patient is required to reproduce sequence at each length.

iv) *Paced Auditory Serial Addition Test (PASAT)*: Extremely sensitive measure of vigilance patient listens to tape recording of digits presented one at time; patient must add each number to one immediately preceding it (e.g. recording presents numbers 1, 7, 5, 4 - patient adds first two numbers (1 + 7) and responds with number 8; patient then adds second two numbers (7 + 5) and responds with number 12; patient then adds third two numbers (5 + 4) and responds Tests assess attention and vigilance (span tests also require working memory).

Measures of Selective Attention

i) *Conners' Continuous Performance Task/Test (CPT)* (Computerised version)

In CPT the respondents are required to press the space bar or click the mouse whenever any letter except the letter 'X' appears on the computer screen. The person must refrain from clicking if they see any other letter presented. The inter-stimulus intervals (ISIs) are 1, 2 and 4 seconds with a display time of 250 milliseconds.

Four types of scores are obtained

Corrects Detection: This indicates the number of times the client responded to the target stimulus. Higher rates of correct detections indicate better attentional capacity.

Reaction Times: This measures the amount of time between the presentation of the stimulus and the client's response.

Omission errors: This indicates the number of times the target was presented, but the subject did not respond/click the mouse. High omission rates indicate that the subject is either not paying attention (distractibility) to stimuli or has a sluggish response.

Commission errors: This score indicates the number of times the client responded but no target was presented. A fast reaction time and high commission error rate points to difficulties with impulsivity.

Measures of Divided Attention

*Triads Tes*t: It consists of verbal triads task with a actual number identification task. The two tasks differ with reference to the stimulus modality and the nature of stimulus processing. Both the tasks require verbal response. The verbal triads task consists of 48 nouns grouped into 16 word triads. In each triad two words belong to same category while the third one does not. The subject names the odd word. In the tactual number identification task an Arabic numeral is written on the right hand and the subject identifies it by calling it out. The subject performs the tasks blindfolded. Number of errors committed on each task is counted.

Learning and Memory

Assessment of Various forms of declarative memory, forms a core part of memory examination in both forms of amnesia.

Assessment of Anterograde Amnesia

The *Wechsler Memory Scale (WMS)* is designed to measure different memory functions in a person. It can be used with people from age 16 through 90. The current version is the fourth edition (WMS-IV) which was published in 2009. WMS-IV is made up of seven subtests:

- Spatial Addition,
- Symbol Span,
- Design Memory,
- General Cognitive Screener,

- Logical Memory,
- Verbal Paired Associates, and
- Visual Reproduction.

A person's performance is reported as five Index Scores:

- Auditory Memory,
- Visual Memory,
- Visual Working Memory,
- Immediate Memory, and
- Delayed Memory.

Rey Auditory Learning Test (RAVLT)

RAVLT involves presentation of a list of 15 words(List A), which an examiner reads aloud at the rate of one per second. The patient's task is to repeat all the words he or she can remember, in any order. This procedure is carried for five trials. Thereafter an interference list (List b) of 15 words is presented followed by an immediate recall of List B. After this the subject is asked to recall List A. Immediate recall of List B and then List A provides measure of proactive/ retroactive interference. A delayed recall of List A is taken after 30 minutes delay period.

Rey-Osterrieth Complex Figure Test (ROCF)

This is a test of complex visual organisation and visual memory. Individuals are asked to reproduce a two dimensional figure without time restrictions, first by copying and then from memory. Scoring focuses on the accuracy of details rendered. Initial copying is done without the knowledge that memory will be examined. Hence initial recall is a measure of incidental learning. Delayed recall performance is examined relevant to rate of forgetting.

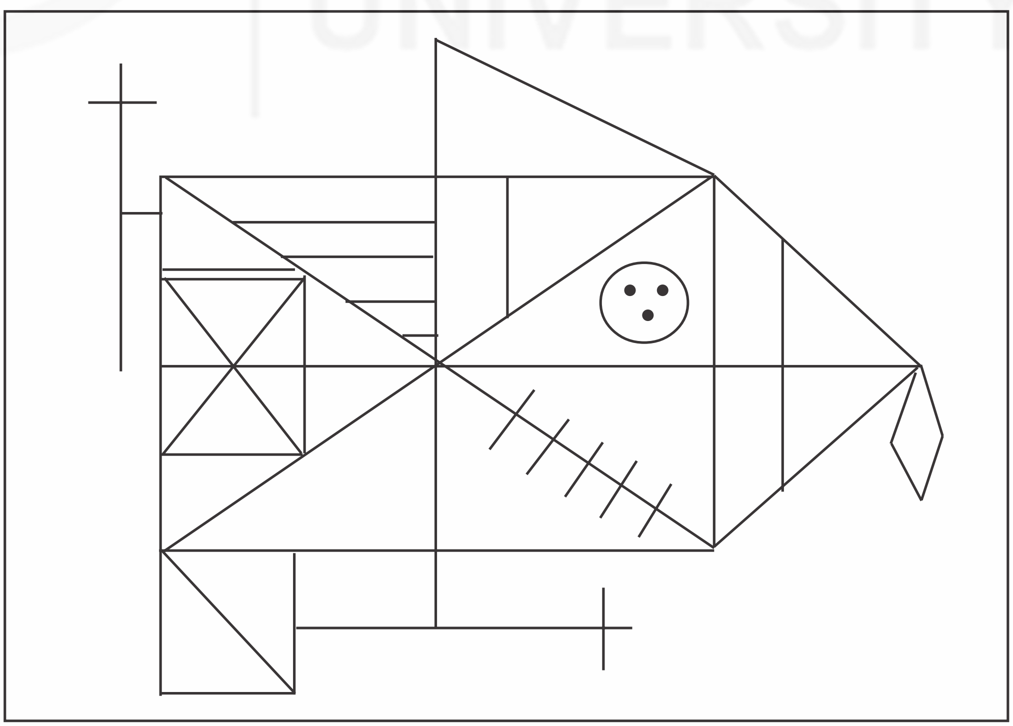

Fig.: The Rey-Osterrieth Complex (Osterrieth, 1946)

Warrington Recognition Memory Test

The Warrington Recognition Memory Test (Warrington,1984) involves recognition of 50 verbal stimuli (words) and 50 nonverbal stimuli (faces). In the first subtest, patients are shown 50 words (one at a time) at a rate of 3 seconds per stimulus.

They are then asked to select the previously viewed words that are presented -in a forced-choice list (one foil paired with each target). In the second subtest, 50 black-and-white photographs of male faces are presented. The patient is then shown two faces (one previously seen and one distractor) and asked to point tothe target stimulus. The Warrington Recognition Memory Test provides useful information regarding material-specific aspects of memory.

The Brief Visuospatial Memory Test—Revised

This is a measure of visual learning and memory. Participants are asked to study a sheet with six figures on it for 10 s, and then draw from memory all the figures accurately and in their correct location. This is repeated for a total of three trials. Following a 25 min delay, participants are asked to freely recall and again draw the six figures.

Assessment of Retrograde Amnesia

There are many factors that make formal assessment of RA difficult. Personal memories from the remote past are difficult to verify, and it is not possible to determine whether errors are due to inadequate storage at the time of initial exposure or disruption of the retrieval process. One method of assessing RA involves recall of public events. The problem with this approach is that there is a great deal of variability in individuals' premorbid fund of knowledge; variations in performance may be due to differences in baseline intelligence or interest in world events. With these caveats in mind, it is recommended that the assessment of RA should encompass different types and classes of memories (i.e., personal history, world history, and popular culture) that may be disrupted differentially in the context of neurological disease.

Autobiographical Memory Interview

The Autobiographical Memory Interview is a semistructured interview that focuses on events from three time periods throughout the life span. Both semantic and episodic aspects of events are probed. Each memory is scored according to the amount of detail and vividness of the recollection. Any assessment of autobiographical memory should be accompanied by an interview with someone who can provide a collateral source of information.

The Famous Face Test

The Famous Faces Test requires the individual to identify photographs of famous individuals from the 1920s through the 1990s. The FFT provides useful information regarding the individual's knowledge and recall of public figures.

Visual perception and constructional ability

Visual neglect

The presence of hemispatial neglect is easily assessed by *cancellation tasks*, which demand that the patient visually scan an array and cross-out designated targets. *Line bisection tasks*, in which patients are asked to, draw a mark through the midpoint of a horisontal line, may also be used. The patient with neglect will fail to cross out target stimuli on one side of the cancellation task, and on line bisection tasks his or her center mark will grossly deviate from the actual midpoint of the line.

Visuoperceptual discrimination

Benton Test of Facial Recognition (BFRT)is a clinically useful test of visuoperceptual discrimination. In BFRT subjects are presented with a target face and several test faces, and they are asked to indicate which of the images match the target face. Male and female faces are used, and the faces are closelycropped so that no clothing and little hair are visible.

Visuospatial Judgment

Benton et al.'s (1994) *Judgment of Line Orientation task* is a clinically useful test of visuospatial judgment. It consists 30 stimuli with one page with two lines and a second page with 11 lines. Participants are asked to compare the two pages and report which two lines on the second page point in the same direction and are in the same location as the two lines on the first page. This measure has high split-half reliability for adults.

Constructional Ability

The *Benton Visual Retention Test* (or simply Benton Test) is an individually administered test for ages 8-adult The individual is shown 10 designs, one at a time, and asked to reproduce each one as exactly as possible on plain paper from memory. The test is untimed, and the results are professionally scored by form, shape, pattern, and arrangement on the paper.

Rey-Osterreith Complex Figure (already discussed)

Block Design or Object Assembly of Weschler Adult Intelligence Scale also provides measure of constructional ability.

Executive functions

Planning is assessed using

Tower of London. This test evaluates the subjects' ability to plan and anticipate the results of their actions to achieve a predetermined goal. The test consists of two identical wooden boards with three round pegs of different sizes and two sets of three balls painted red, green, and blue respectively. The examiner arranges the balls in a predetermined manner (goal state) on one of the wooden boards and instructs the subjects to move the balls on the wooden board placed before him so that he/she achieves that goal state. Tower of London comprises of problems with 2 moves, 3 moves 4 moves and 5 moves. Scoring yields standard scores for the total number of moves, total initiation time, total problem-solving time, total execution time, and the number of correct solutions (i.e., items solved in minimum number of moves), total time violations, and total rule violations.

The Porteus Maze Test is a graded set of paper forms on which the subject traces the way from a starting point to an exit; the subject must avoid blind alleys along the way. There are no time limits. The mazes vary in complexity from simple diamond shape for the average three-year-old to intricate labyrinths for adults.

Set Shifting

Wisconsin Card Sorting Test (WCST)

The test uses stimulus and response cards that show different forms in various colours and numbers. Individually administered, it requires the client to sort the cards according to different principles (i.e., by colour, form, or number). As the test progresses, there are unannounced shifts in the sorting principle which require the client to alter his or her approach: however, the subject is given the feedback whether a particular match is right or wrong. Time taken for the participant to learn the new rules, and the mistakes made during this learning process are analysed to arrive at a score.

Trail Making Test

This comprises two parts and consists of 25 circles distributed over a sheet of paper. In Part A, the circles are numbered 1 – 25, and the patient should draw lines to connect the numbers in ascending order. In Part B, the circles include both numbers (1 – 13) and letters (A – L) and as in Part A, the patient draws lines to connect the circles in an ascending pattern, but with the added task of alternating between the numbers and letters (i.e., 1-A-2-B-3-C, etc.). The patient should be instructed to connect the circles as quickly as possible, without lifting the pen or pencil from the paper. Time taken is noted down.

Response inhibition

Stroop Test-

It comprises of three cards (D,W & C).Card D consists of 24 dots printed in blue, green, red and yellow. Each color is used six times and arranged in a order so that each color appear once in a row. Subjects are instructed to read the color of the dots. Card W is similar to card D except dots are replaced by the words and subjects are instructed to name the colour of the word in which it is printed. In Card stimuli is the name of the colours and the instruction is to read the colour in which the word is printed. Scoring is done in the form of the time taken and the number of errors committed.

Language

Measure of Aphasia

Boston Diagnostic Aphasia Examination:

The tests are organised into five major sections as given below:

i) Conservational and Expossitory Speech

ii) Auditiory Comprehension

iii) Oral Expression

iv) Understanding Written Language

v) Writing

Token Test

Token Test: This test is designed to assess verbal comprehension of commands of increasing complexity. The test employs a set of 20 plastic tokens consisting of 5 colours, two shapes and two sizes. The test sees if an individual can follow orally presented instructions. For example, the examiner may say, “Touch the red square" and then the behaviour or lack of behaviour in the individual is observed and noted.

The *Boston Naming Test*

(BNT) represents a measure of object naming from line drawings that patients with often have greater difficulties with the naming of objects. Thus, instead of there being a simple category of anomia, naming difficulties may be rank ordered along a continuum. It contains 60 items..

Motor Function

Motor Speed

Finger Tapping Test In Finger Tapping Test (FTT) also referred as the *Finger Oscillation Test* the client is asked to initially tap his or her dominant index finger as fast as possible for five consecutive 10- second trials. The procedure is then repeated for the nondominant index finger. Performances are measured on a recording device . The score is simply the average number of taps in a 10-second interval. The two average scores (for dominant and nondominant fingers/ hands) are compared with each other to see if there are wide discrepancies.

Dexterity

It is measured by *Purdue Pegboard Test*. The test board consists of two parallel rows of 25 holes each. Pins, collars and washers are located at the extreme right hand and left hand cups at the top of the board. The procedure for administration and scoring is as follows. Performance of the RH and LH subtests require participants to first use their right hand (dominant) then left hand (nondominant) to place as many pins as possible down the respective row within 30 sec. The score for each of these subtests is the total number of pins placed by each hand in the time allowed. The BH subtest is a bimanual test where the participants use their right and left hand simultaneously to place as many pins as possible down both rows in 30 sec. The score for this subtest is the total number of pairs of pins placed in 30 sec. The assembly subtest requires that both hands work simultaneously while performing different tasks for 60 sec. The score for this subtest is the total number of pins, washers, and collars placed in 60 sec. It can be administered to individuals or groups.

Strength

In order to assess the strength of the voluntary movements of the hands *Hand Dynamometer* is used. The subject is required to hold the upper part of the dynamometer in the palm of the hand and squeeze the stirrup with the fingers as hard as possible. It is conducted on each hand respectively.

4.8 OTHER ASSESSMENTS

Along with the assessment of cognitive functions academic achievement also needs to be assessed

Measures of Academic Achievement – assess standard academic skills (reading, writing, arithmetic skills, spelling, etc.

The Wide Range Achievement Test

This is a test of basic academic skills for ages 5-adult, covering reading (word recognition and pronunciation), written spelling, and arithmetic. The test is given at two levels: Level I (ages 5-11) and Level II (12-adult). It consists of three paper-and-pencil subtests with 50-100 items each, arranged in order of increasing difficulty. The Reading subtest consists of recognising and naming letters and pronouncing printed words. The Spelling subtest includes copying marks resembling letters, writing one's name, and printing words, and the Arithmetic section involves counting, reading number symbols, and oral and written computation.

Peabody Individual Achievement Test-Revised-

This is an individual measure of academic achievement. Reading, mathematics, and spelling are assessed in a multiple-choice format. It comprises of six subtests:

- General Information—100 verbal items assess general knowledge.
- Reading Recognition—100 items measure recognition of printed letters and the ability to read words aloud.
- Reading Comprehension—82 items measure reading comprehension.
- Written Expression—assesses written language skills.
- Mathematics—100 multiple choice items test knowledge and application of math concepts and facts.
- Spelling—100 multiple choice items measure recognition of correct word spelling.

PIAT-R also provides a Written Language Composite, obtained by combining scores on the Spelling and Written Expression subtests, and a Total Reading score, a combination of scores from the Reading Recognition and Reading Comprehension subtests for overall indexes for written expression.

Emotional Status and Level of Adaptive Behaviour

While measures of cognitive and behavioural abilities are important, a client's emotional status and relative level of adaptive behaviour are also of considerable relevance. This information is useful for at least three types of situations. First, clinicians might try to decide whether abnormal cognitive test results are primarily from CNS (central nervous system) involvement or emotional factors. If emotional functioning is relatively normal, but the individual still has cognitive deficits, this would strongly implicate CNS involvement. Second, a clinician might need to know the extent to which emotional reactions are complicating organic impairment. A client with organically based confusion is likely to have this further exacerbated by reactions such as depression.

Third, predictions often need to be made related to a person's overall level of functioning. While level of cognitive deficit is useful, personality and emotional factors have often been found to be better predictors of psychosocial adjustment and rehabilitation outcome.

The assessment of personality and adaptive behaviour can be accomplished through a variety of tests.

Measure of Personality

Minnesota Multiphasic Personality Inventory (MMPI) It is a self administered measure of personality. The revised version MMPI-2 contains 567 test items and takes approximately 60 to 90 minutes to complete. It comprises of following clinical scales that are used to indicate different conditions.

Hs D	Hypochondriasis Depression	Concern with bodily symptoms Depressive Symptoms
Hy	Hysteria	Awareness of problems and vulnerabilities
Pd	Psychopathic Deviate	Conflict, struggle, anger, respect for society's rules
MF	Masculinity/Femininity	Stereotypical masculine or feminine interests/behaviours
Pa	Paranoia	Level of trust, suspiciousness, sensitivity
Pt	Psychasthenia	Worry, Anxiety, tension, doubts, obsessiveness
Sc	Schizophrenia	Odd thinking and social alienation
Ma	Hypomania	Level of excitability
Si	Social Introversion	People orientation

Thematic Apperception Test

The Thematic Apperception Test, or TAT, is a projective measure intended to evaluate a person's patterns of thought, attitudes, observational capacity, and emotional responses to ambiguous test materials. In the case of the TAT, the ambiguous materials consist of a set of cards that portray human figures in a variety of settings and situations. The subject is asked to tell the examiner a story about each card that includes the following elements: the event shown in the picture; what has led up to it; what the characters in the picture are feeling and thinking; and the outcome of the event.

Measure of Adaptive Behaviour

Vineland Adaptive Behaviour Scale (VABS)

VABS assesses the social abilities of an individual, whose age ranges from preschool to 18 years old.

Since adaptive behaviour is a composite of various dimensions, the test measures five domains– Communication, Daily Living Skills, Socialisation, Motor Skills, and Maladaptive Behaviour domains.

The Communication Domain evaluates the receptive, expressive, and written communication skills of the child.

The Daily Living Skills Domain measures personal behaviour as well as domestic and community interaction skills.

The Socialisation Domain covers play and leisure time, interpersonal relationships, and various coping skills.

The Motor Skills Domain measures both gross and fine motor skills.

Maladaptive Behaviour is an optional part of the assessment test. It is used to measure obvious undesirable behaviours.

4.9 LET US SUM UP

In this unit you have read

Neuropsychology is the "applied science of brain behaviour relationships".

There are two areas of neuropsychology: Clinical and experimental

Neurppsychological functioning covers cognitive domains of – attention, motor function, visuoperceptual and constructional ability, language, memroy, and executive functions.

There are two approaches of Neuropsychological assessment: Fixed and Flexible.

Goals of neuropsychological assessment is to diagnose,assess strengths and deficits and monitor recovery process.

Any neuropsychological assessment should assess the general intellectual functioning, academic achievement and emotional and adaptive behaviour of an individual in addition to core cognitive domains.

4.10 UNIT END QUESTIONS

1) Define Neuropsychology. Briefly explain the various domains of neuropsychology.
2) What are the goals of neuropsychological assessment?
3) Briefly discuss the various tests used to assess the different domains of cognitive function.
4) Why it is necessary to assess the emotional and adaptive functioning as a part of neuropsychological assessment. Briefly describe the test used for the assessment of emotional and adaptive behaviour.
5) What is fixed battery approach. Discuss the salient points of any one battery.

4.11 SUGGESTED READINGS

Kolb, B.& Wishaw,I.Q. (1990). *Fundamentals of Human Neuropsychology*. W.H.Freeman and Company. New York

Rao,S.L.,Subbakrishna,D.K.,Gopukumar,K.(2004). *Nimhans Neuropsychology Battery*. Nimhans Publication. Bangalore.

Snyder,P.J.,Nussbaum,P.D.,Robins,D.L.(2006). *Clinical Neuropsychology A Pocket Handbook for Assessment*. American Psychological Association , Washington.

Spreen,O. & Strauss,E.(1991). *A Compendium of Neuropsychological Tests*. Oxford University Press. New York.

UNIT 1 NEUROPSYCHOLOGY METHODS

Structure

1.0 Introduction

1.1 Objectives

1.2 Techniques for Measuring Brain Structure and Functions

- 1.2.1 Examining Tissue
- 1.2.2 Lesions and Ablation
- 1.2.3 Electrical Stimulation
- 1.2.4 Neurochemical Manipulations
- 1.2.5 Electrical Recording
- 1.2.6 In-Vivo Imaging

1.3 Neuropsychological Assessment

1.4 Dissociation and Double Dissociations

1.5 In Vivo Imaging in Psychiatry

1.6 Let Us Sum Up

1.7 Unit End Questions

1.8 Suggested Readings

1.0 INTRODUCTION

In this unit, you will be introduced to some of the methods that researchers use to explore the relationships between brain structure and function. Neuropsychology is a bridging discipline that draws on material from neurology, experimental psychology and even psychiatry; and the area is served by a diverse collection of investigative measures ranging from neuroanatomical procedures at one end of the spectrum to assessments from experimental psychology at the other.

A particularly exciting development over the last 30 years has been the introduction of invivo imaging techniques. The rapid spread in availability of scanning and imaging hardware (particularly during 'the decade of the brain' in 1990s) has provided neuroscientists with research opportunities that were, until recently, unthinkable. In vivo imaging has provided independent confirmation of the suspected role(s) of particular brain regions in psychological processing (for example, the role of the anterior cingulate in attention). In other instances, in-vivo techniques have revealed the true complexity of processes that other procedures had tended to oversimplify.

The application of imaging techniques to language to find out the different areas involved in different processing of language is an example of the same.

Informative though the various procedures can be, it is also important to realise that most neuropsychological techniques (including in vivo scanning) have their limitations. So, although the demise of older procedures has frequently been predicted as imminent, many still have important role to play. In fact, the combination of imaging with traditional techniques can turn out to be a particularly fruitful and informative collaboration. In simple terms using a combination of methods is the best way to follow when studying a phenomenon in neuropsychology.

The unit starts with a brief review of classical techniques that are, for the most part, neuroanatomical in origin. Next, the use of electrical stimulation and electrical recording of the brain is discussed and elaborated. Then some of the in-vivo techniques are identified that allows researchers to visualise the structure and/or function of the 'living' brain. Neuropsychological procedures are elaborated towards the end, some of which can be used in conjunction with in-vivo imaging to provide better insight and understanding of the functioning of the brain. It is tried to keep the information simple and brief, but at the same time pertinent information is not omitted. The unit concludes with an illustration of an exciting application of in-vivo imaging in psychiatry.

1.1 OBJECTIVES

After completing this unit, you will be able to:

- Define and describe neuropsychological assessment;
- Describe the techniques for measuring brain structures and functions;
- Describe the tests and subtests underlying neuropsychological assessment battery;
- Differentiate between dissociation and double dissociation; and
- Elucidate the in vivo imaging in psychiatry.

1.2 TECHNIQUES FOR MEASURING BRAIN STRUCTURE AND FUNCTIONS

The brain is the control center of the human body. It sends and receives millions of signals every second, day and night, in the form of hormones, nerve impulses, and chemical messengers. This exchange of information make us move, eat, sleep and think.

Obstructions such as tumors can interrupt normal brain activity, leading to deficits of normal reasoning, motor control, or consciousness. Many of the signs of neural damage are easily recognisable by an outside observer, but since the actual cause of these problems are internal, the symptoms can be vague. The real deficits can affect the brain's anatomy, or the way signals are processed. A physician can only determine the real cause by examining the brain internally to find irregularities, either in structure or in functioning. Since the brain is extremely fragile and difficult to access without risking further damage, imaging techniques are used frequently as a noninvasive method of visualising the brain's structure and activity.

Today's technology provides many useful tools for studying the brain, and this website will try to briefly describe the most important ones. Some have their most important applications in medical diagnosis, and some are used more for research. The latter are often too expensive or limited for cost-efficient medical use, but can prove valuable and necessary in the future through development and further advances.

There are two main groups of procedures. Structural analysis is used to analyse the anatomy of the brain, in order to find structural deviations. These could be tumors, hemorrhages, blood clots and lesions, or even deficits present at birth. Functional analysis tries to measure and locate brain activity. This is useful for investigating the functioning of special structures, and to diagnose epileptic seizures or diseases affecting brain activity. Functional imaging is also used to aid surgical treatment of brain lesions when it becomes necessary to determine the locality of essential functional cortex to help guide the best surgical approach. Many times a structural and functional method will be used in conjunction to better assess how the activity and region are related.

1.2.1 Examining Tissue

Until quite recently, the options for measurement of brain structure were, effectively, limited to post-mortem, and on very rare occasions, biopsy. The latter is a drastic technique involving the removal and analysis of small (but irreplaceable) samples of brain tissue from the 'appropriate' area of brain. A combination of the 'hit and miss' nature of biopsy and the inevitable damage it causes mean that it is hardly ever used on human. Post-mortem on the other hand, as a long and fairly 'single colourful' history in medicine, but requires the person to be dead! Thus, early signs of disease are likely to be masked by changes that occur as the disease progresses. Sometimes, there are obvious signs of damage in end-stage illness that may nevertheless be of interest: Broca only conducted a superficial post-mortem investigation of Tan's brain but damage to the left frontal region was clear to see.

The brain of a person who has died as a result of Huntington's disease or Alzheimer's disease will look abnormal even to the naked eyes. It will appear shrunken inwards from the skull; gyri (surface bumps) will look 'deflated' and the sulci (surface grooves) will be wider. Usually, however, researchers are less interested in the outward appearance of the brain at death than in the subtle changes that occur during, or even before, the development of overt signs and symptoms. In any case, the external appearance of the brain at post-mortem may be entirely normal, with damage or disease only apparent on closure inspection of internal structures of tissues.

Brain tissue looks solid to the naked eye (it has a consistency of stiff jelly), so 'finger-grain' investigations had to await two technological developments. The first was the gradual refinement over many years of the light microscope, and second was the discovery of tissue staining techniques that had the effect of 'highlighting' particular component structures of tissue. The combinations of these developments enable researchers to identify small groups of neurons, or even individual neurons, using a microscope. Thanks to technological improvements in lens manufacture, microscopy has developed considerably since its first reported use to examine biological tissues (of a cow) by Van Leeuwenhoek in1674. Light microscope can now reliably magnify by a factor of several hundred, but electron microscope can magnify by a factor of several thousands. They can produce images of images of individual synapses (junctions between neurons), or even of receptor sites for neurotransmitters on the surface of neurons.

New staining techniques have also been developed since the pioneering work of Golgi in the late 19th century, although his silver-staining method (which makes stained material appear dark) is still used to produce images of neurons. Other, staining techniques, such as horseradish peroxidise (HRP), have been developed to enable the tracing of connections between neurons. This stain gets absorbed by distal (remote) regions of neuron, but is carried back to the cell body (by retrograde transport within the neuron) to reveal the pathway that the neuron's axon takes. A combination of silver and HRP techniques can be used to establish functional connectivity between the brain regions, such as the innervations of the striatum by the substantia nigra.

Early last century the neuroanatomists Broadmann used a combination of staining and microscopy to map the cytoarcitecture (cell structure\type) of human cerebral cortex. His research lead him to the realisation that different cortical locations comprised structurally distinct types, and his map identified 52 numbered regions, many of which are still used for identification purposes today (Broadmann, 1909). The primary visual cortex is, for example, also known as area 17, and Broca's area straddles Brodmann's areas 44 and 45 in the left hemisphere.

1.2.2 Lesions and Ablation

A long-standing technique in neurology has been observed the effects on behaviour of lesions (cutting) or ablation (removal) of nerve tissue. Karl Lashley used brain lesions and worked exclusively with animals. Many of his studies measured the effects of lesions (removal of brain tissue) in maze learning in rodents. Initially, there would be a period of orientation during which time an animal learned its way around a maze to locate a food pellet. Then he would remove a small region of cortex, and, following a period of recovery, see how many trials it took the animal to relearn the maze and find the food pellet. On the basis of many such trials, Lashley concluded that the amount of lesioned brain tissue rather than its location best predicted how long it would take the rat to learn the maze, supporting his idea of mass action (that the entire cortex is involved in all functions).

For obvious reasons these procedures are not used experimentally on humans, but sometimes brain tissue is ablated for medical reasons such as the excision of tumour. Occasionally, surgical lesioning is also undertaken. Taylor's (1969) study of the effects of lesions to the left and right sides of the cortex in two patients is an example of the former. The surgical procedure of lesioning the corpus callosum as a treatment for epilepsy is an example of the latter. Sometimes, accidents cause lesions (or ablations). The case of Phineas Gage is one celebrated case in point. The case of NA, who developed amnesia following an accident with a fencing foil, is less well known but equally interesting.

It is also possible to induce lesions by the application of chemicals/drugs. The Wada test (Wada and Rasmussen, 1960) involves administering a fast acting barbiturate to one hemisphere at a time, via the left or right carotid artery, to introduce a temporary lesion lasting a matter of minutes. Other drugs may induce permanent lesions through their toxic influence. The substance MPTP, a toxin which was inadvertently mixed with synthetic heroin by recreational drug users in California in the mid-1980s, irreversibly destroys dopamine neurons in the substantia nigra, bringing about a very 'pure' form of induced Parkinson's disease in humans and animals.

Self Assessment Questions

1) Discuss the techniques for measuring brain structures and functions.

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2) What is meant by lesions and ablations? Discuss their role in measuring brain structure.

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3) Discuss Taylor's study of the effects of lesions to the left and right sides of the cortex.

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1.2.3 Electrical Stimulation

Brain stimulation has been used to map connections in the brain and to elicit changes in behaviour. Much of the pioneering work on mapping out the primary somatosensory and motor cortex was done by neurosurgeon Wilder Penfield in 1958. His participants were his patients, many of whom required surgery for life threatening conditions such as removal of brain tumours or blood clots. He asked them whether, in the course of surgery, they would mind if he applied a mild stimulating electrode to the surface of their brains. Partly thanks to the brain's lack of pain receptors and resultant insensitivity to pain, brain surgery is sometimes conducted with the patient awake, so Penfield could talk to his patients as he stimulated different parts of their exposed brains. Using this technique, Penfield was the first researcher to discover the amazing topographic representation of body areas in the primary motor and somatosensory cortex.

1.2.4 Neurochemical Manipulations

Neurochemical and immunological methods have been used to identify groups of neurons in the central nervous system that use specific neurotransmitters. The number of neurotransmitters identified continues to increase, and one neuron may express more than one neurotransmitter. The anatomy of major neurotransmitter pathways has been elucidated, and the molecular mechanisms by which some neurotransmitters function is now known in some detail. Drugs given systematically or applied to specific anatomic areas may stimulate or block specific neurotransmitter receptors. There are also drugs that will selectively destroy neurons containing specific neurotransmitters, and genetic methods are available to produce animals that lack specific enzymes. Through PET studies, specific neurotransmitters such as dopamine can be imaged in humans. Using these and other techniques, it is possible to correlate the behavioural effects of pharmacological agents with dysfunction in anatomical areas defined by chemical criteria.

1.2.5 Electrical Recording

We can also learn about brain function by recording its electrical activity. In electroencephalography (EEG) and the closely-related potential (ERP) recording, electrodes are attached to the scalp and the amplified electrical activity detected by them is displayed on chart recorder or computer screen. Surface recording is possible because the electrochemical activity of the brain is conducted passively through the meninges (protective membranes surrounding the brain), and the skull to scalp. The recorded voltages represent the summed activity of millions of neurons in the area of brain closest to the recording electrode so, in order to get an idea about the spatial distribution of activity, several separate channels of EEG corresponding to electrodes in different positions on the head can be recorded simultaneously. This procedure has proved invaluable in the diagnosis of epilepsy and in the identification of sleep-related disorders.

In order to record ERPs a series of stimuli such as tones or light flashes are presented to the participant, and the raw EEG for a precise one or two second period following each stimulus is recorded and fed into a computer where it is summed and averaged. This will be a response (or ‘event-related potential’) in the brain to each separate stimulus but this will be small (millionths of a volt) in comparison with the background EEG (thousandths of a volt). By summing all EEGs together and averaging them, the more-or-less random EEG averages to zero, to leave an ERP that has a characteristic waveform when shown on the computer screen. Various abnormalities in this waveform have been linked to predisposition to alcoholism and schizophrenia. The ERP technique has also been useful as a tool to explore the mechanism of attention.

Recently, a variant ERP known as magnetoencephalography (MEG) has been developed. MEG, which is still in its infancy, requires upward of 60 electrodes to be attached to the participant’s scalp, and takes advantage of the fact that when neurons are active they generate tiny magnetic fields. Event-related fields (ERFs) can be detected by an MEG analyser in much the same way as ERPs, but they provide a more accurate means of identifying the origin of particular signals. MEG can locate the source of maximum magnetic field activity in response to stimuli, and, if required, map these areas three dimensionally and in real time. This technique has been of use in identifying the precise focal origins of epileptic seizures, and, as I hinted as above, it has also been used to map areas of the somatosensory cortex.

Self Assessment Questions

1) What is the contribution/discovery of Penfield?

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2) How will you correlate the behavioural effects of pharmacological agents with dysfunction in anatomical areas ?

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3) Discuss the ERP.

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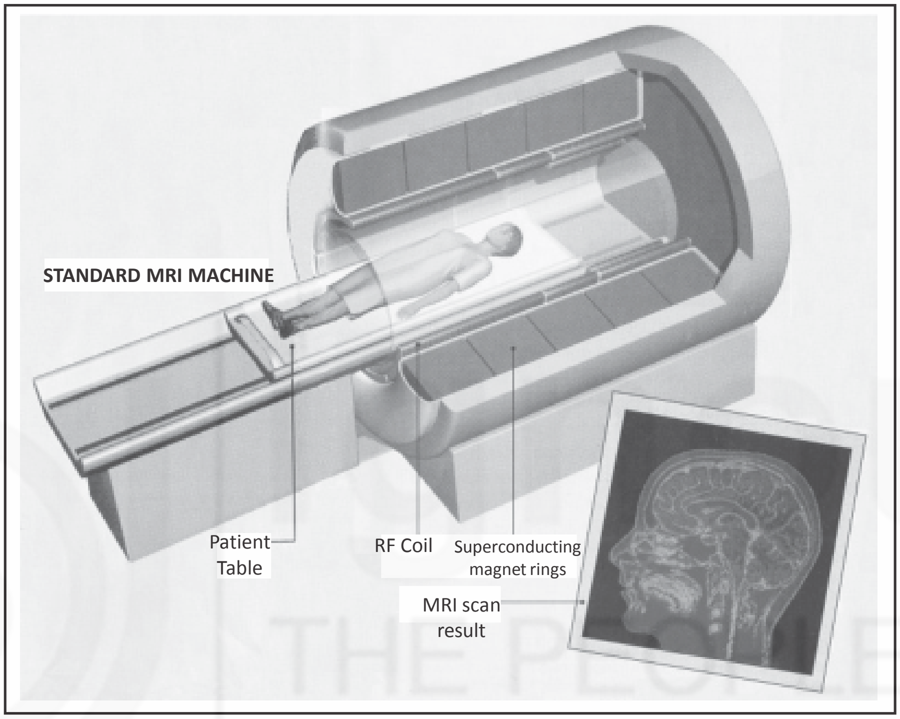
1.2.6 In-Vivo Imaging

The first of the in-vivo imaging techniques, computer tomography (CT) scanning, came on stream in the early 1970s. As technologies developed, and the value of scanning became clearer, it was soon followed by other procedures including PET (positron emission tomography), rCBF (regional cerebral blood flow) and MRI (magnetic resonance imaging). The common feature of these procedures is that researchers can produce images of the structure or functional activity of the brains of living people.

Computerised tomography (CT, but also known as computerised axial tomography, or CAT) provides structural images. To generate brain scans, low levels of X radiation are passed through an individual's head at a series of different angles (through 180 degree). A computer analyses each 'image' and generates what is effectively, a compound X-ray. It can provide a 'slice-by-slice' picture of entire brain, or other parts of the nervous system such as the spinal cord, if required. A drawback of CT scanning is that the contrast between more or dense tissue is not particularly good, although it can be improved by the administration of a dye (injected into the blood stream just before the scan is taken). CT scans cannot measure functional activity but they have provided valuable information about structural changes seen in the brains of some people with dementia, and about the effects and location of brain damage in general.

MRI is a more recent development that was initially introduced as a rival to CT. The technique itself is complex, relying on measurement of the response of hydrogen atoms to radio waves in very strong magnetic field. The MRI scanner measures the tiny magnetic fields that the spinning hydrogen atoms produce, and since the density of hydrogen varies in different types of tissue, the scan data can be computer-processed to generate images. The entire brain can be imaged in successive slices, which can be produced in saggital (side), coronal (front) or horisontal transverse planes. The high resolution of MR images (in comparison with CT images) is a major plus point. A second advantage is that participants are not exposed to radiation sources.



Source: www.mirium-english.org

PET scans provide colour-coded images of person's brain as they undertake different sorts of task, such as reading words, solving mental arithmetic and listening to music. The technique relies on the fact that active neurons use more glucose (fuel), so, shortly before the scan; a small amount of radioactively labelled glucose is given to the participant by injection, some of which will be taken up by active neurons. Several different radioactive markers are now available; some have longer or shorter half-lives; others may have specific targets in the brain. A commonly used isotope is oxygen 15, which has a half-life of about 2 minutes. This means it can only be used for relatively brief scanning periods so repeated administration will be necessary in complex or lengthy studies. As it decays it gives off gamma rays that are detected by the PET scanner, and activity level of different regions of the brain can be assessed.

PET is powerful means of assessing functional brain activity, although it does not directly measures neuronal events. Rather it indicates levels of (or change in) activity under different conditions. To do this 'image subtraction' is often employed, meaning that activity during a control condition is (literally) subtracted by computer from activity during the active test condition, and the remaining PET activity taken as the index of the activation specific to the test condition.

Other in vivo imaging procedures that you may read about include regional cerebral flow (rCBF) and single photon emission computerised tomography (SPECT). Both are variants of PET technology.

In rCBF, the participant inhales a small amount of a radioactive gas such as xenon, which is absorbed into the bloodstream and thus transported around the body. The participant sits in a piece of apparatus that looks a little like dryer seen in hair-saloons! This has a series of sensors that detect the radioactivity from the transported xenon, and because more blood is required by 'active' brain regions, a computer can built up an image of areas of greater (and lesser) activity based on the detection rates.

SPECT differs from PET in certain technical respects, the upshot of which is that the clarity of the scans is less precise because they take longer to generate.

Functional magnetic resonance imaging (fMRI) is a recent development that permits simultaneous measurements of the brain structure and function. The technique relies on the same principles and the hardware as (structural) MRI described earlier. However, it takes advantage of the fact that active neurons require higher levels of oxygenated haemoglobin.

The MRI scanner can be 'tuned' to detect the very subtle disturbances to the magnetic field induced by the different proportions of oxygenated and deoxygenated blood in active and inactive regions. The so-called BOLD (blood oxygenated level dependent) signal can be further improved by the use of more powerful magnets in the scanner, and the spatial resolution (which generates the structural scans) is barely compromised.

Although fMRI has only been available for a few years, it has been adopted enthusiastically by researchers because, like MRI, fMRI scanning does not expose participants to radiation. Among many of its applications, it has recently been used to identify functional changes in frontal brain regions as participants undertake tests of working memory.

Self Assessment Questions

1) Describe Invivo imaging.

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2) What is rCBF?

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3) What is MRI? Describe

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4) What is the function of PET scan?

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5) Differentiate between SPECT and PET.

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1.3 NEUROPSYCHOLOGICAL ASSESSMENT

The neuropsychological approach relies on the use of tests in which poor performance may indicate either focal (localised) or diffuse (widespread) brain damage. A neuropsychological assessment serves several purposes. First, it can give a 'neuro-cognitive' profile of an individual, identifying both strengths and weaknesses. For example, an individual's initial assessment may highlight a specific problem with spatial memory set against a background of above average IQ. Since many tests are 'standardised', a person's performance can be readily compared with scores generated by other age and\or sex matched respondents (a process known as norm referencing). A second advantage is that repeating testing over time can give an insight into changes in cognitive functioning that may relate either to recovery after accident injury or the progression of neurological illness.

Usually, a series of tests (called a test battery) will be given. One widely used battery is Halstead Reitan, which includes measures of verbal and nonverbal intelligence, language, tactile and manipulative skills, auditory sensitivity, and so on (Reitan & Wolfson, 1993). Some of the tests are very straightforward: The tapping test, which assesses motor function, requires nothing more than for the respondent to tap as quickly as possible with each of his\her fingers for a fixed time period on a touch sensitive pad. The Corsi block-tapping test measures spatial memory using a series of strategically placed wooden blocks on a tray. A third test measures memory span for sets of digits. The Luria Nebraska test battery (Luria, 1966) is even more exhaustive procedure taking about two to three hours to administer, including over 250 test items.

Luria-Nebraska Neuropsychological Battery (LNNB)

Source: portal.wpspublish.com

The lengthy administration of test battery may be unsuitable for some individuals (such as demented or psychiatric patients) who simply do not have the requisite attention span. In such instances a customised battery may be more appropriate. Such assessments typically still include some overall index of intelligence: the comprehensively norm-referenced WAIS-R (the revised Wechsler Adult Intelligence Scale; Wechsler, 1981) is commonly used. In addition, specific measures may be adopted to test particular hypotheses about an individual.

For example, if the person has received brain damage to the frontal lobes, tests might be selected that are known to be especially sensitive to frontal damage. The Wisconsin card sort test, the trails test (in which respondents have to join numbered doted on a page according to particular rules) and verbal fluency (generating words starting with particular letter on belonging to a specific category) are cases in point.

Poor performance on one particular test may signal possible localised damage or dysfunction, while poor across the board performance may indicate generalised damage. For example, inability to recognise objects by touch (astereognosis) may be a sign of damage to the parietal lobes.

A poor verbal test score (compared with normal non-verbal test score) may indicate generalised left hemisphere damage.

The WAIS-R is particularly useful in this respect because the eleven components tests segregate into six verbal and five performance sub tests, from which it is possible to derive separate verbal and non verbal estimates of IQ.

The National Adult Reading Test (NART; Nelson, 1982) allows the researcher to obtain an estimate of an individual's IQ prior to damage or disease onset. This may be useful if a neuropsychologist is making an initial assessment of a person who has been brain damaged or ill for some time. The NART comprises 50 words that sound different to their spelling (such as yacht, ache and thought). The respondent reads through the list until they begin to make pronunciation errors. Such words were almost certainly learned before the onset of illness or brain damage, and because this test has been referenced against the WAIS, the cut off point can be used to estimate IQ prior to illness, disease or accident.

Self Assessment Questions

1) Discuss in detail the neuropsychological assessment.

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2) Describe the tests and subtests.

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3) What is the implication of applying these tests.

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1.4 DISSOCIATION AND DOUBLE DISSOCIATIONS

Neuropsychologists typically try to design studies that provide evidence of the differential performance of brain damaged and control subjects because such studies can inform structure function relationships. Consider the following example: The right frontal lobe is thought to be important for memorising designs. To test this hypothesis, a researcher assesses memory for designs (MemD) and memory for words (memW) in group of people with known right frontal damage and a second group of non brain damaged controls.

Table 1.1: Groups and tasks % correct

	GROUP	TASK (% CORRECT)	
		MemD	MemW
A	Single dissociation experiment		
	Right frontal	70%	90%
	Control	90%	95%
B	A double dissociation experiment.		
	Right frontal	66%	93%
	Left frontal	95%	90%
	Control	60%	95%

Hypothetical results from this study are shown in the above table. At first glance they seem to support the hypothesis because the right frontal subjects appear to be selectively impaired on the MemD condition. Many neuropsychological investigations employ this sort of design, and use the evidence of dissociation between groups in the MemD but not the MemW as support for the hypothesis. There is, however design problem with single dissociation studies stemming from the assumption that the two conditions are equally 'sensitive' to differences between the two groups of participants (which may or may not be the case). For example, it could be that right frontal subjects have poor attention, which happens to affect the memD task more than the MemW task.

A much 'stronger' design is one with the potential to show a double dissociation. For example, if we also thought that left frontal damage impaired MemW but not MemD, we could recruit two groups of patients that is (i) one group with left and (ii) the other with right frontal damage, plus (iii) a control group. Then test all participants on both measures. Hypothetical results from this design are shown in the table. They indicate that one group of patients is good at one test but not the other, and the reverse pattern is true for the second group of patients. In other words, we have evidence of a double dissociation, which suggests to neuropsychologists that the two tasks involve non overlapping component operations that may be anatomically separable too.

1.5 IN VIVO IMAGING IN PSYCHIATRY

To illustrate the ingenious applications to which in vivo imaging can be put, consider the use of PET in the study of hallucinations by Frith and Colleagues in London, and a similar application of fMRI by woodruff's group. Silbersweig and Colleagues used PET to measure brain activity in a group of mentally ill patients who were experiencing hallucinations at the time of scanning. Preliminary results indicated that auditory hallucinations were linked to cortical activation in the left temporal lobe and parts of the left orbital region of the frontal lobe.

Woodruff et al. (1997) examined seven schizophrenic subjects on two occasions. First, during a period of severe ongoing auditory hallucinations and secondly after these had diminished. External speech was found to activate the temporal cortex significantly more powerfully and extensively in the hallucinations present conditions. The greatest difference was found in the right mid temporal gyrus (MTG). This finding suggests that auditory hallucinations compete with external stimulation for temporal cortex processing capacity.

A recent update of Woodruff's study has been reported by Shergill et al. (2000). The researchers recorded fMRI activity in six regularly hallucinating schizophrenic patients. Approximately every 60 seconds respondents had to indicate whether (or not) they had 'experienced' an auditory hallucination during the last time epoch.

In comparison with non-hallucinating epochs, the presence of hallucinations was associated with widespread activation, which was especially pronounced in bilateral inferior frontal and temporal regions, the left hippocampus and adjacent cortex (para-hippocampal gyrus). Although it is still too early to say precisely where, or why hallucinations form, the use of 'in vivo' imaging shows beyond doubt that the experience of hallucinations is related to changes in activity in various regions of cortex.

1.6 LET US SUM UP

Researchers interested in understanding brain function and its relationship to psychological function can now draw on a wide range of investigative techniques. In this unit, you were introduced to lesion and ablation, electrical stimulation and recording, and the structural and functional in vivo imaging procedures. Consideration is also given to the burgeoning use of neuropsychological testing. Researchers have moved rapidly from an era in which analysis of brain structure could usually only be assessed after the person has died to an era in which the various in-vivo imaging techniques are quickly becoming almost common place as a particularly promising research area. Although we have not yet reached the point where invivo imaging can be used to establish what people are thinking, the applications of PET and fMRI to psychiatry are bringing us close to identifying brain areas that may contribute to the types of disordered thinking so characteristic of mental illness.

1.7 UNIT END QUESTIONS

1) Describe major methods of study in neuropsychology.
2) What is the difference between MRI and fMRI?
3) What do you understand by neuropsychological assessment as a method?
4) Describe in detail, the early methods of neuropsychology.
5) What is meant by dissociation and double dissociation? Describe
6) What are main in-vivo imaging methods in neuropsychology?

1.8 SUGGESTED READINGS

Cullum.C.M (1998). *Neuropsychological Assessment of Adults*. Bellack A.S, Herson M, Reynolds. C.R (eds) *Comprehensive Clinical Psychology*: 4 328-333.

Davis, K. (1983). Potential neurochemical and neuroendocrine validators of assessment instruments. Paper presented at conference on clinical memory Assessment of older adults, Wakefield, M.A.

Filskov, S. B., & Bold, T. J (1981). *Handbook of Clinical Neuropsychology*. New York: Wiley-Interscience.

Kapur. M, Hinsave. U, Oommen A (2002). *Psychological Assessment of Children in the Clinical Setting*. NIMHANS publications Bangalore

Kolb B, Whishaw I.Q (1990). *Fundamentals of Human Neuropsychology* (3rd ed). W.H Freeman and company New York.

Lezak, M.(1976). *Neuropsychological Assessment* (Ist ed.). New York: Oxford university press.

Walsh K.(1994). Neuropsychology: *A Clinical Approach* (3rd ed). B.I Churchill Livingstone Pvt. Ltd. New Delhi.

UNIT 2 NEUROPSYCHOLOGICAL ASSESSMENT AND SCREENING

Structure

2.0 Introduction

2.1 Objectives

2.2 Neuropsychological Assessment of Infants and Young Children

2.2.1 Localisation of Functions in the Brain

2.2.2 Categorisation of Neuropsychological Assessment

2.2.3 Categorisation of Major Brain Functions

2.2.4 Approaches to Neuropsychological Assessment

2.2.5 Functional Domains in Children

2.2.6 Developmental Concepts Unique to Infants and Young Children

2.2.7 Nonhuman Experimental Studies

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2.3.1 Clinical Studies

2.3.2 Nature and Degree of Abnormality

2.3.3 Social Attention and Environmental Influences

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2.6 Validity and Reliability

2.7 Neuropsychological Screening of Adults

2.8 Let Us Sum Up

2.9 Unit End Questions

2.10 Suggested Readings

2.0 INTRODUCTION

The clinical practice of neuropsychology involves an integration of knowledge bases from the disciplines of psychology, psychometrics, neuroscience, clinical neuropsychology and psychiatry. In this unit you will be presented with an introduction to how neuropsychologists assess brain function. First we will look at the area from a developmental perspective illustrating how neuropsychologists evaluate young preschool children, older children, youngster adults, and elderly adults. The brain is an evolving organ and functions very differently at different stages of life span. Assessment issue are different during these stages, as are the prevalence and characteristics of the various brain disorders. Obviously, the behavioural evaluation of a 3-years-old child cannot use the same materials and methods as the evaluation of a 40-year-old adult. It has therefore has been necessary to develop different tests and methods for neuropsychological evaluations across the life span, and consequently we have now tests and test batteries specifically designed for infants and young children, older children, adults, and the elderly.

Neuropsychological assessment provides information concerning the status of brain function across the life span. It does so primarily by testing those functions and abilities may be evaluated in a comprehensive, specialised, or combined manner. The areas typically assessed in a neuropsychological evaluation include the ability to reason and conceptualise; to remember; to speak and understand spoken and written language; to attend to and perceive the environment accurately through the senses of vision, hearing, touch, and smell; to construct objects in two- or three-dimensional space; and to perform skilled, purposive movements. Clinical neuropsychology in particular has the task of identifying in individual patients the level and pattern of disruption of these abilities as a result of brain dysfunction.

The present unit starts with Neuropsychological Assessment of Infants and Young Children followed by the developmental Concepts Unique to Infants and Young Children. Then we deal with the various experimental studies especially the non human ones. We then discuss the advances that have taken place in the neurodiagnostic techniques and how one could accurately measure and assess the neurological damages in the brain. These are substantiated by clinical studies. This is followed by social attention and environmental influences. We then take up the clinical evaluation of infants and young children. This is followed by neuropsychological assessment of older children, the general principles associated with the same, the methods of assessment etc. Finally we take up neuropsychological assessment of adults and discuss the validity and reliability associated with these assessments. Then we describe the neuropsychological screening.

2.1 OBJECTIVES

After completing this unit, you will be able to:

- Define and describe neuropsychological assessment;
- Elucidate the neuropsychological methodology for assessing infants and young children;
- Explain the developmental concepts unique to infants and young children;
- Describe the advances in the neurodiagnostic techniques;
- Delineate the methods for neuropsychological assessment of older children;
- Describe the neuropsychological assessment with adults;
- Analyse the validity and reliability of these tests; and
- Explain Neuropsychological Screening.

2.2 NEUROPSYCHOLOGICAL ASSESSMENT OF INFANTS AND YOUNG CHILDREN

Neuropsychological assessment is the clinical practise of using tests and other behavioural evaluation instruments to determine the status of brain function. It is based on the assumption that the brain is the organ of behaviour, and so the status of the brain can be evaluated through the use of behavioural measures. Over many years of research, particular procedures have been found to have particular sensitivities to alteration on brain function, and these procedures have come to be known as psychological tests.

A neuropsychological test therefore is defined as behavioural procedure that is particularly sensitive to the condition of the brain. While any purposeful behaviour involves the brain, neuropsychological tests provide the clearest demonstrations of behaviour that indicate that the brain is functioning normally, or that something is wrong with it. There are many factors that can produce brain dysfunction including genetic endowment, developmental abnormalities, physical injury, exposure to toxic or infectious agents, systemic diseases (e.g. vascular disorders, cancer, metabolic disorders), and progressive disorders that specifically affect central nervous system tissue, such as multiple sclerosis.

2.2.1 Localisation of Functions in the Brain

Neuropsychologists and neurologists studying behaviour have been greatly concerned with localisation of function in the brain. The first great discovery of neuropsychology is thought to be Paul Broca's identification of the relationship between language and left hemisphere of brain. Neuropsychological tests are often used to assist in determining localisation of brain damage, and that practise continues even after the development of the relatively new neuroimaging procedures. However, contemporary views of brain function tend to conceptualise localisation in interaction with a number of developmental and pathological considerations. Localisation of function in the brain of an infant is not the same as it is in adult. Localisation in women is not same as it is in men. Furthermore, the neurobehavioural characteristics of disease or destruction of the very same brain regions may vary substantially with the particular pathological process. We have therefore chosen to introduce neuropsychological assessment on the basis of these different processes, with localisation treated within the contexts of those processes.

2.2.2 Categorisation of Neuropsychological Assessment

One can divide neuropsychological assessment into two areas:

i) comprehensive and

ii) specialised assessment.

Comprehensive assessment generally employs standard test batteries, notably the Halstesd Reitan or Luria Nebraska batteries. A comprehensive assessment typically evaluates all of the areas evaluated by specialised assessments, or may do only specialised assessments in response to the referral question. This matter is controversial in the field, but the more productive approach is probably highly related to the setting in which one works, and the nature of its patient population.

2.2.3 Categorisation of Major Brain Functions

As a framework, the major brain functions typically divided into modalities and domains. The major modalities are motor function and the senses of vision, hearing, touch, and rarely, smell. The major domains are the cognitive abilities and include abstract reasoning and intellectual function, memory, language, spatial abilities and motor skills. We will also discuss how assessments are conducted by behavioural neurologists. Behavioural neurologists typically do specialised evaluations based on their initial examination and review of the history, but they use a somewhat different conceptual framework and methodological approach from clinical neuropsychologists, providing an interesting and important contrast.

Domain	**Syndrome**
Abstraction\intellectual function	Dementia
Memory	Amnesia
Language	Aphasia, Alexia, Acalculia
Spatial abilities	Constructional apraxia, visuospatial defects
Motor skills	Apraxia

The aim of specialised assessment is often to identify a syndrome and specify its probable basis in abnormal brain function. The basic purpose for identifying a syndrome is to characterise the deficit and make a formulation concerning possible neurological correlates. For example, in the case of memory, the diagnostic question often involves whether the patient has amnesia, and if so, what type. Thus, there is an association between the domain and a class of abnormal syndromes, illustrated in the table above. This table is gross oversimplification, but is only meant to suggest the association of certain cognitive domains to different non behavioural syndromes.

The neuropsychology of the various modalities and domains involves applications from the knowledge base concerning the domain or modality itself, its neurobiological substratum, and the functional changes that take place as a result of brain damage or injury. Thus, neuropsychology of memory involves application of the experimental psychology of memory. Also, our knowledge of memory is represented in the brain, and the changes that take place in the memory as a consequence of brain damage. These changes are characterised as the amnesic syndromes. Similarly, disorders of speech, language, reading, writing, and mathematical abilities are understood in terms of linguistics and the psychology of language and of what is known about the relationship between the brain and language. Lacking definitive knowledge of how the brain really works, neuropsychologists have constructed an elegant conceptual model of how the brain processes information within and across modalities and domains.

2.2.4 Approaches to Neuropsychological Assessment

Probably the most useful model of neuropsychological interpretation is described in Reitan and Wolfson’s (1993) four approaches to assessment which are given below:

i) level of performance,

ii) pathognomonic signs,

iii) pattern of performance, and

iv) comparison of the left and right sides of the body.

The last approach can also include comparisons between the anterior and posterior parts of the brain, or between cortical and sub cortical structures, but our knowledge base remains strongest for right versus left comparisons.

A comprehensive assessment ideally uses all four approaches. Some forms of specialised assessment rely heavily on pathognomic signs, behaviours that are almost exclusively seen in brain damaged patient and that have some specific, often localising significance. Other forms of specialised evaluations rarely use the general level of performance approach, which is generally reflected in some kind of summary index of impairment based on tests of varying domains and modalities. While all these approaches are important, relative emphases on any of them may relate to setting in which one practises and the clinical characteristics of the clientele in that practice. In the light of contemporary patterns of health care provision, the distinction between being in a primary care, “first-line” setting and a specialised tertiary care practise is very important.

2.2.5 Functional Domains in Children

There are three functional domains of particular interest in this age range:

- attention,
- memory, and
- executive function.

The goal of neuropsychologist is to challenge clinicians to develop concepts about brain behaviour relationships in this group, and to provide a basis from which the clinicians could generate hypotheses in their own clinical evaluations and effect appropriate interventions. The objective is not to provide an exhaustive listing of tests and measures, but instead to consider the functional domains for which a judicious selection of tests can be made.

Whether one should refer to “neuropsychology” of infants and young children is perhaps controversial. The questions that need to be answered include the following:

- How does one reliably assess and evaluate brain behaviour relationships in the newborn, neonate or very young child?
- If this is even possible, how practical would such evaluation be?
- Is the methodology used by paediatric neuropsychologists applicable to the youngest ages? and
- If so, with what degree of reliability or validity?
- Which variables are traceable to the very youngest ages?
- Which will result in long lasting (i.e., adult) cognitive compromise?
- What interventions can be applied in these very early years to lessen the impact of early insults?

Since these and other related questions remain largely unanswered, many practitioners are naturally reluctant to endorse terminology that may be misleading or inappropriate.

What is *not* controversial is the fact that paediatric and psychological specialists frequently encounter infants and young children whose developmental delays or cognitive deficiencies are attributable to underlying neurodevelopmental abnormality or to documented neurological disease or disorder that occurred in the earliest stages of growth and development. The increased recognition that these etiological factors exist and have an important influence on the child's later cognitive outcome is a result of a number of converging developments.

These include:

1) a better definition of the unique developmental concepts that are applicable to infants and young children,
2) finely detailed analyses of normal and abnormal brain development from experimental studies of nonhumans,
3) major advances in neurodiagnostic techniques,
4) an expanding clinical and research literature on human developmental studies, and
5) an increase in societal attention to the needs of infants and young children, in part emphasised by preschool screening and intervention programs.

2.2.6 Developmental Concepts Unique to Infants and Young Children

The cognitive and social emotional development of infants and very young children has unique features. This age range is associated with less differentiation of some functional areas, the presence of early developmental constructs that are less dominant than in older children, and an increased variability of performance compared to older children. Understanding the critical precursor behaviours during these early years allows the neuropsychologist to generate early predictions about later patterns of strength and weakness, for example, in attention, memory, and executive function domains.

Two concepts that are especially critical to understanding brain development in the very young child are:

- symbolic representation and
- imitation in learning.

Knowing these concepts helps us better understand developmental progress and provide a stronger foundation for understanding cognitive and social development. The social environment also has a special role.

Symbolic representation is the representation of both the external and internal world through symbols and has been discussed in relation to important neuropsychological domains, including executive self-regulation and memory.

The concept of *imitation* in the learning process is also a key developmental concept for infants and young children.

Although the social learning theory has long posited that behaviour is an important element in learning, imitation behaviours etc., they are significantly more pronounced and overt in infants and young children. From a neuropsychological perspective, imitation can be an adaptive form of stimulus bound behaviour, which can be considered pathological at older ages.

2.2.7 Nonhuman Experimental Studies

How normal brain development proceeds is essential knowledge for professionals concerned with understanding infant and young child development. Laboratory studies of nonhumans have contributed substantially to our knowledge about normal and abnormal human brain function. Our understanding of the abnormalities that can occur and that may explain and individual's neurobehavioural dysfunctioning has broadened considerably as a result of these studies.

Self Assessment Questions

1) Discuss the neuropsychological assessment of infants and young children.

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2) Delineate the localisation functions in the brain.

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3) What are the categories of neuropsychological assessment and main brain functions.

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4) Discuss the approaches to neuropsychological assessment.

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5) What are the developmental concepts that are unique to infants and young children?

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2.3 ADVANCES IN NEURODIAGNOSTIC TECHNIQUES

Major scientific and technology advances have made it easier to correlate behaviours suspected as having a neurological basis with actual neuroanatomical (structural) and neurophysiological abnormalities. Many of these advances have been applied to the study of infants and young children, such as techniques to examine the foetus in utero and to monitor development in the perinatal period. For example, real time ultrasonography is useful for determining the presence, timing, and course of intraventicular behaviour in a preterm infant.

Some techniques visualise anatomy, provide objective confirmation of structural abnormality. These include neuroradiological imaging procedures such as computed tomography (CT) and magnetic resonance imaging (MRI). However, gross brain structure may appear normal despite functional behavioural abnormality that suggests to the clinician that there is an underlying neurological etiology. This may be particularly perplexing when a formal neuropsychological evaluation has documented dysfunction.

2.3.1 Clinical Studies

The opportunity to investigate the conditions that influence stages of growth and development from gestation to infancy to early childhood and their impact on eventual neurobehavioural outcome is especially challenging. It is precisely these investigations that are being addressed now by researchers in neuroscience, psychology, and related fields concerned with neurodevelopment. Empirical data have only recently been more widely collected to verify or negate claims of clear casual connections between certain medical conditions and later cognitive functioning.

The paediatric clinical literature has expanded greatly in its coverage of the wide variety of medical circumstances that can negatively affect the developing human brain. As a consequence, populations of children who are at risk for cognitive impairment have been identified, and formal investigations have provided insight into the influence of the many factors that influence the success or failure of cognitive development. That infants at risk are more likely to have learning difficulties than infants not at risk is well established.

The link between structural abnormality and unique behavioural aberration has become clearer as technological advances have allowed for even more finely tuned discrimination than that obtained from study of gross structural anatomy. This was made dramatically apparent by several early neuropathological studies of dyslexia. The classic diagnosis of dyslexia was based on psychoeducational features until advances in neurological diagnosis enabled identification of associated neuropathological mechanisms and anatomic abnormalities.

2.3.2 Nature and Degree of Abnormality

The nature and degree of abnormality will effect normal neural growth and maturational outcome. For example, in an adult damage to the developing brain may be the result of toxic exposure (e.g., alcohol abuse, lead exposure, and maternal drug use), nutritional deprivation, trauma, or environmental circumstances. Early birth and very low birth weight have received much attention and are often accompanied by a number of neonatal complications that may contribute to eventual cognitive compromise, including intraventricular behavioural (IVH), hyaline membrane disease and associated respiratory distress syndrome, hyperbilirubinemia, asphyxia, bronchopulmonary dysplasia, and apnea. The effects of prenatal or perinatal oxygen deprivation are perhaps most commonly cited as a main pathogenetic factor in neurodevelopmental problems.

Temporal Factors: Given the on going schedule of postnatal neurodevelopment, the age of the child at the time of exposure and the behaviour can have a significant effect on the type of neuropsychological damage and dysfunction. Given the ongoing development of brain connectivity and the progressively greater reliance on the more complex cognitive and behavioural functions during school age, adolescence, and young adulthood, the actual damage or dysfunction resulting from brain injury or disorder may not be fully realised until years after the child's exposure.

Plasticity: The notion of brain plasticity has been of interest to researchers and clinicians alike for decades. The outcome of injury is the result of the underlying plastic potential of the brain and varies with the neurodevelopmental stage at the time of insult, the type of lesion, the severity of the lesion, the behaviour being measured, the range of the scores of the individual at assessment, and other factors. It has been proposed that the brain modifies itself through change at the synapse, that is, by alterations in the axon terminal, spine density, dendritic behavioural, or structure of the existing synapse. The neural process occurring in the recovery from brain injury are thought to be similar to the processes involved in learning from experience, which result in the production of new synapse, the loss of old synapses (pruning), and the modification of existing synapses. Adaptation in response to insult is also an impressive finding.

Early therapeutic Intervention: Since outcome may be ameliorated by well timed and appropriate treatment, the prevailing belief is that dysfunction should be identified early to allow for optimal outcome. There is great interest in examining which early intervention strategies will result in a significantly improved neurobehavioural outcome.

2.3.3 Social Attention and Environmental Influences

The importance of social environment and early experiences in neurodevelopment is increasingly recognised. Due to developmentally adaptive aspects of imitation, that is behaviour boundendness, infants and young children rely on the environmental context for the appropriate acquisition of knowledge and cognitive stimulation. Children's cognitive function may be more strongly influenced by social and environmental factors than that of adults. The brain may be thought of as a "dependant variable" that is shaped in part by the facilitative stimulation that is experienced. Further, whether a young child will respond and demonstrate knowledge acquisition is often dependent on "optimal" environmental conditions. Thus, this context must be taken into account when considering a child's demonstrated strengths and weakness and their generalisability from the evaluation setting to the real world. Assessment of the sequel of brain insult may be confounded by these important factors, and consideration of these influences is needed to avoid simplistic hypotheses about brain behaviour functioning.

2.3.4 Clinical Evaluation of Infants and Young Children

Approaches to clinical practice advanced in recent year are mostly directed at older children and adolescents. There has not been a similar focus on the infant and young child. To date, theoretical models developed for older children and adults have had little impact on clinical practice with young children. The absence of a model of neuropsychological development that spans the entire age range is limiting and in part responsible for the relative lack of attention directed to the very youngest children.

A comprehensive model would

1) provide continuity in understanding developmental progress, or lack thereof, in those disorders that affect neurological development;

2) encourage a broader consideration of function and a more diverse selection of methodologies, that is, not restricting assessment to general cognitive development alone;

3) allow for earlier definition and differentiation of functions during an active stage of developmental gain or delay;

4) encourage early and specific recommendations that can directly influence the developmental course and reduce the impact of and obstacle to development;

5) provide a basis for measurement of the effectiveness of treatment recommendations;

6) encourage the elaboration of existing knowledge about the natural history of normal and abnormal brain behaviour relationships in the early years; and

7) stimulate the development of innovations and techniques that can lead to better science and practice. For example, to evaluate etiological factors more precisely or to increase understanding of later concomitants of early injury or illness. The power that such a model would offer explains why the focus should be increasingly on the very youngest children and on a comprehensive understanding of the full life span.

In the evaluation of infants and young children, all sources of reliable and valid data available to the paediatric neuropsychologist must be used, including the history, direct and indirect observations of behaviour, and performance on selected tests. Although the evaluation of an individual at any age should never rest solely upon test performance, work with infants and young children demands an even greater degree the use of multiple sources of data. Some of the sources of data are given below.

a) **Child History Questionnaire:** A clinical investigation begins with a careful history taking. One must consider the many factors that may alone, or in combination, affect behaviour and outcome. A thorough history taking includes an exploration of events that precede birth, factor that surrounded the time of birth, and developmentally relevant issues that extend from delivery up to the present time. An outline of the types of questions that are generally asked in clinical history interview is presented in the box below.

Sample Outline of Child History Questionnaire

Basic identifying data:

- Child's name
- Date of birth
- Date of evaluation
- Person referring for evaluation
- Person filling out the questionnaire
- Child's behavioural problems for which being referred to

Referral information:

- Reason for referral
- Circumstances/factor judged responsible for this problem
- Child's strength
- Child's weakness
- Do parents agree about the nature and causes of the problem?

Family information:

- Address
- Telephone
- Parents (name, age, education, marital status)
- Child's natural, adopted, or fosters status
- Siblings (name, age)
- Other's living in home
- Approximate family income
- Father's occupation
- Mother's occupation
- Significant family or marital conflict

Pregnancy, birth history, neonatal period:

- Age of mother at delivery
- Health problems of mother during pregnancy
- Length of labour and any complications
- Delivery type (vaginal, Caesarean) and any complications
- Term length (full, premature, number of week's gestation)
- Birth weight and height
- Condition of baby (e.g., baby breathed spontaneously, Apgar scores)
- Type of nursery (e.g. normal new-born, paediatric intensive care)
- Days until discharge from the hospital after birth
- Medical problems after discharge (e.g., jaundice, fever)
- Any problems in the first few months

Developmental history

- Motor development
- Age at first accomplishment (e.g., sat alone, crawled, walked alone)
- Was child slow to develop motor skills or awkward compared to sibling/ friends (e.g., running skipping, climbing, biking, playing ball)?
- Handedness (right, left, both); history of left – handedness
- Need for physical therapy or occupational therapy

Language

- Age at first accomplishment (e.g., first word, put two or three words together)
- Speech/language delays/problems (e.g., stutters, difficult to understand, poor comprehension)
- Oral motor problems (e.g., the alphabet, name colours, count)
- Language spoken in home
- Provision of speech/language therapy

Toileting

- Age when toilet trained
- Associated problems (e.g., bedwetting, urine accidents, soiling)

Social behaviour

- Relationships with other children; with adults
- Ability to begin and maintain friendships
- Understanding of gestures, nonverbal stimuli, social cues
- Appropriateness of sense of humour

Medical history

- Results of vision check
- Results of hearing check
- Serious illness/injuries/hospitalisations/surgeries
- Head injuries (e.g., date, type, loss of consciousness?, changes in behaviour)
- Current medications and reasons

Personal history

- Febrile seizures
- Epilepsy

- Lead poisoning/toxic ingestion
- Asthma or allergies
- Loss of consciousness
- Abdominal pains/vomiting, and when they occur
- Headaches, and when they occur
- Frequent ear infections
- Sleep difficulties
- Eating difficulties
- Tics/twitching
- Repetitive/stereotyped movements
- Impulsivity
- Temper tantrums
- Nail biting
- Clumsiness
- Head banging
- Self-injuries behaviour

Family history
Learning difficulty
Neurological illness
Seizures
Psychiatric disorder
Instances of similar problem in any family member

Education history
Current school and address
Grade and type of placement (e.g., regular, resource, special education, emotionally disturbed)
Grades skipped or repeated
Teachers reported problems areas (e.g., reading, spelling, arithmetic, writing, attention/concentration
Problems with hyperactivity or inattention in the classroom

Prior psychological history
Previous contact with a social agency, psychologist, clinic, or private agency

Although it was once thought that the capacities of the very young child were quite limited, it is now well understood that the infant has cognitive abilities that can be demonstrated with appropriate techniques. An examination of the literature on three domains, namely attention, memory, and executive function, provides data that support this idea.

b) **Psychological tests**

Attention

The construct of attention has been found to comprise several interrelated elements that the paediatric neuropsychologist can consider in the clinical evaluation. For example, attention may be conceptualised as involving more specific components, such as the ability to initiate, sustain, inhabit, and shift, or the ability to focus / execute (scan the stimulus field and respond), sustain (be vigilant, attend for a time interval), encode (sequential registration, recall and mental manipulation of information), and shift. The ability to focus and sustain attention is especially relevant to the study of attention in the infant and the preschool child. The shift dimension of attention is related to executive function.

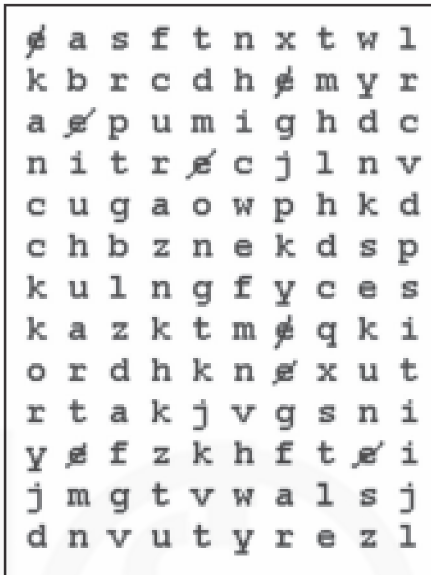

Fig.2.1: Letter cancellation test

Fig.2.2: Stoop test

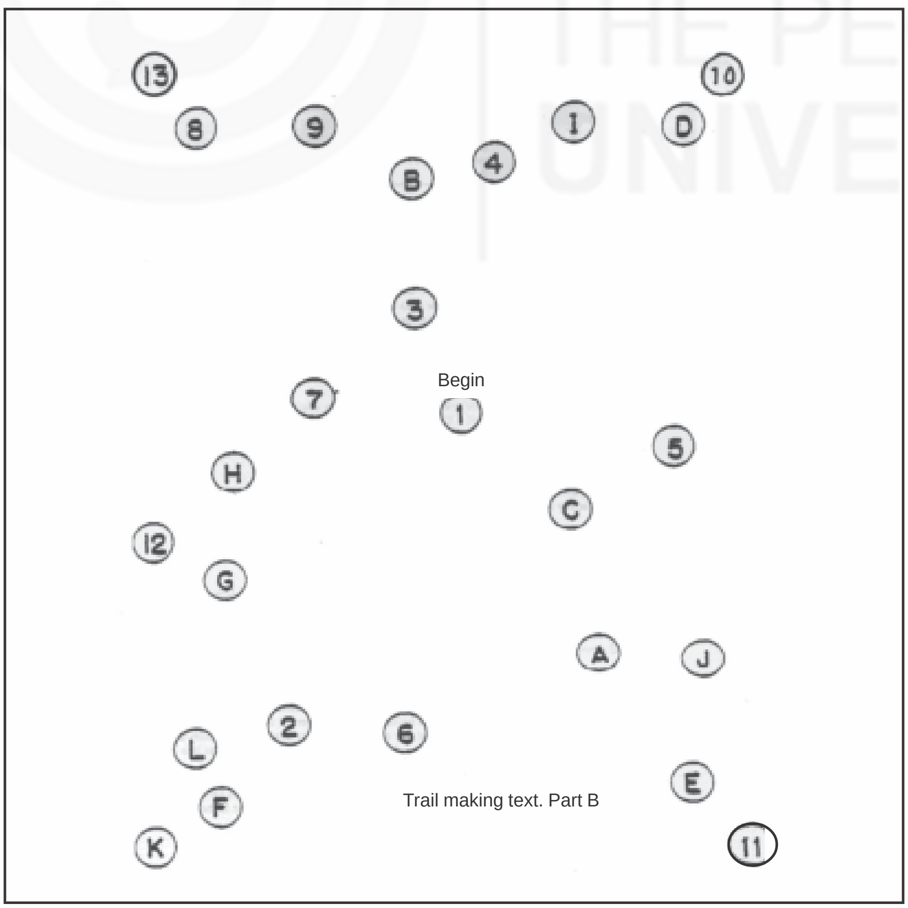

Fig.2.3: Trail making test

Memory: The acquisition, reaction, and retrieval of new information is a domain of much importance in infants and young children at risk, for neuropsychological dysfunction (e.g., those with acquired brain injuries, neurotoxic exposure, developmental language disorders, hydrocephalus, or a history of hypoxia).

Memory research with young children has provided some examples of functioning analogous to that described for older children and adults and has resulted in a new appreciation for the capacity of the very young child. For example, in their first year, children can retain information about object location.

Event recall has been shown to be possible in the months following the event. Accurate long term recall over a 1 week delay was found in 13 month olds. Children ages 21 to 29 months were tested for information presented when they were 8 months younger, and novel events were recalled over the long delay, even by the youngest children. Children aged 3 years were found to have well organised representation of familiar events. Young children can recall events from when they were 2 years old although adults cannot remember events occurring before 3 or 4 years of age. Further, the complexity of children's event representation increases with age. It is suggested that what determines event recall is what the child is asked to remember, the number of exposures to the event, and the availability of cues and reminders of the event, much as in the older child and adult.

Specifically, tasks of infant habituation/recognition memory, immediate memory span, and verbal learning/memory list, story passage, names) are available (see Table below).

Table 2.1: Assessment Tools: Memory

Test name	**Age**	**Type of measure**
Bayley scales of infant Development – Recognition & memory	Habituation 1-3 months	Novelty preference stimuli (Selected tests)
DAS Number Recall	Immediate Memory Span 2 years	Digit Span (forward)
SB4 Sentence Memory	2 years	Sentence Span
DAS Picture Recognition	2½ years	Picture (object) recognition of increasing number of stimuli
MSCA Picture Memory	5 years	Picture name recall, six –item card
K-ABC Spatial memory	2 years	Recall of picture location of on matrix; simultaneous presentation of x-y items
SB4 Bead Memory	Active learning and Memory task	Memory for picture of beads, of increasing quantity
DAS Object Recall	4 years	Three-trial verbal recall of 20 picture names; immediate learning trial; delayed recall
MSCA Story Memory	$2^{1/2}$ years	Immediate verbal recall of story passage

Executive Functions: Executive functions are those involved in the planning, organisation, regulation and monitoring of goal directed behaviour. In the past, the assessment of those skills and related abilities, such as problem solving and abstract reasoning, has often been conducted informally, often by examining the quality of performance on tests falling within other measurement domains. Recently however, a wider variety of tests has been employed to assess executive functions, including measures such as Wisconsin Card Sorting Test, the Tower of London, and the Children's Category Test. Executive Function would appear to play a critical role in determining a child's adaptive functioning.

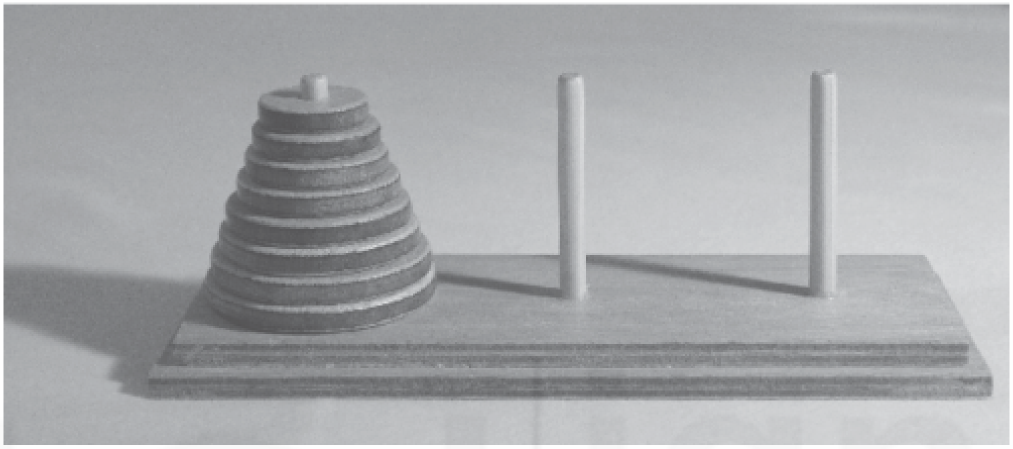

Fig.2.4: Tower of London

Self Assessment Questions

1) Discuss the advances in neurodiagnostic techniques.

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2) How are clinical studies considered important in neurodiagnostics?

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3) Discuss the nature and degree of abnormality that are encountered during neuropsychological testing.

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4) How are social attention assessed? How do environmental influences affect the neuropsychological assessment?

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5) Discuss all aspects related to clinical evaluation of infants and children.

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2.4 NEUROPSYCHOLOGICAL ASSESSMNET OF OLDER CHILDREN

In the recent years, the field of child neuropsychology has undergone tremendous growth. There has been a burgeoning interest in the neuropsychological assessment of children with disorders of the central nervous system, systematic medical illnesses, neurodevelopmental and related learning disabilities, and psychiatric disorders. Recent surveys indicate that a significant proportion of neuropsychologists now devote most of their clinical services to children and adolescents.

We will discuss a set of general principles that help to conceptualise neuropsychological assessment. The principles acknowledge that child development is driven by a complex interplay of multiple forces, including, but not limited to, brain function. We then describe more concretely the methods and procedures of neuropsychological assessment. We briefly examine some of the recent clinical and scientific applications of child neuropsychological assessment.

2.4.1 General Principles

The neuropsychological assessment of school age of children and adolescents is not primarily a technological enterprise. That is, it is not defined on the basis of specific interview procedures or test instruments because the latter methods are subject to substantial change and refinement over time. Instead, child neuropsychological assessment is based on a conceptual foundation and knowledge base, the application of which is grounded in an interest in understanding brain-behaviour relationships for the purpose of enhancing children's adaptation. Thus, recent models of child neuropsychological assessment, whether characterised as behavioural or systemic neurodevelopmental, have shared several general principles. These include the following.

1) **Principle of Adaptation**

The first principle is that the central goal of assessment is to promote the adaptation of the child, rather than simply to document the presence or location of brain damage or dysfunction. Adaptation can be understood as resulting from the interactions between children and the contexts within which they develop, or as reflecting the functional relationship between children and their environments.

Failures in adaptation, such as poor school performance or unsatisfactory peer relationships are usually problems that bring children to the attention of clinical neuropsychologist. Neuropsychological assessment is useful largely to the extent that it helps explain those failures and facilitates more successful future outcomes. Indeed, the broader goal of assessment extends beyond the facilitation of learning and behaviour in the immediate context of school and home to include the promotion of long term adaptation to the demand of adult life.

2) **Principle of Brain and Behaviour**

A second principle is that insight into children's adaptation can be gained through an analysis of brain behaviour relationships. Advances in neurosciences over the past two decades have begun to yield a clearer appreciation of the relationship between the brain and behaviour. Old notions of localisation have been replaced by more dynamic models involving the interaction of multiple brain regions. The assessment of brain behaviour relationships in children is quite complex and clearly depends upon factors such as the age of the child, the specific cognitive skills and behaviours assessed, the type of disorder under consideration and the nature of the documented or hypothesized brain impairment.

3) **Principle of Context**

A third principle guiding the neuropsychological assessment of children is that environment contexts help to constraint and determine behaviour. Thus, the ability of neuropsychological assessment to determine whether brain impairment contributes to failures of adaptation or of adaption rests on a careful examination of the influences of environmental or contextual variables that also influence behaviour. The reasons for examining these influences are to rule out alternative explanations for a child's adaptive difficulties and to assess the nature of the child's environment and as the situational demands being placed on the child. In this regard, neuropsychological assessment is designed not so much to measure a child's specific cognitive skills, but to determine how a child applies thesse skills in the environment.

4) **Principle of Development**

The final guiding principle is that assessment involves the measure of change, or development, across multiple levels of analysis. Developmental neuroscience has highlighted the multiple processes that characterise brain development. For example the cell differentiation and migration, the dendritic behavioural and pruning as well as the timing of these processes. Although less research has been conducted concerning developmental changes in children's environment, there is nevertheless a natural history of environment that is characteristic of most children in a culture. Behavioural development in turn can be conceptualised as the result of the joint interplay of these biological and environmental time tables and is characterised by the emergence, stabilisation and maintenance of new scales as well as the loss of earlier ones. The neuropsychological assessment therefore requires appreciation for the developmental changes that occur in brain, behaviour and context because the interplay between these levels of analysis determines adaptation outcomes.

Self Assessment Questions

1) Discuss the neuropsychological assessment of older children. What are all the aspects to be considered?

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2) Elucidate the general principles of neuropsychological assessment of older children.

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2.4.2 Methods of Assessment

The four general principles outlined above, that is, adaptation, brain and behaviour, context, and development serve as the foundation for the specific methods of assessment used by child neuropsychologists.

Although neuropsychological assessment is equated with the administration of a battery of tests designed to assess various cognitive skills, the most typical combination of methods involves the collection of historical information, behavioural observations and psychological investigations which together permit a border and a detailed characterisation of neuropsychological functioning.

1) **History taking**

The careful collection of historical information is accomplished by a combination of questionnaires and parent interviews which are essential in neuropsychological assessments. Thorough history not only clarifies the nature of a child's presenting problems but also assists in determination of its source. A careful history can help to determine a child's present problems have a neuropsychological basis or may be related primarily to psychological or environmental factors.

a) **Birth and Developmental History:** Collection of information regarding a child's early development usually begins with the mother's pregnancy, labour and delivery, and extends to the acquisitions of developmental milestones. Information about such issues and events is useful in identifying early risk factors, as well as these are early indicators of anomalous development. The presence of early risk factors or developmental anomalies makes a stronger case for a constitutional or neuropsychological basis for a child's failures in adaptation.

The early development of the child also warrants study, including interactions with parents, socialisation with peers, gross and motor skills, receptive and expressive language skills, constructional skills (i.e., block/puzzle/picture play), attention disabilities, feeding and sleeping patterns and development of hand preference/ delays or anomalies in these domains are often early precursors of later learning problems.

b) **Medical History:** A child's medical history often contains predictors of neuropsychological functioning. Perhaps the most obvious predictor is the presence of some documented brain abnormality or insult. For instance, closed head injuries during childhood can clearly compromise cognitive and behavioural function. Similarly seizure disorders are frequently associated with neuropsychological deficits.

c) **Family and Social History:** Recent studies suggest that genetic variation plays an important role in etiology of learning problems. Hence, the collection of information regarding a family's history of academic difficulties is often relevant in establishing a possible familial basis for learning problems. Family History should also be collected regarding psychiatric disturbances, language disorders, and neurological illnesses, each of which can also signal a biological foundation for later neuropsychological deficits.

d) **Educational History:** A complete school history includes information regarding a child's current grade placement, any grade repetitions or specialisation programs, and changes in school placement. Information about school history is usually available from parents. School personnel also can be contacted to obtain additional descriptions of a child's academic and behavioural difficulties at school. The value of school reports is that teachers and other school personnel are aware of the child's ability to meet educational demands and of how the child compares to peers. School reports often corroborate parental information, but can frequently add new or even contradictory impressions.

2) **Behavioural Observations**

Behavioural observations of the child are the second critical source of information available to the neuropsychologist. Qualitative observations are extremely important, not only in interpreting the results of neuropsychological testing, but also in judging the adequacy of social, communicative, problem solving, and sensorimotor skills that may not be amenable to standardised testing.

Behavioural observations are often noteworthy to the extent that they involve alterations in the examiner's usual responses to a child. That is, changes in the examiner's usual style of interaction may signal anomalies in a child's functioning. For instance, the need for the clinician to modify his or her utterances may signal a language disorder.

Similarly, if the clinician must use verbal prompts more frequently than usual in order to keep the child on task, then the child may be considered to have attention problems. Rigorous observation, though, must be referenced to certain basic domains of functioning to which neuropsychologists routinely attend.

A typical list of domains would include the following:

- Mood and affect
- Motivation and cooperation
- Social interaction
- Attention and activity level
- Response style
- Speech, language and communication
- Sensory and motor skills
- Physical appearance

3) **Psychological Testing**

Psychological testing is the third source of information about the child, and the source most often equated with neuropsychological assessment. The findings obtained from formal testing allow for normative comparisons. The findings obtained from formal testing allow for normative comparisons. Formal testing also provides a context for making qualitative observations of response styles and problem-solving strategies under standardised test batteries, such as Halstead-Reitan Neuropsychological Test Battery, as opposed to more flexible approaches to assessment. In general, however, most child neuropsychologists administer a variety of tests that sample from a broad range of behavioural domains. The administration of a comprehensive battery provides converging evidence for specific deficits or problems and ensures an accurate portrayal of a child's overall profile of functioning.

Test batteries typically assess the following domains:

- General cognitive ability
- Language ability
- Visuoperceptual and constructional abilities
- Attention
- Learning and memory
- Executive functions
- Corticosensory and motor capacities
- Academic skills
- Emotional status, behavioural adjustment and adaptive behaviours

Let us deal with each of them above domains

a) **General Cognitive Ability:** General cognitive ability is usually assessed using standardised intelligence tests, such as Wechsler Intelligence Scale for Children Third Edition (WISC-III), the Stanford Binet Intelligence Scale Fourth Edition, and the Kauffman Assessment Battery for Children.

b) **Language Abilities:** The study of aphasia and acquired language disorders was one of the driving forces in the growth of neuropsychology in this century. Thus, when using batteries, such as the Neurosensory Center Comprehensive Examination of Aphasia, they also make use of tests used by speech pathologists and other psychologists, such a Peabody Picture Vocabulary Test Revised.

c) **Attention:** From a neuropsychological perspective, attention is a multidimensional construct that overlaps with the domain of "executive" functions discussed below. Neuropsychological assessment therefore usually involves tests that assess various aspects of attention, such as vigilance. Exemplary procedures include the Gordon Diagnostic System, which is one of the several continuous performance tests, The Contingency Naming Test, and the Arithmetic, Digit Span, Coding and Symbol Search subtests from the WISC-III.

d) **Executive Functions**: Executive functions are those involved in the planning, organisation, regulation and monitoring of goal-directed behaviour. In the past, the assessment of those skills and related abilities, such as problem-solving and abstract reasoning, has often been conducted informally, often by examining the quality of performance on tests failing within other measurement domains. recently however, a wider variety of tests has been employed to assess executive functions, including measures such as Wisconsin Card Sorting Test, the Tower of London, and the Children's Category Test. Executive Function would appear to play a critical role in determining a child's adaptive functioning.

e) **Corticosensory and Motor Capacities**: Tests of corticosensory and motor capacities usually involve standardised versions of various components of the traditional neurological examination. Relevant corticosensory skills include finger localisation, sereogenesis, graphesthesia, sensory extinction, and left right orientation, for which a variety of standardised assessment procedures are available.

f) **Academic skills:** These are tested for reading, writing and mathematics by giving achievement tests etc. appropriate to the age and class levels of the students.

g) **Emotional status etc.** These are tested with personality tests such as the personality trait questionnaires, sentence completion tests etc.

Self Assessment Questions

1) Discuss the methods of assessment.

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2) What are all the aspects to be covered in history taking?

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3) What is meant by behavioural observations? What aspects need to be covered here?

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4) What are the various psychological tests to be used in assessment?

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2.5 NEUROPSYCHOLOGICAL ASSESSMENT OF ADULTS

This section provides a general introduction of the field of neuropsychological assessment and deals specifically with the extensive standard test batteries and individual tests used with adults. The focus of neuropsychological assessment has traditionally been in the brain damaged patient, but there have been major extensions of the field to psychiatric disorders, functioning of normal individuals, and normal aging.

Perhaps the best definition of a neuropsychological test has been offered by Ralph Reitan, who described it as a test that is sensitive to the condition of the brain. If performance on a test changes with a change in brain function, then the test is a neuropsychological test. However, neuropsychological assessment is not restricted to the use of only neuropsychological tests. It should also contain some tests that are often useful for providing a baseline against which the extent of impairment associated with acquired brain damage can be measured.

The practise in neuropsychology is roughly divided into two approaches. Some practitioners use standard comprehensive neuropsychological test batteries, while others use individual tests that do not constitute a formal battery. Sometimes the tests used vary from patient to patient depending on referral and diagnostic considerations, and sometimes essentially the same tests are always used by the practitioner, but the collection of tests does not constitute a standard battery.

A great standard comprehensive battery is a procedure that assesses all of the major functional areas by structural brain damage. We use the term an ideal because none of the standard, commonly available procedures entirely achieves full comprehensiveness. Since brain damage most radically affects cognitive processes, most neuropsychological tests assesses various areas of cognition, but perception and motor skills also are frequently evaluated.

Thus, neuropsychological tests are generally thought of as assessment instruments for a variety of cognitive, perceptual, and motor skills. While the emphasis is on cognitive function, neuropsychologists in general practice, typically add brief personality assessments using the Minnessota multiphasic personality Inventory (MMPI) or similar procedure, and some measure of academic achievement, such as the Revised Wide Range Achievement Test.

Neuropsychological assessment typically involves the functional areas of general intellectual capacities; memory; speed and accuracy of psychomotor activity; visual-spatial skills; visual, auditory, and tactile perception; language; and attention. Thus, a comprehensive neuropsychological assessment may be defined as a procedure that at least surveys all of these areas.

Neuropsychological tests have the same standardisation requirements as all psychological tests. That is, there is the need for appropriate qualification, norms, and related test construction considerations, as well as the need to deal with issues related to validity and reliability. However, there are some special considerations regarding neuropsychological tests. Neuropsychological test batteries must be administered to brain damaged patients who may have substantial cognitive impairment and severe physical disability.

Thus, stimulus and response characteristics of the tests themselves, as well as of the test instructions, become exceedingly important considerations. In general, the test material should consist of salient stimuli that the patient can readily see or hear and understand. Instructions should not be unduly complex, and if the patient has a sensory deficit, it should be possible to give the instructions in an intact modality, without jeopardising the use of established test norms. The opportunity should be available to repeat and paraphrase instructions until it is clear that they are understood. Similarly, the manner of responding to the test material (e.g. pressing a lever or writing on a multiple choice form) should be within the patient's capabilities.

Neuropsychological assessments aim at specifying in as much detail as possible the functional deficits that exists in a manner that allows for mapping of these deficits onto known systems in the brain. There are several methods of achieving these goals, and not all neuropsychologists agree as to the most productive route. In general, some prefer to examine patients in what may be described as a liner manner, with a series of interlocking component abilities, while others prefer using more complex tasks in the form of standard, extensive batteries and interpretation through examination of performance configurations.

The linear approach is best exemplified in the work of A.R. Luria and various collaborators, while the configurational approach is seen in the work of Ward

Halstead and collaborators. In either case, however, the aim of the assessment is to determine the pattern of the patient's preserved and impaired functions and infer from this pattern the nature of the disturbed brain function. Individual tests and test batteries are really only of neuropsychological value if they can be analysed by one of these two methods.

2.6 VALIDITY AND RELIABILITY

With regard to concurrent validity, the criterion used in most cases is the objective identification of some central nervous system lesion arrived at independently of the neuropsychological test results. Therefore, validation is generally provided by neurologists or neurosurgeons. Historically, identification of lesions of the brain has been problematic because, unlike many organs of the body, the brain cannot usually be visualised directly in the living individual. The major exception occurs when the patient undergoes brain surgery or a brain biopsy. In the absence of these procedures, validation has been dependent on autopsy data or the various brain imaging techniques.

Autopsy data are not always entirely usable for validation purposes, in that numerous changes may have taken place in the patient's brain between the time of testing and time of examination of the brain. Currently, the new neuroimaging procedures and the very extensive research associated with them have made substantial progress towards resolution of this problem. Of the various imaging techniques, magnetic resonance imaging (MRI) is currently the most widely used.

Cooperation among neuroraudiologists, neurologists, and neuropsychologists has already led to the accomplishment of several important studies correlating MRI data with neuropsychological test results. Most of the neropsychological tests and batteries used today have proven reliability and validity.

In the next section, we will discuss neuropsychological batteries for adults in detail that form a large part of adult neuropsychological assessment.

2.7 NEUROPSYCHOLOGICAL SCREENING OF ADULTS

Normally, a neuropsychological examination explores in depth an individual's performance in a wide range of functional domains. There are instances, however, in the early phases of diagnostic exploration when the presence of a brain injury or disease is not compelling but when a suspicion reasonably might be considered. In such cases, along with other diagnostic procedures, a neuropsychological screening examination may be employed.

A neuropsychological screening examination is a considerably abbreviated version of a full neuropsychological assessment, looking only at key sensitive areas of function.

The purpose of a neuropsychological screening examination is to determine if there is reasonable evidence, beyond initial clinical impression, for a diagnosis of brain injury or brain disease. Even though it is "screening," the examination must be definitive in this regard.

To miss a neurological diagnosis on the basis of a screening examination could be quite unfortunate. Once a screening points to reasonable probability that a neurological condition exists, a full neuropsychological examination would be indicated to attain further diagnostic, prognostic, and treatment planning information. A referral for neurological examination would also be appropriate at this point.

Both screening and full neuropsychological examinations offer the opportunity for diagnosis of probability of brain dysfunction (as opposed to diagnosis of psychodynamic, personality, and/or emotional disorder not associated with neurological causes).

For a screening examination, assessing probability of brain dysfunction is about as far as the diagnosis goes. A full neuropsychological examination, on the other hand, is necessary to delineate the wide variety of functional manifestations of brain damage or disease. Such detail is necessary to understand the life consequences of functional impairment (e.g., work, school, relationships, driving potentials, competency, and so forth).

Indications for neuropsychological screening

- Nature of referral question warrants it.
- Situational explanation for changes in emotions or cognitive functioning cannot be readily identified;
- A medical or injury condition is suspected to have impacted brain health (for example, compromised circulation, chronically poor nutrition, or drug toxicity);
- Any relatively sudden, unexpected, and unaccounted for changes appear in mental or cognitive performance that impacts work or daily functioning;
- Gradual or sudden onset of unusual physical, sensory, or motor changes (an examination by a physician is always indicated in these instances, as well);
- An individual fails to improve with special educational or therapeutic interventions designed to address a specific mental or cognitive problem.
- Feasibility issue (e.g. time, cost, etc.)

Strengths of Brief Screening Measures

1) Inexpensive, rapid, portable
2) Needs less training in administration and interpretation
3) Differentiating between dementia and pseudo-dementia

Weaknesses of Brief Screening Measures

1) High rate of false negatives in early stage of disease

Strengths of Full Battery Measures

1) Wide range of scores allow differential diagnosis in various cognitive disorders
2) More reliable, and sensitive
3) Breadth of domains covered help in treatment planning

Weakness of Full Battery Measures

1) Expensive and time consuming.

2.8 LET US SUM UP

A neuropsychological test is defined as behavioural procedure that is particularly sensitive to the condition of the brain. While any purposeful behaviour involves the brain, neuropsychological tests provide the clearest demonstrations of behaviour that indicate that the brain is functioning normally, or that something is wrong with it. The general format of assessment essentially includes detailed case history, behavioural observation, interview and information from various sources and use of neuropsychological assessment tools.

The cognitive and social emotional development of infants and very young children has unique features. This age range is associated with less differentiation of some functional areas, the presence of early developmental constructs that are less dominant than in older children, and an increased variability of performance compared to older children. While the approach to the neuropsychological examination of infants and young children is similar in its general form to that used in the evolution of older individuals, there are differences in terms of the existence of a body of knowledge regarding the cognitive and social emotional development process in this age group and brain behaviour relationships in normal and abnormal developmental condition; and there is relatively less reliance on standardised test measures to assess all desired functional areas.

There is a set of general principles that help to conceptualise neuropsychological assessment of older children and adolescents. The principles acknowledge that child development is driven by a complex interplay of multiple forces, including, but not limited to, brain function in this age range as it is a transitional stage.

In adults neuropsychological assessment typically involves the functional areas of general intellectual capacities; memory; speed and accuracy of psychomotor activity; visual spatial skills; visual, auditory, and tactile perception; language; and attention. Thus, a comprehensive neuropsychological assessment may be defined as a procedure that at least surveys all of these areas.

2.9 UNIT END QUESTIONS

1) How non-human experiments and clinical studies contributed in the development and understanding of neuropsychological assessment.

2) Explain the concept of plasticity and its significance in neuropsychological assessment.

3) What are the main domains need to be evaluated in developmental history.

4) Give examples and explain tests of attention and memory in children.

5) Discuss the reliability and validity of neuropsychological assessment.

2.10 SUGGESTED READINGS

Filskov, S. B., & Bold, T. J (1981). *Handbook of Clinical Neuropsychology*. New York: Wiley-Interscience.

G. Golstein & T. M. Incagnoli (Eds) (1974). *Contemporary Approaches to Neuropsychological Assessments.* ,New York: Plenum Press.

Lezak, M. (1976). *Neuropsychological Assessment* (Ist ed.). New York: Oxford university press.

References

Christensen, A.L. (1975a). Luria's neuropsychological investigation. New York spectrum.

Christensen, A.L. (1975b). Luria's neuropsychological investigation: manual. New York spectrum.

Davis, K.(1983,october). Potential neurochemical and neuroendocrine validators of assessment instruments. paper presented at conference on clinical memory Assessment of older adults, Wakefield, M.A.

Golden, C. J(1981). A standardised version of Luria's neuropsychological tests;a quantitative and qualitative approach to neuropsychological evaluation. In Filskov, S. B., & Bold, T. J (Eds.),handbook of clinical neuropsychology(pp.608 to 642). New York: Wiley-Interscience.

Golden, C. J., Hemmeke, T. & Purisch, A. (1980). The Luria-Nebraska battery manual, Los Angeles: Western psychological services.

Golden, C. J., Hemmeke, T. & Purisch, A(1985) Luria-Nebraska neuropsychological battery manual form I & II. Los Angeles: Western psychological services.

Goldstein, G. (1982). Overview: clinical application of Halstead-Reitan and Luria-nebraska batteries. Paper presented at NE-RMEC conference, Northport, NY.

Goldstein, G., & Watson, J. R (1989). Test-retest reliability of the Halstead-Reitan battery and the WAIS in a neuropsychiatric population. The clinical neuropsychologist,3,265-273.

Heaton, R. K, Grant, I., & Matthews, C. G.(1991).comprehensive norms for an expanded *Halstead-Reitan battery*. Odessa, FL: psychological assessment resources.

Heaton, R. K, Pendleton, M. G. (1981). Use of neuropsychological test to predict adult patients everyday functioning. Journal of consulting and clinical psychology,49, 807-821.

Jastak, S.,& Wilkinson, G. S (1984).*wide range achievement test-revised*. Wilmington, DE: Jastak Associates, Inc.

Levin, H. S., Benton, A. L., & Grossman, R. G. (1982).*neurobehavioural consequences of closed head injury.* New York Oxford university press.

Luria, A. R.(1973).the working brain. New York basic books.

Meier, M.J.(1974).some challenges for clinical neuropsychology. In R. M. Reitan & L. A. Davison(Eds), *clinical neuropsychology. Reed, J.C, & H.B.C(1997), Halstead-Reitan neuropsychological battery. In G. Golstein & T. M. Incagnoli (Eds) ,Contemporary approaches to neuropsychological assessments(pp.93-129),New York: Plenum Press.*

Reitan, R. M (1958*).Qualitative versus quantitative mental changes following brain damage.* journal of psychology,46,339-346.

Reitan, R. M (1964). Psychological deficits resulting from cerebral lesion in man. In J. M. Warren & K. Akert (Eds.), *the frontal granular cortex and behaviour* (pp.295-312). New York: McGraw Hill.

Reitan, R. M., & Wolfson, D. (1993). The *Halstead-Reitan neuropsychological test battery: theory and clinical interpretation* (2nd ed.).Tucson, AZ: Neuropsychology Press.

Russell, E. W., & Starkey, R. I (1993). *Halstead-Russell neuropsychological evaluation system: manual and computer program.* Los Angeles; Western Psychological Services.

Selz, M., & Reitan, R. M. (1979).Rules for neuropsychological diagnosis: classification of brain function in older children. *Journal of consulting and clinical psychology,47 ,258-264.*

Shelly, C., & Goldstein, G. (1983). Discrimination of chronic schizophrenia and brain damage with the Luria-Nebraska battery: A partially successful replication. *clinical neuropsychology,*5,82-85

Sherrill, R. E. jr. (1987). options for shortening Halstead's category test for adults. I Archives of clinical neuropsychology,*2,343-352.*

Wechsler, D. (1955). Wechsler adult intelligence scale manual. San Antonio, TX: The psychological corporation.

References (for pictures)

brainfitnessresources.com
en.wikipedia.org/wiki/Brain_fitness
assessmenttoolshop.com

UNIT 3 NEUROPSYCHOLOGY TEST BATTERIES

Structure

3.0 Introduction

3.1 Objectives

3.2 Neuropsychological Assessment

- 3.2.1 The Nervous System and Behaviour
- 3.2.2 Neuropsychological Examination

3.3 Neuropsychological Understanding of Behavioural Deficits

3.4 Goals of Neuropsychological Assessment

3.5 Nature of Neuropsychological Tests

3.6 Identifications of a Deficit by Neuropsychological Tests

3.7 The Luria-Nebraska Neuropsychological Battery

- 3.7.1 History
- 3.7.2 Structure and Content
- 3.7.3 Theoretical Foundations
- 3.7.4 Standardisation Research

3.8 The Halstead-Reitan Neuropsychological Battery

- 3.8.1 History
- 3.8.2 Structure and Content
- 3.8.3 Theoretical Foundations of Component Tests
- 3.8.4 Standardisation Research
- 3.8.5 The NIMHANS Neuropsychological Battery

3.9 Let Us Sum Up

3.10 Unit End Questions

3.11 Suggested Readings

3.0 INTRODUCTION

In this unit we are dealing with neuropsychological batteries and tests. We start with the definition of neuropsychological assessment and present the various aspects related to the same. Then we discuss how Neuropsychological Assessment would also lead to obtaining information regarding the neurological deficits resulting in behavioural deficiencies. Then we take up Goals of Neuropsychological Assessment and discuss the various factors and clues that may be obtained in regard to the neurological problems within the individual. This is followed by a discussion on the nature of neuropsychological tests and how to identify a deficit with the help of neuropsychological test battery. Two major batteries, the Luria Nebraska and the Halstead Reitan Neuropsychological batteries are presented with their history, structure and content within the tests, the theoretical foundations underlying these tests and the validity and reliability of these tests. Then we deal with the NIMHANS Neuropsychological battery and give a description of the various tests within the same.

3.1 OBJECTIVES

After completing this unit, you will be able to:

- Define and describe Neuropsychological;
- Explain how neuropsychological tests can be used for understanding of behavioural deficits;
- Elucidate the goals of neuropsychological assessment;
- Describe the nature of neuropsychological tests;
- Explain how to identify a deficit through neuropsychological tests;
- Describe the various aspects of the Luria-Nebraska Neuropsychological Battery;
- Delineate how the test was evolved and devised;
- Describe the Halstead-Reitan battery and its contents, tests and subtests; and
- Explain the NIMHANS Neuropsychological Battery.

3.2 NEUROPSYCHOLOGICAL ASSESSMENT

Neuropsychological assessment has its roots in neurology, the branch of medicine that focuses on the nervous system and its disorders. It focuses on the relationship between brain functioning and behaviour. It used to be a specialty area within clinical psychology. In neuropyshcological assessment the psychologists screen for signs and symptoms of a neurological deficit during:

- History Taking
- Interviewing
- Test-taking
- Intelligence Tests
- Other Tests.

3.2.1 The Nervous System and Behaviour

Damage to certain parts of the brain will be reflected as behaviour deficits. For example, damage to the temporal lobe may affect: sound discrimination, sound recognition, voice recognition, visual memory storage.Tests and procedures employed in a neuropsychological examination vary as a function of: Purpose of examination, Neurological intactness of the examinee, Thoroughness of the examination.

3.2.2 Neuropsychological Examination

For a neuropsychological examination a battery of tests administered should include, at a minimum:

- Intelligence Tests
- Personality Tests
- Perceptual-Motor / Memory Tests

If impairment is discovered, the examinee will be referred for further and more detailed tests.

The typical neuropsychological exam begins with a careful history taking. Areas of interest include:

- Medical history of patient.
- Medical history of patient's family.
- Presence of absence of developmental milestones.
- Psychosocial history.
- Character, severity, and progress of any history of complaints.

The MSE deals with questions concerning the addressee's Consciousness, Emotional State, Thought Content and Clarity, Memory, Sensory Perception, Performance of Action, Language, Speech, Handwriting, Handedness.Tests and assessment procedures assess various aspects of functioning including aspects of:

- Perceptual functioning
- Motor functioning
- Verbal functioning
- Memory Functioning
- Cognitive Functioning

These tests are also used in screening for deficits and in adjunct to medical examinations.

The tests can be helpful in the assessment of:

- Change in mental status
- Abnormalities in function before abnormalities in structure can be detected.
- Strengths and weaknesses of patient.
- Ability of individual to stand trial.
- Changes in disease process over time.

The Wechsler Scales are often used as a diagnostic tool for intellectual ability testing.

Formal testing for memory may involve the use of instruments such as the Wechsler Memory Scale-Revised:

- The task is to recall stories and other verbal stimuli.
- The test is appropriate for people within the ages of 16-74.

Verbal memory, non verbal memory etc. are tested through the presentation of stimuli such as verbal learning test, selective reminding test Benton test of visual retention etc. As for tests of cognitive functioning, difficulty in thinking abstractly is a relatively common consequence of brain injury. One popular measure of verbal abstraction ability is the Wechsler Similarities Subtest in which the task is to identify how two objects are alike. Proverb interpretation is another way to assess ability to think abstractly. Nonverbal tests of abstraction include sorting tests such as the Wisconsin Card Sorting Test.

A neuropsychological assessment is a clinical examination of both the working brain and dysfunctional brain. Neuropsychological tests are an aid in this examination. The objective of neuropsychological assessment is to chart the deficits and adequacies in the behaviour of patients. The behavioural deficits are explained by underlying cognitive, emotional, and volitional deficits as well as changes in the patient's behaviour. The outcome of a neuropsychological assessment is a profile of the patient's deficits and adequacies.

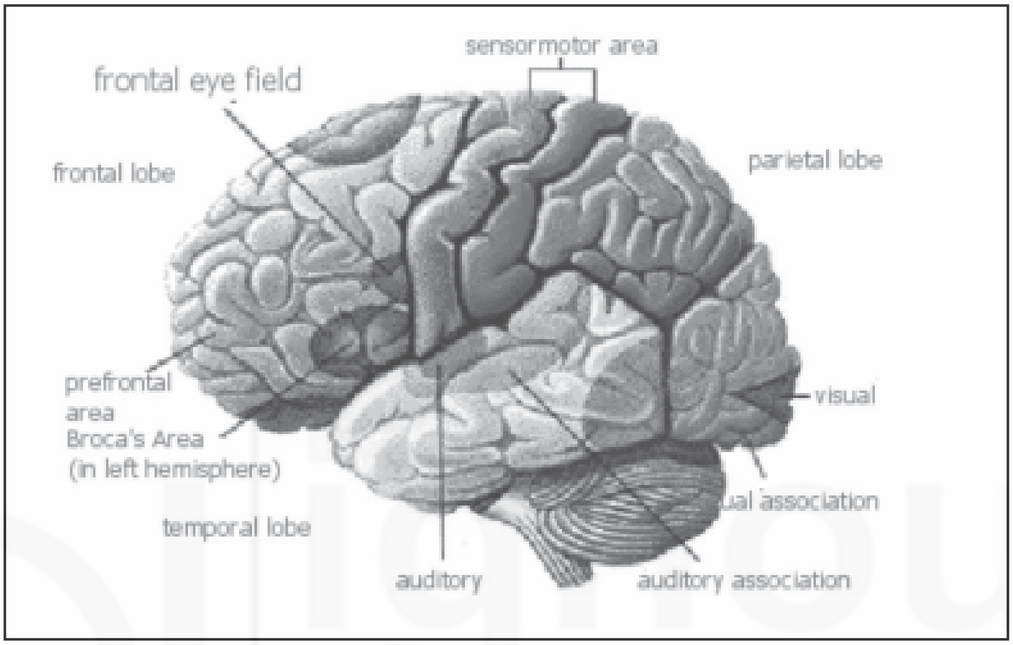

Fig.3.1: Structural and functional brain

3.3 NEUROPSYCHOLOGICAL UNDERSTANDING OF BEHAVIOURAL DEFICITS

Behaviour is an outcome of the interaction of the brain with the environment. A composite of multiple psychological processes shape behaviour. The chief domains of the psychological processes are cognition, emotion and volition. Each of these three cardinal domains has specialised processes and each of the specialised process has components, which constitute the sub process. Nuances in behaviour arise because of the nuances of the domains/ process/ components. The objective of neuropsychological assessment is to identify the disturbed psychological domain/process/ component, which could be giving rise to the behavioural disruption.

3.4 GOALS OF NEUROPSYCHOLOGICAL ASSESSMENT

The psychological domains/processes/ components are mediated by specific brain structures and connected brain structures forming functional networks. Identification of disruptions in specified psychological components/processes/ domains indicate damage to the brain structures/networks, which mediate these processes.

Neuropsychological assessment therefore has twin goals.

i) The first goal is to identify the disrupted psychological components/ processes/domains in an individual patient and arrive at a profile of adequacies and deficits of psychological functions.

ii) The second goal is to identify the brain structures/ functional networks, which are dysfunctional or damaged using the neuropsychological profile that has previously been derived. Finally, this information is used to lateralise and localise the bran lesion.

3.5 NATURE OF NEUROPSYCHOLOGICAL TESTS

Neuropsychological tests are aids in the neuropsychological examination. The tests measure specified psychological processes including the constituent components of the process. The level of difficulty is not high, as the goal of the testing is to identify a deficit in functioning and not to test the limits of the top end of performance. These are that the test should have adequate reliability and validity, the scoring should be objective, and the test should have adequate normative data.

3.6 IDENTIFICATIONS OF A DEFICIT BY NEUROPSYCHOLOGICAL TESTS

Ideometric approach and psychometric approach are the two methods that are used in the identification of deficits through neuropsychological tests. Ideometric approach is suitable for clinical examinations of individual patients. Psychometric approach is suitable for the assessment of abilities/ aptitudes using quantitative scores. While the first is used in a clinical examination that takes into account the background of the patient, the second is used in an examination of abilities and aptitudes of the patient irrespective of his or her background.

Ideometric approach in the context of neuropsychological assessment emphasises the patient's premorbid functioning with reference to education, occupation, social and occupational functioning as well as performance on other neuropsychological tests. Factors such as the patient's currents sensory/motor deficiencies, motivational deficits and fatigue level are noted. These are taken into account in interpreting the neuropsychological examination. Because the complete background of the patient and his/her current level of functioning are obtained, the diametric is well suited for clinical examination.

On the other hand, the psychometric approach takes a 'here and now' view. It interprets objective scores with reference to normative data, without taking into account previous history or current functioning in other areas.

Comprehensive neuropsychology testing requires a combination of Context related ideometric and quantitative psychometric approaches. While the patient is undergoing the test the neuropsychologists must observe the factors which may contribute to the failure of the patient in performance of a given task. Examples of such factors include unfamiliarity with timed tests, inability to pay attention for the required length of time, inability to modulate the mental effort required by a task, poor motivation, poor insight, premorbid characteristics such as impulsivity, unwillingness to try out new things, etc. Another set of factors that affects patients level of functioning is deficits in specific areas, which can hamper the patients' performance in a specific test.

Example of these include deficits of visuo-spatial perception hampering performance on construction tasks, poor comprehension hampering performance on verbal memory tests, and visual difficulties impairing performance on visual memory tests. A comprehensive account of the patients' premorbid functioning and current performance is essential to understand the performance on a neuropsychological test.

At the same time, it is essential to have objective scores, in order to identify and classify deficits in psychological components and processes. The need for objective scores becomes greater when the deficits are mild or when minimal levels of temporal improvement or deterioration are being tracked. Objective scores can be obtained if the tests are constructed according to the psychometric approach.

Normative data, which take into account the effects of socio-demographic variables such as age, education and gender, are also used in such an approach.

Thus, while neuropsychological tests have to be constructed using the psychometric approach the interpretation of test performance would require a blend of both ideometric and psychometric approaches. The scores would then be compared with normative data. Finally, interpretation of the results would again require a blend of ideometric and psychometric approaches.

Self Assessment Questions

1) What is neuropsychological assessment?

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2) Discuss the relationship between the nervous system and behaviour.

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3) In what way neuropsychology helps in understanding the behvarioural deficits?

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4) What are the goals of neuropsychological assessment?

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5) Discuss the nature of neuropsychological tests.

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6) How would neuropsychological test identify a deficit?

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3.7 THE LURIA-NEBRASKA NEUROPSYCHOLOGICAL BATTERY

3.7.1 History

This procedure was first reported in 1978 in the form of two initial validity studies. Historically, Chirstensen, a student of the prominent Russian neurologist and neuropsychologist, A. R. Luria, published a book called Luria's neuropsychological investigation. The book was accompanied by a manual and a kit containing test materials used by Luria and his co-workers. Although some of Luria's procedures had previously appeared in English, they had never been presented in a manner that encouraged direct administration of the test items to the patients. The material published initially did not contain information relevant to standardisation of these items. There was no scoring system, norms, data regarding validity and reliability, or review of research accomplished with the procedure as a standard battery.

This work was taken on by a group of investigators under the leadership of Charles J. Golden. Thus, in historical sequence, Luria adopted or developed these items over the course of many years, Christensen published them in English but without standardisation data, and finally Golden and collaborators provided quantification and standardisation. Since that time, Golden's group as well as other investigators have produced a massive amount of studies with what is now known as the Luria Nebraska Neuropsychological Battery.

The battery was published in 1980 by Western Psychological Services and is now extensively used in clinical and research applications. An alternate form of the battery is now available, as is a children's version.

3.7.2 Structure and Content

The battery contains 269 items, each of which may be scored on a 2- or 3- point scale. A score of 0 indicates normal performance. Some items may receive a score of 1, indicating borderline performance. A score of 2 indicates clearly abnormal performance. The items are organised into the categories provided in the Christensen kit, but while Christensen organised the items primarily to suggest how they were used by Luria, the Luria-Nebraska version is presented as a set of quantitative scales.

The raw score for each scale is the sum of the 0, 1 and 2 item scores. Thus, the higher the score, the poorer the performance. The scores for the individual items may be based on speed, accuracy, or quality of response. In some cases, two scores may be assigned to the same task, one for speed and the other for accuracy. These two scores are counted as individual items. For example, one of the items is a block counting task, with separate scores assigned for number of errors and time to completion of the task. In case of time scores, blocks of seconds are associated with the 0, 1 and 2 scores. When quality of response is scored, the manual provides both rules for scoring and, in the case of copying tasks, illustrations of figures representing 0, 1 and 2 scores.

The 269 items are divided into 11 content scales, each of which may be administered individually. Since these scales contain varying number of items, raw scale scores are converted to T score with a mean of 50 and a standard deviation of 10. These T scores are displayed as a profile on a form prepared for that purpose. In the alternate form of the battery, the names of the content scales have been replaced by abbreviations. Thus, we have Motor, Rhythm, Tactile, Visual, Receptive Speech, Expressive Speech, Writing, Reading, Arithmetic, Memory, and Intellectual Processes scales, which are referred to as the C1 through C11 scales in the alternate form.

In addition to these 11 content scales, there are three derived scales that appear on the standard profile form: the Pathognomonic, Left Hemisphere scales. The Pathognomonic scale contains from throughout the battery found to be particularly sensitive to the presence or absence of brain damage. The left and right hemisphere scales are derived from the Motor and Tactile scale items that involve comparisons between the left and right sides of the body. They therefore reflect sensorimotor asymmetries in the two sides of the body.

Several other scales have been developed by Golden and various collaborators, all of which are based on different ways of scoring the same 269 items. These special scales include new (empirically derived) right and left hemisphere scales, a series of localisation scales a series of factor scales and double discrimination scales. The new right and left hemisphere scales contain items from throughout the battery and are based on actual comparisons among patients with right hemisphere, left hemisphere, and diffuse brain damage.

The localisation scales are also empirically derived, being based on studies of patients with localised brain lesions. There are frontal, sensorimotor, temporal, and parieto-occipital scales for each hemisphere. The factor scales are based on extensive factor analytical studies of the major content scales. The new right and left hemisphere scales contain items from throughout the battery and are based on actual comparisons among patients with right hemisphere, left hemisphere and diffuse brain damage. The new right and left hemisphere, localisation factor scales may all be expressed in T scores with a mean of 50. There are also two scales that provide global indices of dysfunctions, and are meant as equivalents to the Halstead impairment index. They are called the Profile Elevation and Impairment Scales.

The Luria Nebraska procedure involves an age and education correction. It is accomplished through computation of a cutoff score for abnormal performance based on an equation that takes into consideration both age and education. The computed score is called the critical level and is equal to .214(Age) + 1.47 (Education) + 68.8 (Constant). Typically, a horisontal is drawn across the profile at the computed critical level point. The test user has the option of considering scores above the critical level, which may be higher or lower than 60, as abnormal.

As indicated above, extensive factor analytic studies have been accomplished, and the factor structure of each of the major scales has been identified. These analyses were based on item intercorrelations, rather than on correlations among the scales. It is important to note that most items on any particular scale correlate better with other items on that scale than they do with items on other scales (Golden, 1981). This finding lends credence to the view that the scales are at least somewhat homogeneous, and thus that the organisation of the 269 items into those scales can be justified.

3.7.3 Theoretical Foundations

As in the case of the Halstead- Reitan battery, one could present two theoretical bases for the Luria- Nebraska, one revolving around the use of Luria’s name and the other around the Nebraska group, namely, Golden and his collaborators. This view is elaborated upon in by Goldestein. Luria himself had nothing to do with the development of the Luria Nebraska battery, nor did any of the co workers. The use of his name in the title of battery is, in fact, somewhat controversial and seems to have been essentially honorific in intent, recognising his involvement in development of items and the underlying theory for their application. Indeed, Luria died some time before publication of battery but was involved in the preparation of the Christensen materials, which he endorsed. Furthermore, the method of testing employed by the Luria- Nebraska was not Luria’s method, and the research done to establish the validity, reliability, and clinical relevance of the Luria- Nebraska was not done by Luria and his collaborators.

Therefore, our discussion of the theory underlying the Luria Nebraska battery will be based on the assumption that the only connecting link between Luria and that procedure is the set of Christensen items. In doing so, it becomes clear that the basic theory underlying the development of Luria- Nebraska is based on a philosophy of science that stresses empirical validity, quantification and application of established psychometric procedures. Indeed, as pointed out elsewhere, it is essentially the same epistemology that characterises the work of the Reitan group.

Thus, research done with the Luria Nebraska battery determined

1) whether it discriminates between brain damaged patients in general and normal controls;
2) whether it discriminates between patients with structural brain damage and those with schizophrenia;
3) whether the procedure has the capacity to lateralise and regionally localise brain damage; and
4) whether there are performance patterns specific to particular neurological disorders, such as alcoholic dementia or multiple sclerosis.

Since this research was accomplished in recent years, it was able to benefit from the new brain imaging technology, notably the CT scan, and the application of high speed computer technologies, allowing for extensive use of powerful multivariate statistical methods. With regard to methods of clinical inference, the same method suggested by Reitan that is level of performance, pattern of performance, pathognomonic signs, and right left comparisons etc., are used with the Luria Nebraska battery.

Adhering to our assumption that the Luria Nebraska bears little resemblance to Luria's methods and theories, there seems little point in examining the theoretical basis for the substance of the Luria Nebraska battery. For example, there is little point in examining the theory of language that underlies the Receptive Speech and Expressive Speech scales or the theory of memory that provides the basis for the Memory scale. We believe that the Luria Nebraska battery is not a means of using Luria's theory and methods in English speaking countries, but rather a standardised psychometric instrument with established validity for certain purposes and reliability.

The choice of using items selected by Christensen to illustrate Luria's testing methods was, in retrospect, probably less crucial than the research methods chosen to investigate the capabilities of this item set. Indeed, it is somewhat misleading to characterise these items as "Luria's tests," since many of them are standard items used by neurologists throughout the world. Surely, one cannot describe asking a patient to interpret proverbs or determine 2 point thresholds as being exclusively "Luria's tests". They are, in fact, venerable, widely used procedures.

3.7.4 Standardisation Research

There are published manuals for the Luria Nebraska that describe the battery in detail and provide information pertinent to validity, reliability, and norms. There are also several reviews articles that comprehensively describe the research done with the battery. Very briefly reviewing this material, satisfactory discriminative validity has been reported in studies directed toward differentiating miscellaneous brain damaged patients from normal controls and from chronic schizophrenics. Cross validations were generally successful, but Shelly and Goldstein (1983) could not fully replicate the studies involved with discriminating between brain-damaged and schizophrenic patients.

Discriminative validity studies involving lateralisation and localisation achieved satisfactory results, but the localisation studies were based on small samples. Quantitative indices from the Luria-Nebraska were found to correlate significantly with CT scan quantitative indices in alcoholic and schizophrenic samples. There have been several studies of specific neurological disorders including multiple sclerosis, alcoholism, Huntington's disease, and learning disability, all with satisfactory results in terms of discrimination.

The test manual reports reliability data. Test-retest reliabilities for the 13 major scales range from .78 to .96. The problem of interjudge reliability is generally not a major one for neuropsychological assessment, since most of the test used is quite objective and have quantitative scoring systems. However, there could be a problem with the Luria-Nebraska, since the assignment of 0, 1, and 2 scores sometimes requires a judgement by the examiner.

During the preliminary screening stage in the development of the battery, items in the original pool that did not attain satisfactory interjudge reliability were dropped. A 95% inter-rater agreement level was reported by the test constructors for the 282 items used in an early version of the battery developed after dropping those items. The manual contains means and standard deviations for each item based on samples of control, neurologically impaired, and schizophrenic subjects. An alternate form of the battery is available. To the best of our knowledge, there have been no predictive validity studies. It is unclear whether or not there have been studies that address the issue of construct validity.

Self Assessment Questions

1) Discuss in detail the Luria Nebraska Neuropsychological battery.

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2) Trace the history of how the Luria Nebraska battery was devised.

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3) What are the structure and content in the Luria Nebrasks Neuropsychological battery?

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4) Discuss the theoretical foundation on which Luria Nebraska battery is devised.

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5) What are the validity and reliability of this test battery?

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3.8 THE HALSTEAD-REITAN NEUROPSYCHOLOGICAL BATTERY

3.8.1 History

The beginnings of the battery can be traced to the special laboratory established by Halstead in 1935 for the study of neurosurgical patients. The first major report on the findings of this laboratory appeared in a book called Brain and intelligence: A *Quantitative study of the frontal lobes*), suggesting that the original intent of Halstead's test was describing frontal lobe function. In this book, Halstead proposed his theory of "biological intelligence" and presented what probably the first factor analysis that was done with neuropsychological test data. Perhaps more significantly, however, the book contains descriptions of many of the tests now contained in the Halstead Reitan battery. In historical perspective, Halstead's major contributions to neuropsychological assessment, in addition to his very useful tests, include the concept of the neuropsychological laboratory in which objective tests are administered in standard fashion and quantitatively scored, and the concept of impairment index, a global rating of severity of impairment and probability of the presence of structural brain damage.

Reitan adopted Halstead's methods and various test procedures and with them established a laboratory at the University of Indiana. He supplemented these tests with a number of additional procedures in order to obtain greater comprehensiveness and initiated a clinical research program that is ongoing. The program began with cross validation of the battery and expanded into numerous areas, including validation of new tests added to the battery (e.g. the Trail Marking Test), lateralisation and localisation of function, aging, and neuropsychological aspects of a wide variety of disorders such as alcoholism, hypertension, disorders of children, and mental retardation.

Theoretical matters were also considered. Some of the major contributions included the concept of type locus interaction, the analysis of quantitative as opposed to qualitative deficits associated with brain dysfunction, the concept of the brain age quotient, and the scheme for levels and types of inference in interpretation of neuropsychological test data. In addition to the published research, Reitan and his collaborators developed a highly sophisticated method of blind clinical interpretation of the Halstead Reitan battery that continues to be taught at workshops conducted by Dr. Reitan and associates.

The Halsted Reitan battery, as the procedure came to be known over the years, also has a history. It has been described as a fixed battery, but the sets of tests are grown by accretion and revision and continues to be revised. The tests that survived a long research history include the Category Test, The Tactual Performance Test, The Speech Perception Test, The Seashore Rhythm Test, and Finger Tapping.

There have been numerous additions, including the various Wechsler Intelligence scales, the Trail Making test, a sub-battery of perceptual tests the Reitan aphasia Screening Test, the Klove Grooved Pegboard, and other tests that are used in some laboratories but not in others.

Most recently, a procedure described as an "expanded Halsted Reitan battery" has appeared that includes the original tests plus several additional ones, listed below. Three major new methods have also been developed for scoring the battery and computing the impairment index.

The Halstead Reitan battery continues to be widely used as a clinical and research procedure. Numerous investigators use it in their research, and there have been several successful cross validations done in settings other than Reitan's laboratory. In addition to the continuation of factor analytic work with the battery, several investigators have applied other forms of multivariate analysis to it in various research applications.

Some of this research has been conducted relative to objectifying and even computerising interpretation of the battery; the most well-known efforts are the Selz Reitan rules for classification of brain function in older children and the Russel, Neuringer, and Goldstein "neurological keys".

The issue of reliability of the battery has been addressed, with reasonably successful results. Clinical interpretation of the battery continues to be taught at workshops and in numerous programs engaged in the training of professional psychologists.

3.8.2 Structure and Content

Although there are several versions of the Halsted Reitan battery, the differences tend to be minor, and there appears to be a core set procedures that essentially all versions of the battery must be administered in a laboratory containing specific equipment. It is probably best to plan on about 6 to 8 hours of patient time. Each test of the battery is independent and may be administered separately from the other tests. However, it is generally assumed that a certain number of the tests must be administered in order to compute an impairment index.

Scoring for the Halsted Reitan varies with the particular test, such that individual scores may be expressed in time to completion, errors, number correct, or some form of derived score. These scores are often converted to standard scores or ratings so that they may be profiled. All of the tests contributing to the impairment index on a 6-point scale, the data being displayed as a profile of the ratings. They have also provided quantitative scoring systems for the Reitan Aphasia Test and for the drawing of a Greek cross that is part of that test. However, some clinicians do not quantify those procedures, except in the form of counting the number of Aphasic symptoms elicited.

Theoretical Foundation: There are really two theoretical bases for the Halsted Reitan battery, one contained in brain and intelligence and related writings of Halstead. The other are found in numerous papers and chapters written by Reitan and various collaborators. Halstead was really the first to establish a human neuropsychology laboratory in which patients were administered objective tests, some of which are semi automated, utilising standard procedures and sets of instructions. His Chicago laboratory may have been the stimulus for the now common practice of administration of neuropsychological tests by trained technicians. Halstead was also the first to use sophisticated, multivariate statistics in the analysis of neuropsychological test data.

Reitan’s program can be conceptualised as an effort to demonstrate the usefulness nad accuracy of Halstead’s tests and related procedures in clinical assessment of brain damaged patients. Halstead’s of a standard neuropsychological battery administered under laboratory conditions and consisting of objective, quantifiable procedure was maintained and expanded by Reitan. Both Halsted and Reitan shared what might be described as a Drawinian approach to neuropsychology.

Halstead’s discriminating tests are viewed as a measure of adaptive abilities, of skills that ensured man’s survival on the planet. Many neuropsychologists are now greatly concerned with the relevance of their test procedures to adaptation, that is the capacity to carry on functional activities of daily living and to live independently (Heaton & Pendleton, 1981). This general philosophy is somewhat different from the more traditional models emanating from behavioural neurology, in which there is a much greater emphasis on the more medical-pathological implications of behavioural test findings.

One could say that Reitan’s great concern has always been with the empirical validity of test procedures. Such validity can only be established through the collection of large amounts of data obtained from patients with reasonably complete documentation of their medical\neurological conditions. Both presence and absence of brain damage had to be well documented, and if present, findings related to site and type of lesion had to be established. He described his work informally as one large experiment, necessitating maximal consistency in the procedures used, and to some extent, in the methods of analysing the data. Reitan and his various collaborators represent the group that was primarily responsible for the introduction of standard battery approach to clinical neuropsychology. It is clear from reviewing the Reitan group's work that there is substantial emphasis on performing controlled studies with samples sufficiently large to allow for the application of conventional statistical procedures.

It would probably be fair to say that the major thrust of Reitan's research and writings has not been espousal of some particular theory of brain function, but rather an extended examination of the inferences that can be made from behavioural indices relative to the condition of the brain. There is a great emphasis on methods of drawing such inferences in case of the individual patient. Thus, this group's work has always involved empirical research and clinical interpretation, with one feeding into the other. In this regard, there has been a formulation of inferential methods used in neuropsychology that provides a framework for clinical interpretation. Four methods are outlined: level of performance, pattern of performance, specific behavioural deficits (pathognomonic signs), and right-left comparisons. In other words, one examines whether the patient's general level of adaptive function is comparable to that of normal individuals, whether there is some characteristics performance profile that suggests impairment even though the average score may be within normal limits, whether there are unequivocal individual signs of deficits, and whether there is a marked discrepancy in functioning between the two sides of the body.

3.8.3 Theoretical Foundations of Component Tests

Some form of lateral dominance examination administered, generally including tests for hand, foot, and eye dominance

Halstead's Biological Intelligence Tests: There are five subtests in this section of Halsted-Reitan battery developed by Halstead.

The Halstead Category Test: This test is a concept identification procedure in which the subject must discover the concept or principle that governs various series of geometric forms and verbal and numerical material. The apparatus for the test includes a display screen with four horisontally arranged numbered switches placed beneath it. The stimuli on slides and the examiner use a control console to administer the procedure. The subject is asked to press the switch that the picture reminds him or her of, and is provided with additional instructions.

The point of the test is to see how well the subject can learn the concept, idea, or principle that connects the pictures. If the correct switch is pressed, the subject will hear a pleasant chime, while wrong answers are associated with a rasping buzzer. The conventionally used score is the total number of errors for the seven groups of stimuli that forms the test. Booklet forms (Adams & Trenton, 1981; DeFillippis, McCampbell & Rogers, 1979) and abbreviated forms (Calsyn, O'Leary, & Chaney, 1980; Russel & Levy, 1987; Sherril, 1987) of this test have been developed.

The Halstead Tactual Performance Test: This procedure used a version of the Seguin-Goddard Form board, but it is done blindfold. The subject's task is to place all the 10 blocks into the board, using only the sense of touch. The task is repeated three times, once with the preferred hand, once with the non preferred hand, and once with both hands, after which the board is removed. After removing the blindfold, the subject is asked to draw a picture of the board, filling in all of the blocks he or she remembers in their proper locations on the board. Scores from this test include time to complete the task for each of the three trials, total time, number of blocks correctly drawn, and number of blocks correctly drawn in their proper locations on the board.

The Speech Perception Test: The subject is asked to listen to a series of 60 sounds, each of which consists of a double *e* digraph with varying prefixes and suffixes. The test is given in a four-alternative multiple-choice format, the task being to underline on an answer sheet the sound heard, the score is the number of errors.

The Seashore Rhythm Test: This test consists of 30 pairs of rhythmic patterns. The task is to judge whether the two members of each pair are the same or different and to record the response by writing an S or a D on an answer sheet. The score is either the number correct or the number of errors.

Finger Tapping: The subject is asked to tap his or her extended index finger on a typewriter key attached to a mechanical counter. Several series of 10-second trials are run, with both the right and the left hand. The scores are the average number of taps, generally over five trials, for the right and left hand.

Tests added to the battery by Reitan. Reitan added four components to the battery and these are given below:

The Wechsler Intelligence Scales: This test is given according to manual instructions and is not modified in any way. Most clinicians use the most current revision of these scales, although much of the early research was done with the Wechsler-Bellevue and the Wechsler Adult Intelligence scale (WAIS).

The Trail Making Test: In part A of this procedure the subject must connect in order a series of circled numbers randomly scattered over a sheet of 81\2 X 11 paper. In part B, there are circled numbers and letters and the subject's task involves alternating between numbers and letters in serial order. The score is time to completion expressed in seconds for each part.

The Reitan Aphasia Screening Test: This test serves two purposes in that it contains both copying and language-related tasks. As an Aphasia screening procedure, it provides a brief survey of the major language functions: naming, repetition, spelling, reading, writing, calculation, narrative speech, and right-left orientation. The copying task involves having the subject copy a square, Greek cross, triangle, and key. The first three items must each be drawn in one continuous line. The language section may be scored by listing the number of aphasic symptoms or by using the quantitative system developed by Russel and co-workers. The drawings are either not formally scored are rated through a matching to model system also provided by Russel and Colleagues.

Perceptual Disorders: The procedure actually constitute a sub-battery and include tests of the subject's ability to recognise shapes by touch and identifies numbers written on the fingertips, as well as tests of finger discrimination and visual, auditory, and tactile neglect. The number of errors is the score for all these procedures.

Other Tests: The Halsted Reitan battery was expanded further by other researchers to include more tests.

The Klove Grooved Pegboard Test: The subject must place pegs shaped like keys into a board containing recesses that are oriented in randomly varying directions. The test is administered twice, once with the right and once with the left hand. Sores are the time to completion in seconds in each hand and errors for each hand, defined as the number of pegs dropped during performance of the task.

The Klove roughness Discrimination Test: The subject must order four blocks covered with varying grades of sandpaper presented behind a blind with regards to degree of roughness. Time and error scores are recorded for each hand.

Visual Field Examination: Russel et. al include a formal visual field examination using a parameter as part of their assessment procedure.

Tests in the expanded version include the Wisconnin card Sorting, Thurstone word Fluency, Story Memory, Figural Memory, Seashore Tonal Memory, Digit Vigilance, Peabody Individual Achievement, and Boston naming Tests, plus a part of Boston Diagnostic Aphasia Examination.

3.8.4 Standardisation Research

The Halsted Reitan battery, as a whole, meets rigorous validity requirements. Following Halstead's initial validation it was cross-validated by Reitan and in several laboratories. Validity, in this sense, means that all component tests of the battery that contribute to the impairment index, discriminate at levels satisfactory for producing usable cut off scores for distinguishing between brain-damaged and non brain-damaged patients. The major expectations, the time sense and Flicker Fusion Tests, have been dropped from the battery by most of its users. In general, the validation criteria for these studies consisted of neurological and other definitive neurological data. It may be mentioned, however, that most of these studies were accomplished before the advent of computed tomography (CT) scan, and it would probably now be possible to do more sophisticated validity studies, perhaps through correlating the extent of impairment with quantitative measures of brain damage (e.g. CT scan or MRI measures). Validity studies were also accomplished with tests added to the battery such as the Wechsler scales, the Trail Making Test, and the Reitan Aphasia Screening Test, with generally satisfactory results.

By virtue of the level of inferences made by clinicians from Halsted-Reitan battery data, validity studies must obviously go beyond the question of presence or absence of brain-damage. The first issue raised related to discriminative validity between patients with left hemisphere and right hemisphere brain-damage such measures as Finger Tapping, the Tactual Performance, the Perceptual disorders sub-battery, and the Reitan Aphasia Screening test all were reported to have adequate discriminative validity in this regard. There have been very few studies, however, that goes further and provides validity data related to more specific criteria such as localisation and type of lesion.

It would appear from one impressive study that valid inferences concerning prediction at this level must be clinically, and one cannot call upon the standard univariate statistical procedures to make the necessary discriminations. The study provides the major impetus for Russel and co-workers' neuropsychological key approach, which was an essence an attempt to objectify higher-order inferences.

The discriminative validity of Halsted-Reitan battery in the field of psychopathology, mainly regarding schizophrenia, has been widely studied, and has been substantially reconceptualised since the discovery of numerous neurobiological abnormalities in schizophrenia. What we have now is really a neuropsychology of schizophrenia, to which the Halsted-Reitan battery has contributed.

Although there have been several studies of the predictive validity of neuropsychological tests with children and other studies with adults that does not use the full Halsted-Reitan battery no major formal assessment of the predictive validity of Halsted-Reitan battery has been accomplished with adults. Within neuropsychology, predictive validity has two aspects:

Predicting everyday academic, vocational, and social functioning and Predicting course of illness.

With regard to the first aspect, Heaton and Pendleton (1981) document lack of predictive validity studies using extensive batteries of the Halsted Reitan type. However they do not report one study in which Halsted Reitan successfully predicted employment status on 6-month follow-up. With regard to prediction of course of illness, there appears to be a good deal of clinical expertise, but no major formal studies in which the battery's capacity to predict whether the patient will get better, worse, or stay the same is evaluated. This matter is of particular significance in such conditions as head injury and stroke, since outcome tends to be quite variable in these conditions. The changes that occur during the early stages of these disorders are often the most significant ones related to prognosis.

In general, there has not been a great deal of emphasis on studies involving the reliability of the Halsted Reitan battery, probably because of nature of the tests themselves, particularly with regard to the practice effect problem, and because of the changing nature of those patients from whom the battery was developed. Golstein and Watson (1989) provided a review of Halsted Reitan battery reliability studies, as well as a test-retest study of their own, concluding that reliability levels were satisfactory in a number of different clinical groups.

The category test can have its reliability assessed through the split-half method.

Self Assessment Questions

1) Discuss in detail the Halstead-Reitan Neuropsychological battery.

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2) Trace the history of how the Halstead-Reitan battery was devised.

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3) What are the structure and content in the Halstead Reitan Neuropsychological battery?

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4) Discuss the theoretical foundation on which Halstead Reitan battery is devised.

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5) What are the validity and reliability of this test battery?

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3.8.5 The NIMHANS Neuropsychological Battery

There are two approaches of NIMHANS Neuropsychological Battery

I) The first approach was proposed by Dr. C.R Mukundan. The battery constitutes tests, some of which are adapted for the local patient population and some developed on the basis of principles of cerebral localisation and lateralisation of higher mental functions. This is a loosely packed battery from which appropriate tests can be chosen according to diagnostic needs and used along with other tests to form an integrated interpretation. The various tests included are:

Tests for Eliciting Frontal Lobe Dysfunction

1) Attention
   - Spontaneous arousal of attention
   - Distraction
   - Excessive broadening/ narrowing of attention
2) Tests of visual search
   - Visual scanning of numbers
   - Visual scanning of pictures
   - Visual exploration test
3) Mental set- Psychomotor perseveration
4) Psychomotor deficits
   - Test of Optic-kinaesthetic organisation
   - Test of optic-spatial organisation
   - Kinetic melody disturbance
5) Deficits in working memory
   - Test of mental control
   - Delayed response tests
6) Deficits of ideational and design fluency test
7) Deficits in visuospatial planning tasks
   - Bender gestalt test
   - Alexander passalong test
   - Object assembly test
   - Maze tests
8) Frontal Amnesia
9) Expressive speech disturbances
10) Changes in voluntary activity, personality and affect

Tests for Eliciting Temporal Lobe Dysfunction

1) Deficits of visual integration
   - Block design test
   - Object assembly test
2) Verbal and Visual learning and memory functions test
   - The verbal learning and memory functions test
   - Visual learning and memory functions test
3) Benton's visual retention test
4) Test of comprehension
5) Presence of nominal aphasia
6) Presence of conduction aphasia
   - Sentence repetition test

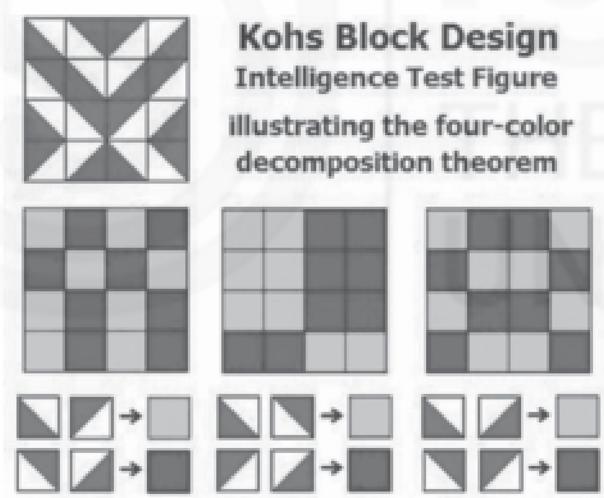
7) Recent history of cognitive, emotional and personality changes

Tests for Eliciting Parietal Lobe Dysfunction

1) Tests for visuospatial perception

 – Bender gestalt test

 – Block design test



 – Spatial comparison test
 – Spatial comparison using verbal report of differences

2) Presence of

 – Apraxia (ideomotor, ideational and constructional)
 – Agnosia (Visual object agnosia, prospagnosia, finger agnosia, autotopagnosia, hemisomatagnosia, simultagnosia, visual inattention, astereognosia and left-right disorientation)

II) The second approach was developed by Dr. Shobhani Rao et.al in 2004: This approach is more quantitative and the tests are organised on the basis of various neuropsychological functions. Performance on neuropsychological tests is influenced by socio-demographic variables such as age, education, and the test-taking attitude of the population. For example, the Indian population has wide variation with reference to education hence normative data collected elsewhere will be invalid in an Indian context, has seen the development of many tests in the recent past, these tests may have to be changed, as they may not have carry meaning to our population. For the above two reasons, we need to collect normative data for our population. The present study is the outcome of an endeavour to collect normative data for 18 widely used tests, which assess various domains and are in current international usage. The various tests included are:

Tests of Speed: can be categorised into

1) Motor speed - Finger tapping tests and
2) Mental speed -Digit Symbol Substitution Test

Tests of Attention:

3) Focused attention-Colour trails test
4) Sustained attention- digit vigilance test
5) Divided attention- the triads test

Tests of executive functions:

6) Phonemic fluency-controlled oral word association test (COWA)
7) Category Fluency-Animal names test
8) Design fluency-design fluency test

Working memory:

9) N back test (Verbal working memory and Visual working memory)
10) Self ordered pointing test

Planning

11) Tower of London test

Set shifting

12) Wisconsin card sorting test (WCST)

Response inhibition

13. Stroop test-NIMHANS version

Verbal comprehension

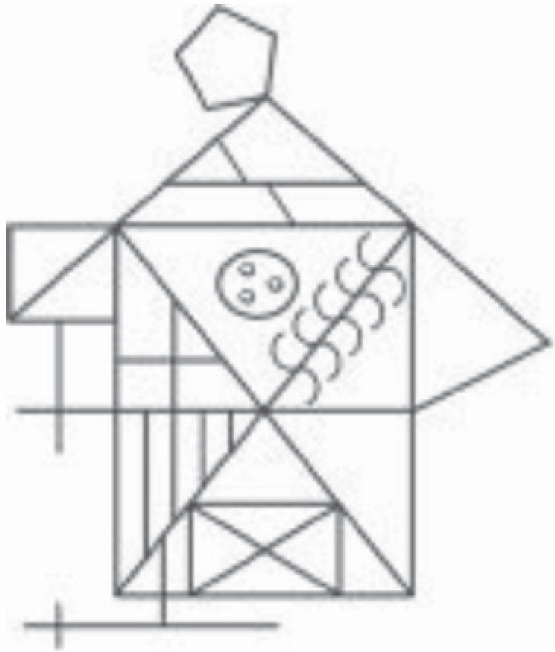
14) Token test

Tests of verbal Learning and memory:

15) Rey's Auditory verbal learning test
16) Logical memory test

Visuo constructive ability

17) Complex figure test



18) Design learning test

3.9 LET US SUM UP

In the first part of this chapter, general problems in the area of standardisation of comprehensive neuropsychological test batteries were discussed, while the second part contained brief reviews of the two most widely used procedures, the Halstead Reitan and the Luria Nebraska Neuropsychological batteries. These batteries have their advantages and disadvantages. The Halstead-Reitan is well established and detailed but is lengthy, cumbersome, and neglects certain areas, notably memory. The Luria Nabraska is also fairly comprehensive and briefer than the Halstead Reitan but is currently quite controversial and is thought to have major deficiencies in standardisation and rationale, at least by some observers. We have taken the view that all of these standard batteries are screening instruments, but not in the sense of screening for presence or absence of brain damage. Rather, they may be productively used to screen a number of functional areas, such as memory, language, or visual-spatial skills that may be affected by brain damage. With the development of the new imaging techniques in particular, it is important that the neuropsychologist not simply tally the referring agent what he or she already knows. The unique contribution of standard neuropsychological assessment is the ability to describe functioning in many crucial areas on a quantitative basis. The extent to which one procedure can perform this type of task more accurately and efficiently than other procedures will no doubt greatly influence the relative acceptability of these batteries by the professional community.

3.10 UNIT END QUESTIONS

1) Discuss the goals of neuropsychological assessment.

2) Describe structure and content of Luria-Nebraska neuropsychological test battery.

3) Mention the major contents of Halstead- Reitan battery of neuropsychological assessment.

4) Discuss the need and benefits of Indian standardisation of neuropsychological test batteries.

5) Explain the tests of executive functioning and working memory tests of NIMHANS neuropsychological battery.

3.11 SUGGESTED READINGS

Filskov, S. B., & Bold, T. J (1981). *Handbook of Clinical Neuropsychology*. New York: Wiley-Interscience.

G. Golstein & T. M. Incagnoli (Eds), *Contemporary Approaches to Neuropsychological Assessments* (pp.93-129),New York: Plenum Press.

Lezak, M. (1976). *Neuropsychological Assessment* (Ist ed.). New York: Oxford university press.

References

Christensen, A.L. (1975a). Luria's neuropsychological investigation. New York spectrum.

Christensen, A.L. (1975b). Luria's neuropsychological investigation: manual. New York spectrum.

Davis, K.(1983,october). Potential neurochemical and neuroendocrine validators of assessment instruments. paper presented at conference on clinical memory Assessment of older adults, Wakefield, M.A.

Golden, C. J(1981). A standardised version of Luria's neuropsychological tests;a quantitative and qualitative approach to neuropsychological evaluation. In Filskov, S. B., & Bold, T. J (Eds.),handbook of clinical neuropsychology(pp.608 to 642). New York: Wiley-Interscience.

Golden, C. J., Hemmeke, T. & Purisch, A. (1980). The Luria-Nebraska battery manual, Los Angeles: Western psychological services.

Golden, C. J., Hemmeke, T. & Purisch, A(1985) Luria-Nebraska neuropsychological battery manual form I & II. Los Angeles: Western psychological services.

Goldstein, G. (1982). Overview: clinical application of Halstead-Reitan and Luria-nebraska batteries. Paper presented at NE-RMEC conference, Northport, NY.

Goldstein, G., & Watson, J. R (1989). Test-retest reliability of the Halstead-Reitan battery and the WAIS in a neuropsychiatric population. The clinical neuropsychologist,3,265-273.

Heaton, R. K, Grant, I., & Matthews, C. G.(1991).comprehensive norms for an expanded *Halstead-Reitan battery*. Odessa, FL: psychological assessment resources.

Heaton, R. K, Pendleton, M. G. (1981). Use of neuropsychological test to predict adult patients everyday functioning. Journal of consulting and clinical psychology,49, 807-821.

Jastak, S.,& Wilkinson, G. S (1984).*wide range achievement test-revised.* Wilmington, DE: Jastak Associates, Inc.

Levin, H. S., Benton, A. L., & Grossman, R. G. (1982).*neurobehavioural consequences of closed head injury.* New York Oxford University Press.

Luria, A. R.(1973).the working brain. New York basic books.

Meier, M.J.(1974).some challenges for clinical neuropsychology. In R. M. Reitan & L. A. Davison(Eds), *clinical neuropsychology. Reed, J.C, & H.B.C(1997), Halstead-Reitan neuropsychological battery. In G. Golstein & T. M. Incagnoli (Eds) ,Contemporary approaches to neuropsychological assessments(pp.93-129),New York: Plenum Press.*

Reitan, R. M (1958*).Qualitative versus quantitative mental changes following brain damage.* journal of psychology,46,339-346.

Reitan, R. M (1964). Psychological deficits resulting from cerebral lesion in man. In J. M. Warren & K. Akert (Eds.), *the frontal granular cortex and behaviour* (pp.295-312). New York: McGraw Hill.

Reitan, R. M., & Wolfson, D. (1993). The *Halstead-Reitan neuropsychological test battery: theory and clinical interpretation* (2nd ed.).Tucson, AZ: neuropsychology press.

Russell, E. W., & Starkey, R. I (1993). *Halstead-Russell neuropsychological evaluation system: manual and computer program.* Los Angeles; Western psychological services.

Selz, M., & Reitan, R. M. (1979).Rules for neuropsychological diagnosis: classification of brain function in older children. *Journal of consulting and clinical psychology,47 ,258-264.*

Shelly, C., & Goldstein, G. (1983). Discrimination of chronic schizophrenia and brain damage with the Luria-Nebraska battery: A partially successful replication. *clinical neuropsychology,*5,82-85

Sherrill, R. E. jr. (1987). options for shortening Halstead's category test for adults. I Archives of clinical neuropsychology,*2,343-352.*

Wechsler, D. (1955). Wechsler adult intelligence scale manual. San Antonio, TX: The psychological corporation.

References (for pictures)

brainfitnessresources.com

en.wikipedia.org/wiki/Brain_fitness

assessmenttoolshop.com

UNIT 4 BEHAVIOURAL NEUROPSYCHOLOGY, BRAIN FITNESS AND ACTIVITIES THAT PROMOTE BRAIN FITNESS

Structure

4.0 Introduction

4.1 Objectives

4.2 Neuropsychology

- 4.2.1 Definition of Neuropsychology
- 4.2.2 Brief History of Neuropsychology
- 4.2.3 Neuropsychology and Related Fields

4.3 Behavioural Neuropsychology

- 4.3.1 Introduction
- 4.3.2 Techniques Used in the Cognitive Retraining

4.4 Brain and Behaviour

4.5 Brain Fitness

4.6 Brain Training

- 4.6.1 General Activities that Promote Brain Fitness
- 4.6.2 Activities for Improving Specific Cognitive Domains

4.7 Let Us Sum Up

4.8 Unit End Questions

4.9 Suggested Readings

4.0 INTRODUCTION

This unit is about neuro bio behavioural psychology. It starts with the definition of Neuropsychology and continues on to discuss the evolution of neuropsychology. The historical aspects are covered in detail in tis section. This is followed by a detailed discussion of the relationship of neuropsychology to other scientific and related fields such as experimental neuropsychology, cognitive neuropsychology etc. Then a definition of behavioural neuropsychology will be presented followed by the various techniques used in cognitive training. The next section deals with brain behaviour relationship and the various aspects related to the same. This is followed by a section on brain fitness and how to retain such fitness and the exercises needed for the same. Then the section presents measures to be used to improve specific cognitive domains.

4.1 OBJECTIVES

After completing this unit, you will be able to:

- Define Neuropsychology;
- Trace historically the development of neuropsychology;
- Describe the relationship of neuropsychology to other related fields;

- Define behavioural neuropsychology;
- Elucidate the technbiques used in cognitive retraining;
- Delineate the relationship between brain and behaviour;
- Explain what is brain fitness;
- Explain the various methods used to retain the fitness of the brain; and
- Analyse the various activities related to mental stimulation.

4.2 NEUROPSYCHOLOGY

4.2.1 Definition of Neuropsychology

According to Bruce, the term neuropsychology was first used by Williams Osler. It was then used by D.O. Hebb, in a subtitle in his 1949 book The Organisation of behaviour: A Neuropsychological Theory. Although neither defined nor used in the text itself, the term was probably intended to represent a study that combined the neurologist's and physiological psychologist's common interest in brain function. Traditionally defined, neuropsychology is the study of (and the assessment, understanding, and modification of) brain-behaviour relationships. The contemporary definition is strongly influenced by two traditional foci for experimental and theoretical investigations in brain research: the brain hypothesis, the idea that the brain is the source of behaviour; and the neuron hypothesis, the idea that the unit of brain structure and function is the neuron.

Neuropsychology seeks to understand how the brain, through structure and neural networks, produces and controls behaviour and mental processes, including emotions, personality, thinking, learning and remembering, problem solving, and consciousness. The field is also concerned with how behaviour may influence the brain and related physiological processes, as in the emerging field of psychoneuroimmunology (the study that seeks to understand the complex interactions between brain and immune systems, and the implications for physical health). Neuropsychology seeks to gain knowledge about brain and behaviour relationships through the study of both healthy and damaged brain systems. It seeks to identify the underlying biological causes of behaviours, from creative genius to mental illness, that account for intellectual processes and personality

Neuropsychology is a multidisciplinary science. It draws information from many different areas of study across many different scientific disciplines. The areas of study which contribute to neuropsychology include: anatomy, animal biology, biophysics, ethology, human experimental psychology, human clinical psychology, psychiatry, medicine, neurology, chemistry, physiology, physiological psychology, philosophy and physics.

The neuropsychologist uses objective tools, that is neuropsychological tests to tie the biological and behavioural aspects together. Through the use of tests, the clinical neuropsychologist is able to differentiate whether or not a behavioural abnormality is more likely caused by a biological abnormality in the brain or by an emotional or learned process.

Neuropsychological understanding is achieved through a comprehensive exploration of the neurophysiological foundation of behaviour and seemingly infinite potential contributing factors. Everyone's brain is wired differently, a product of native biological structure, past experiences, physical health, learned responses and personality, injuries and diseases, and a host of other factors. Clinically, it is the role of the neuropsychologist to sort out the factors that influence how the brain is working in order to understand disease expression, progress, and recovery.

4.2.2 Brief History of Neuropsychology

Greek and Roman Period

This period shows a great advancement in thinking: Medicine begins to be seen as a science, and philosophers/physicians begin to study the relationship between the body and behaviour.

One important question is debated: What structure in the body is the "seat of intellect"?

Hippocrates: argued that disease was a result of an unhealthy brain or body, rather than the result of more mystical influences such as demons, gods, or evil spirits. He was a critical force in developing his Humoral Theory. According to the humoral theory, disease is owing to imbalance among the four humors.

Plato: argued for a tripartite theory of behaviour, according to which:

- head is the seat of intellect;
- heart is the seat of anger, fear, pride and courage;
- liver is the seat of lust, greed, and desire.

Galen, the most influential physician in the Roman Empire, also has great impact on western ideas regarding the mind and brain. This physician to four Roman emperors wrote between five hundred and six hundred treatises.

- focused again on the brain as the location of cognitive function in the body.
- argued that the brain transforms "vital spirits" to "animal spirits"; this idea was basically a variation on the older humoral theories of Hippocrates.
- believed animal spirits are then stored in the ventricles, and the function of the neurons was to carry the spirits throughout the body and thus control behaviour.

Middle Ages

The Middle Ages was a period of little significant advancement in understanding the brain or behaviour. In particular, the accepted understanding of brain physiology and function came from Galen, and the church argued that the most important parts of the brain were the ventricles:

- Anterior ventricle controls perception.
- Middle ventricle controls cognition.
- Posterior ventricle controls memory.

The Renaissance-Important philosophical advances: DaVinci showed that the ventricles in higher animals such as humans looked very different than previously believed (though he still believed in the humoral theory).

Andreas Vesalius: In "On the Workings of the Human Body," he made several important observations: human ventricles and the ventricles of other mammals are very similar; yet, other mammals are not able to show similar "reasoning." In fact, relatively stupid animals like cows had larger ventricles than humans. It became obvious that large ventricles were not the key to intelligence.

Descartes thought of the body as an automaton. The nerves and brain control the reflexive actions of the automaton. Also believed that at the pineal gland in the brain. And concluded that there is a spiritual soul and the physical brain, and the soul and brain interact to generate human behaviour.

Gall theorised (correctly) that different parts of the brain carried out different cognitive and behavioural functions.

Flourens argued that neuroscience had to be empirical. He developed the theory of cortical equipotentiation:

- **Cerebellum:** important for movement (correct)
- **Medulla:** important for vital functions (correct)
- **Cerebral cortex:** completely undifferentiated (incorrect).

Broca: studied the functional localisation of human speech in patients with cortical brain damage. Broca's work did not conclude the debate about localisation of function, in part because replicating clinical patient studies is difficult. Thus, the debate between localisation and holism continued.

Fritsch and Hitzig supported the theory of functional localisation via their discovery of the motor cortex. Unlike Broca's work, which depended on the use of clinical patients (hence, it's imprecision), Fritsch and Hitzig did electrical stimulation and lesion work with dogs. These tools and methods allowed more precise replication.

The Neuron Debate

During this same period in which clinical patient data and comparative physiological studies were helping advance the field of neuropsychology, new tools played an important role in the study of the brain. The development of more powerful microscopes and new staining techniques that allowed researchers to see the structure of the neuron.

- **Neuron doctrine:** By arguing that neurons are individual units or cells that are physically isolated from each other, this theory was preferred for most in the functional localisation school.

- **Nerve nets theory:** This theory proposed that neurons grow together to form interconnected nets that are physiologically inseparable in adult animals, more consistent with the theory of holism.

This debate was eventually resolved because of research carried out by Camillo Golgi; she developed an important staining technique that allowed scientists to see the neuron cell structure much more clearly. Using Golgi's new staining technique, Santiago Ramon y Cajal was able to show that neurons were in fact separate individual cells. These findings also provided additional support for the more general theory of localisation of function.

4.2.3 Neuropsychology and Related Fields

1) **Clinical Neuropsychology:** Clinical neuropsychology is the application of neuropsychological knowledge to the assessment, management and rehabilitation of people who have suffered illness or injury (particularly to the brain) which has caused neurocognitive problems. In particular they bring a psychological viewpoint to treatment, to understand how such illness and injury may affect and be affected by psychological factors. They also can offer an opinion as to whether a person is demonstrating difficulties due to brain pathology or as a consequence of emotional or other (potentially) reversible cause.

   Clinical neuropsychology seeks such understanding, particularly, in the case of how damaged or diseased brain structures alter behaviours and interfere with mental and cognitive functions.

   In the application of clinical neuropsychology, understanding the biological sources of individual differences, particularly, helps identify brain-based disorders in memory, personality, self-awareness (conscious experience), cognition, and emotional expression. Working backwards, then, from a look at abnormal behaviour obtained using formal tests, reasonable inferences about brain disorders can be reached. Understanding these neurofunctional changes (i.e., abnormalities) as a result of brain changes (i.e., injury) defines parameters for current and future behavioural expectations in the lifestyle of the individual.

   Combined with additional understanding of biopsychosocial factors that coalesce into behavioural expression, the neuropsychologist can gain a comprehensive impression of what is normal or abnormal behaviour. As our knowledge of recovery from brain injury improves, such understanding provides realistic expectations for remediation (restoration or adjustment) of disordered behaviour.

2) **Experimental neuropsychology**: This is an approach which uses methods from experimental psychology to uncover the relationship between the nervous system and cognitive function. The majority of work involves studying healthy humans in a laboratory setting, although a minority of researchers may conduct animal experiments. Human work in this area often takes advantage of specific features of our nervous system (for example that visual information presented to a specific visual field is preferentially processed by the cortical hemisphere on the opposite side) to make links between neuroanatomy and psychological function.

3) **Cognitive neuropsychology:** is a relatively new development and has emerged as a distillation of the complementary approaches of both experimental and clinical neuropsychology. It seeks to understand the mind and brain by studying people who have suffered brain injury or neurological illness. One model of neuropsychological functioning is known as functional localisation. This is based on the principle that if a specific cognitive problem can be found after an injury to a specific area of the brain, it is possible that this part of the brain is in some way involved.

However, there may be reason to believe that the link between mental functions and neural regions is not so simple. An alternative model of the link between mind and brain, such as parallel processing, may have more explanatory power for the workings and dysfunction of the human brain. Yet another approach investigates how the pattern of errors produced by brain-damaged individuals can constrain our understanding of mental representations and processes without reference to the underlying neural structure. A more recent but related approach is cognitive neuropsychiatry which seeks to understand the normal function of mind and brain by studying psychiatric or mental illness.

4) **Neuroscience** generally refers to the study of neurons and the way they work in either animals or humans.

5) **Psychophysiology :** This refers to the study of psychological theories using physiological measures. In other words, psycho-physiologists normally try to understand some kind of behaviour or cognitive process. Their data generally includes some kind of physiological response, such as heart rate.

6) **Functional neuroanatomy** focuses on the study of anatomy using psychological measures. One application of this kind of research is to help medical professionals anticipate the possible problems a patient might experience following brain injury.

7) **Clinical neuroscience** concerns the study of clinical populations both to better understand neuroanatomy and to test psychological theories. A clinical neuroscientist often works in a hospital setting.

8) **Behavioural neurology** includes the study of disorders of mood, personality, intelligence, perception and arousal and is concerned with the structural basis of normal and abnormal behaviour.

9) **Neuropsychiatry** includes the study of organic basis of psychiatric illnesses.

Self Assessment Questions

1) Define Neuropsychology.

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2) Give a historical account of the development of neuropsychology.

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3) Elucidate the neuron debate.

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4) Discuss the relationship between neuropsychology and related fields.

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5) What is the difference between neuropsychology and experimental neuropsychology?

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4.3 BEHAVIOURAL NEUROPSYCHOLOGY

4.3.1 Introduction

Behavioural neuropsychology has been defined as 'the application of behaviour therapy techniques to problems of organically impaired individuals while applying a neuro-psychologically based assessment and treatment perspectives.' Essentially it is a meeting ground between clinical neuropsychology and behaviour therapy. In recent years, numerous important efforts have been made to apply behaviour therapy techniques to the rehabilitation and management of individuals with brain damage.

Behavioural neuropsychology approaches are based on the principles of learning theory and behavioural modification. Behavioural psychology principles are applicable in the following areas.

Visuoperceptive disorders

It relates to the way in which brain damage impairs people's ability to adapt to the visual world and the methods used to treat these disabilities which consist of

- Restoration of memory
- Cognitive retraining of attention and concentration

- Cognitive retraining of Language and communication
- Management of effects of brain damage on affect and mood
- Restoration of Executive functioning
- Management of impairments in the Activities of daily living

4.3.2 Techniques Used in the Cognitive Retraining

The techniques of behaviour therapy which are used in the cognitive retraining of various brain functions are the following.

Antecedent and consequence control

Therapy and consultation cannot be effective unless the behaviours to be changed are understood within a specific context. The process of understanding behaviour in context is called functional behavioural assessment. Therefore, a functional behavioural assessment is needed before performing behaviour modification. One of the simplest yet effective methods of functional behavioural assessment is called the "ABC" approach, where observations are made on Antecedents, Behaviours, and Consequences. In other words, "What comes directly before the behaviour?", "What does the behaviour look like?", and "What comes directly after the behaviour?" Once enough observations are made, the data are analysed and patterns are identified. If there are consistent antecedents and/or consequences, an intervention should target those to increase or decrease the target behaviour.

Environmental control

Restructuring and adaptations are set up to cue appropriate behaviours.

Response cost

This is a type of punishment in which the subject has to return back the token (positive reinforcement) earned earlier if the subject displays undesirable or maladaptive behaviour like anger, distraction etc.

Differential reinforcement (Training of incompatible behaviour)-

Differential reinforcement of incompatible behaviour (DRI) is used to reduce a frequent behaviour without punishing it by reinforcing an incompatible response. An example would be reinforcing clapping to reduce nose picking.

Differential reinforcement of other behaviour (DRO)

This is used to reduce a frequent behaviour by reinforcing any behaviour other than the undesired one. An example would be reinforcing any hand action other than nose picking.

Differential reinforcement of low response rate (DRL)

This is used to encourage low rates of responding.example: "If you ask me for a potato chip no more than once every 10 minutes, I will give it to you. If you ask more often, I will give you none."

Differential reinforcement of high rate (DRH)

This is used to increase high rates of responding. It is like an interval schedule, except that a minimum number of responses are required in the interval in order to receive reinforcement.

Contingency management

Here the use of positive and negative reinforcement schedules for discouraging distractions and maintaining goal directed behaviours.

Chaining

Chaining involves reinforcing individual responses occurring in a sequence to form a complex behaviour. It is frequently used for training behavioural sequences (or "chains") that are beyond the current repertoire of the learner. The chain of responses is broken down into small steps using task analysis. Parts of a chain are referred to as links. The learner's skill level is assessed by an appropriate professional and is then either taught one step at a time while being assisted through the other steps forward or backwards or if the learner already can complete a certain percentage of the steps independently, the remaining steps are all worked on during each trial total task. A verbal stimulus or prompt is used at the beginning of the teaching trial. The stimulus change that occurs between each response becomes the reinforcer for that response as well as the prompt/stimulus for the next response without requiring assistance from the teacher.

As small chains become mastered, i.e. are performed consistently following the initial discriminative stimulus prompt, they may be used as links in larger chains. (Ex. teach hand washing, tooth brushing, and showering until mastered and then teach morning hygiene routine which includes the mastered skills). Chaining requires that the teachers present the training skill in the same order each time and is most effective when teachers are delivering the same prompts to the learner. The most common forms of chaining are backward chaining, forward chaining, and total task presentation.

Shaping

The differential reinforcement of successive approximations, or more commonly, shaping is a conditioning procedure used primarily in the experimental analysis of behaviour. In shaping, the form of an existing response is gradually changed across successive trials towards a desired target behaviour by rewarding exact segments of behaviour.

Relaxation exercises

A relaxation technique (also known as relaxation training) is any method, process, procedure, or activity that helps a person to relax, to attain a state of increased calmness, or otherwise reduce levels of anxiety, stress or anger. Relaxation techniques are often employed as one element of a wider stress management program and can decrease muscle tension, lower the blood pressure and slow heart and breath rates, among other health benefits. Examples are- Jacobson's Progressive muscular relaxation technique, deep breathing exercise and pranayam.

Neurobiofeedback

Neurofeedback (NFB), also called neurotherapy, or EEG biofeedback, is a type of biofeedback that uses real time displays of electroencephalography to illustrate brain activity, often with a goal of controlling central nervous system activity. Sensors are placed on the scalp to measure activity, with measurements displayed using video displays or sound.

Neurofeedback is a type of biofeedback that uses electroencephalography to provide a signal that can be used by a person to receive feedback about brain activity.

Token economy

A token economy is a system of behaviour modification based on the principles of operant conditioning. Specifically, the original proposal for such a system emphasised reinforcing positive behaviour by awarding "tokens" for meeting positive behavioural goals. Ayllon's study included only adolescent males. Ayllon's tokens were secondary reinforcers, a secondary reinforcer is something that has no use to the individual in itself, but can be exchanged for a primary reinforcer. Secondary reinforcers include money, tokens or vouchers. A primary reinforcer is something that fulfills out needs directly, e.g. food, warmth or cigarettes satisfy a craving.

Observational learning

This is also known as vicarious learning, social learning, or modelling. This is a type of learning that occurs as a function of observing, retaining and replicating novel behaviour executed by others. It is argued that reinforcement has the effect of influencing which responses one will partake in, more than it influences the actual acquisition of the new response.

Prompting

A prompt is a cue or assistance to encourage the desired response from an individual. Types of prompts:

Verbal prompts: Utilising a vocalisation to indicate the desired response.

Visual Prompts: a visual cue or picture.

Gestural prompts: Utilising a physical gesture to indicate the desired response.

Positional prompt: The target item is placed closer to the individual.

Modeling: Modeling the desired response for the student. This type of prompt is best suited for individuals who learn through imitation and can attend to a model.

Physical prompts: Physically manipulating the individual to produce the desired response. There are many degrees of physical prompts. The most intrusive being hand-over-hand, and the least intrusive being a slight tap to initiate movement.

Self Assessment Questions

1) What do you understand by behavioural neuropsychology?

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2) Describe visuoperceptual disorders.

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3) What are the techniques used in cognitive retraining?

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4) Discuss chaining and shaping and neurobiofeedback.

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5) Describe token economy and observational learning.

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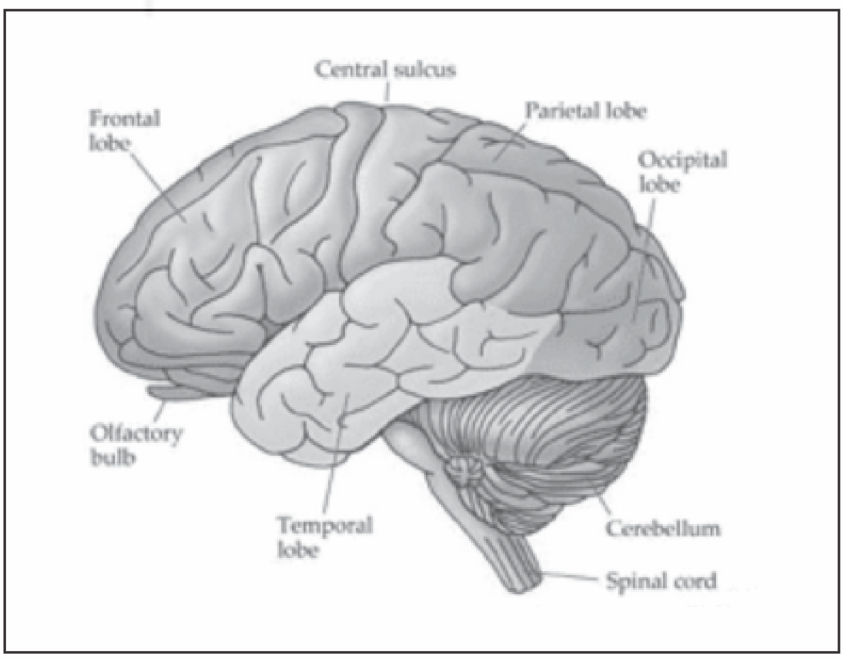
4.4 BRAIN AND BEHAVIOUR



Four pounds and several thousand miles of interconnected nerve cells (about 100 billion) control every movement, thought, sensation, and emotion that comprises the human experience. Within the brain and spinal cord there are ten thousand distinct varieties of neurons, trillions of supportive cells, a few more trillion synaptic connections, a hundred known chemical regulating agents, miles of minuscule blood vessels, axons ranging from a few microns to well over a foot and a half in length, and untold mysteries of how almost flawlessly all these components work together. This is the amazing brain.

The brain behaviour relationships, namely the functional system, were developed in the many works of Luria. A preferred term might be the 'distributed anatomical system'. The term emphasise that every complex psychological process has as its underpinning collections of nerve cells, both in the cerebral cortex and sub cortex, linked together through fibre pathways usually of greater complexity. Each of these anatomical systems has extensive connections with numerous other systems. Mesulam (1981) has expressed the major features clearly as follows:

- Components of a single complex function are represented within distinct but interconnected sites which collectively constitute an integrated network for that function.
- Individual cortical areas contain the neural substrate for components of several complex functions and may therefore belong to several partially overlapping networks.
- Lesions confined to a single cortical region are likely to result in multiple deficits.
- Severe and lasting impairments of an individual complex function usually involve the simultaneous involvement of several components in the relevant network and
- The same complex function may be impaired as a consequence of a lesion in one of several cortical areas, each of which is a component of an integrated network for that function.

4.5 BRAIN FITNESS

The term brain fitness reflects a hypothesis that cognitive abilities can be maintained or improved by exercising the brain, in analogy to the way physical fitness is improved by exercising the body. Although there is strong evidence that aspects of brain structure remain plastic throughout life, and that high levels of mental activity are associated with reduced risks of age-related dementia, scientific support for the concept of "brain fitness" is limited. The term is virtually never used in the scientific literature, but is commonly used in the context of self-help books and commercial products.

Brain fitness is the capacity of a person to meet the various cognitive demands of life. It is evident in an ability to assimilate information, comprehend relationships, and develop reasonable conclusions and plans. Brain fitness can be developed by formal education, being actively mentally engaged in life, continuing to learn, and exercises designed to challenge cognitive skills. Healthy lifestyle habits including mental stimulation, physical exercise, good nutrition, stress management, and sleep can improve brain fitness. On the other hand, chronic stress, anxiety, depression, aging, decreasing estrogen, excess oxytocin, and prolonged cortisol can decrease brain fitness as well as general health.

Brain fitness can be measured physically at the cellular level by neurogenesis. It can also be evaluated by behavioural performance as seen in cognitive reserve, improved memory, attention, concentration, executive functions, decision-making, mental flexibility, and other core capabilities. Neurogenesis is the creation of new neurons. The more active a particular brain cell is, the more connections it develops with its neighbouring neurons through a process called dendritic sprouting. A single neuron can have up to thirty thousand such connections, creating a dense web of interconnected activity throughout the brain. Each neuron can then be stimulated directly through experience (real or imagined) or indirectly through these connections from its neighbours, which saves the cell from cell death.

Consistent mental challenge by novel stimuli increases production and interconnectivity of neurons and nerve growth factor, as well as prevents loss of connections and cell death. The Advanced Cognitive Training for Independent and Vital Elderly (ACTIVE) nationwide (America) clinical trial is so far the nation's largest study of cognitive training. Researchers found that improvements in cognitive ability roughly counteract the degree of long-term cognitive decline typical among older people without dementia. The results, published in the Journal of the American Medical Association in 2002, showed significant percentages of the 2,802 participants age 65 and older who trained for five weeks for about 2½ hours per week improved their memory, reasoning and information-processing speed.

Joe Verghese, M.D. found that people with higher activity score had lower risks of Alzheimer's and dementia. An open question in the field is whether people who will later develop Alzheimer's are naturally less active, or whether intervening to raise an activity score will delay or prevent Alzheimer's. If the latter hypothesis were true, people could lower their dementia risk by 7% simply by adding one activity per week (such as doing a crossword puzzle or playing a board game) to their schedule. According to the findings of that same study, subjects who did crossword puzzles four days a week had a 47% lower risk of dementia than subjects who did a crossword puzzle just once a week.

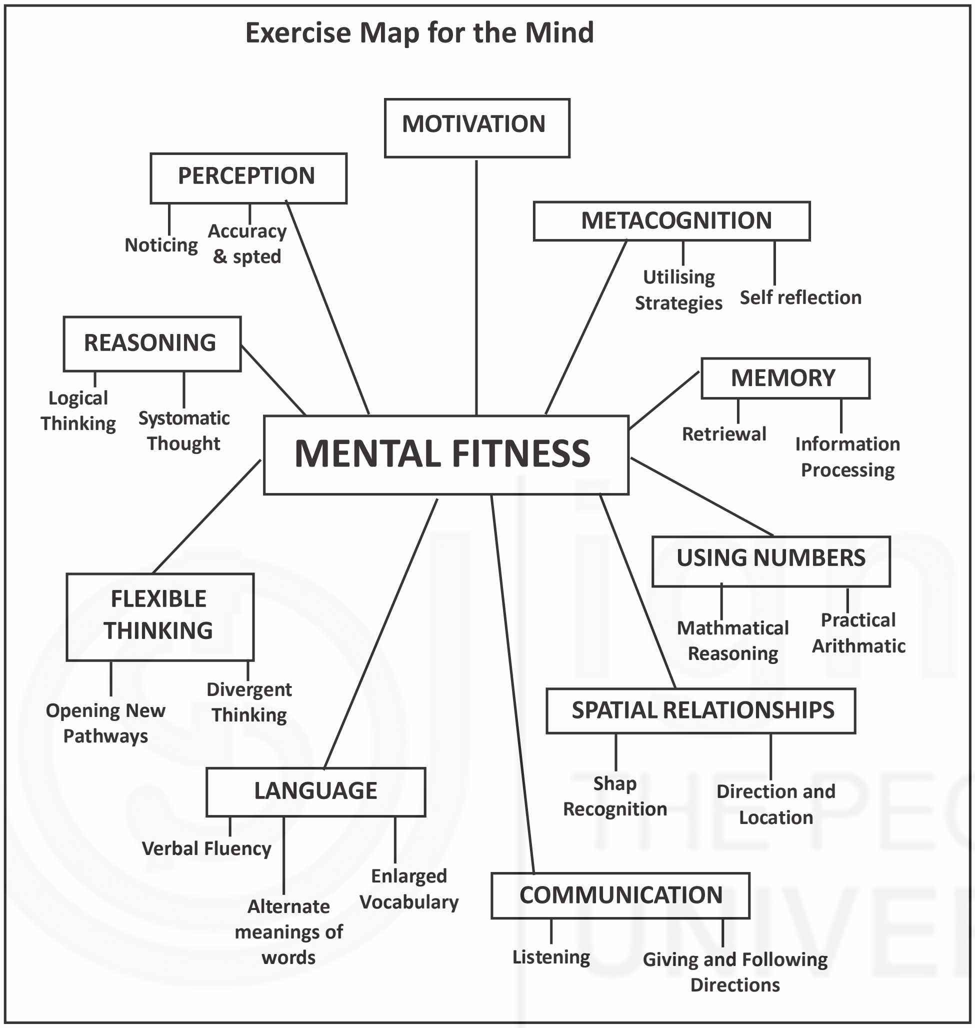
Brain fitness is a national health priority, as positive adaptation and healthy living clearly improves brain function. The good news is that the brain is adaptable and able to grow new brain cells with our experiences and new learning. We should examine the relationship between our lifestyle and our brain fitness. From before birth, through childhood, adolescence, and through adulthood and beyond we can optimize brain fitness. Continuing education about brain fitness is needed to maximize our potential.

Recent studies have culminated in an appreciation of importance of brain health and brain fitness, whether related to learning in school, participating in sports, work productivity, memory enhancement or mind-body health.

Brain health is a national priority. What is good for the heart is good for the brain. Lifestyle and brain fitness go hand-in-and Brain fitness programs should begin early in life and continue across the life span that involve positive adaptation and brain health.

Neuroplasticity and neurogenesis have fuelled the imagination toward increasing the brain's connectivity and improve speed of transmission which are based on your experiences and health.

4.6 BRAIN TRAINING



4.6.1 General Activities that Promote Brain Fitness

Physical fitness

It is an old saying that 'sound mind lies in sound body'. So the first and most important step towards the brain fitness is to be physically fit. Maintain physical health by monitoring blood pressure, blood sugar, cholesterol levels and calorie intake; immobilisation and physical inactivity are to be avoided at all costs. Physical exercise boosts the brain's rate of neurogenesis throughout life. Both physical exercise and the challenge from mental exercise increase the secretion of nerve growth factor, which helps neurons grow and stay healthy. For example

Dancing regularly

practicing yoga

Aerobic exercise 3 hours per week for 3 months helped healthy seniors grow new brain cells in their frontal lobes (increased attention and memory) and corpus callosum (speed of processing)

Stretching exercises and supervised weight-bearing exercises are recommended. The best single exercise done without equipment is standing on one foot for as long as possible and then switching to the other foot and doing the same thing. This combines muscle strengthening, balance, and coordination;

Walk at least four hours a week

Learn the art of napping for short periods during the day. These provide a temporary respite from the day's activity and lead to improvements in energy, alertness and mood; Melatonin may make sense for night-time sleep disturbances, but no convincing research exists that it exerts any positive effect on longevity.

Adopt a brain healthy diet

Research suggests that high cholesterol may contribute to stroke and brain cell damage. A low fat, low cholesterol diet is advisable. And there is growing evidence that a diet rich in dark vegetables and fruits, which contain antioxidants, may help protect brain cells.

Remain socially active

Social activity not only makes physical and mental activity more enjoyable, it can reduce stress levels, which helps maintain healthy connections among brain cells.

Mental Health: Positive mental health is very necessary for happiness and good functioning of the body and the brain. It can be attained through the following measures:

- Work as long as possible in a career
- Retain consistent level of physical activity
- Find opportunities to converse
- Avoid excessive use of alcohol and other drugs
- Active group activities – tennis, dancing
- Passive group activities – volunteering, art class
- Active individual activities – walking, swimming
- Passive individual activities – cooking, word puzzle

Try to retain a sense of humor and do everything you can to keep up your present friendships and strike up new ones.

Try cultivating a few with the younger generation, loneliness is the greatest challenge to overcome as you advance toward the mature years.

Build up your tolerance for being alone; find pleasure in your own company; consider a pet.

Reduce stress: Mentally reformulate everyday frustrations and problems into challenges.

When facing mental challenges, go slowly, check your work, draw on your years of experience, and rely less on your speed of response. Reaction time lengthens with age. Compensate by using your wisdom and accumulated life experience.

Mental stimulation: Activities of mental stimulation directly contributes for improving the brain fitness. Some research shows that brain stimulation can help prevent age-related cognitive decline, reverse behavioural assessment declines in dementia and Alzheimer's and can also improve normally functioning minds. Brain fitness can be improved by various challenging activities such as playing chess or bridge.

Structured computer based workouts: This is not a substitute for a social life, but a place to be stimulated with new information, find others who share common interests, and engage in activities (internet bridge groups) that you may not be able to attend outside the home; games like bingo, bridge, and chess help maintain sharpness in different mental domains.

Stay curious and involved commit to lifelong learning

Read, write, work crossword or other puzzles. Activities that involve ahead planning, like chess or crossword puzzle, stimulate the Frontal lobe area of the brain

Attend lectures and plays

Enroll in courses at your local adult education center, community college or other community group

Activities like learning a new language or painting require the coordinating of multiple regions of the brain.

Self Assessment Questions

1) Discuss brain behaviour relationship.

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2) What is meant by brain fitness?

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3) What are the activities that will promote brain fitness?

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4) Describe positive mental health and how to ensure the same?

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5) How do you reduce stress? Give the methods to reduce stress.

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6) What is meant by mental stimulation?

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4.6.2 Activities for Improving Specific Cognitive Domains

- Attention and Concentration
- Letter cancellation
- Word cancellation
- Grain sorting
- Stringing work
- Matching
- Dot joining
- Spot the difference
- Finger dexterity games
- Scissor work
- Computer games

Reasoning, Planning and Problem Solving

- Mazes
- Games on computer like minesweeper and solitaire
- Soduku
- Puzzles
- Tower games
- Chinese checker
- Matrices

Memory

1) Talk to yourself, either aloud or to yourself about tasks you are performing to keep your mind on the task and help you recall whether the job has been accomplished.

2) Paraphrase and repeat back what you have said as a way to focus on the conversation and recall the important details.

3) Control the rate at which information is presented to you by taking small breaks and rest between tasks.

4) Reduce interference by limiting distractions by turning off the television or radio when having a conversation.

5) When shopping, group items into categories that can later act as reminders. Group grocery store items into fruits, meats and canned goods to assist in recalling the items as you go through the store.

7) Connect new information with old information. When meeting a new person named "Brenda", compare and contrast her characteristics with those of another person named "Brenda".

8) Rhyme new information with old.

9) Practice a new task in shorter, more frequent intervals rather than longer and less frequent sessions.

10) To reduce the anxiety of retrieving information, try deep breathing or other relaxation techniques.

11) Caregivers can help out a forgetful loved one by cuing them with the first letter of the word they are looking for or by saying the category of the lost word, like hardware, clothing or food.

Memory enhancing devices to consider:

1) *Written Reminders:* Write yourself a note about a certain task and put it where you will easily see it. Remember to write it down, and always write it down in one place.

2) *Timers:* To provide an auditory cue for tasks in the future, set a watch alarm, alarm clock or cooking timer to go off when a task needs to be performed.

3) *Computerised Paging System:* Set your paging system to vibrate or produce a tone to display a message about the event or task you need to be reminded of.

4) *Electronic Organiser:* Besides personal information, you can enter the task you need to perform and the time you need to begin.

5) *Digital Voice Recorder:* These can store simple information to be used throughout the day to effectively remind you of things to do or even where your car is parked at the mall.

Self Assessment Questions

1) What are the activities to improve the cognitive domains?

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2) How do we help a person to improve reasoning, planning etc abilitieis?

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3) How do we help improve memory in a person?

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4) What are the various memory enhancing devices?

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Language and Communication

1) **The direct stimulation technique:** In this technique, repetitive verbal exercises are given to the patient to stimulate language.

2) **PACE (Promoting Aphasics Communicative Effectiveness) Therapy:** Davis and Wilcox (1981) proposed promoting aphasics communication effectiveness technique. In it the patient and therapist exchange the functions of transmitter and receiver in such a way that during the treatment, real situations of communication are produced. In a natural situation of communication, the adequate use of language requires constructing a scheme of mental representation. PACE uses graphic representations of objects unseen by receiver as message.

This focuses the patient to use different strategies of communication and introduce new elements into the message with the aim of facilitating comprehension. Thus the patient achieves a more integrated development of language whether acting as a transmitter or receiver. The technique thus allows the use of different forms of communication fulfilling its aim of increasing communication skills. Finally patient must receive adequate feedback of his communication efficiency.

3) **Compensatory approach:** Bliss symbols are flash cards which contain symbols instead of words as means of communication. Communication boards, picture charts and electrical scanning units can also be used for facilitating communication.

4) **Behavioural rehearsal through Role playing**: In the patients whose communication problem like stuttering increases in a particular social situation, role-playing can be used for rehearsal of desired communication pattern, reducing anxiety associated with the situation and building up self-confidence.

5) **Tea party technique:** In this technique language is taught in a meaningful setting like tea party, dinner situation etc. The idea is that the client learns how a tea party runs in terms of using different material, associated actions and comprehending and communicating various aspects of language.

6) **Joint action routines:** In it a situation or series of situations such as bus travel, lunch period etc., with a unifying theme are selected and the expected words, sentences, gestures, or signs are carefully selected so that the roles can be assigned. While the situation is carried out the following techniques can be used to vary the use of different utterances

   Sabotage- Deliberately modifying equipment so as to lead an unpredictable event

   Omission- not doing something expected

   Error- doing something incorrectly

   Events- doing new things in routine contexts and

   Choice-Offering alternatives e.g. two kinds of food offered in a lunch break setting.

7) **Management for reading and writing problem**

Step I

Error analysis: This involves identification and analysis of the types of errors the patient does. It involves knowledge of basic sight words, configuration cues (like word lengths, capital letters, double letters and letter height), context cues (like pictures and words), phonetic analysis of consonents, phonetic analysis of vowels, prefixes, suffixes and dictionary skills etc. Once the error analysis is done following techniques can be used to develop reading and writing skills.

a) **For improving basic sight words:** Flash cards can be used and making the patient familiar with 4 to 5 words

b) **Multisensory method or Fernald method:** In it a written word on flash card is presented in front of the patient. Then the patient has to trace the word with finger and saying it aloud while tracing. Then the patient writes the word without tracing, patient recognise the word with memory and then each word is filed in alphabetic order and used in stories.

c) **Gillingham method or Phonetic method:** A small card with one letter printed on it is exposed to the patient and the name spoken by therapist. The name is then repeated by patient.

As soon as the name is mastered, its sound is made by the therapist and repeated by patient. The original card is then exposed and the therapist asks what this letter says. The patient is expected to give the sound.

Without the card exposed, the therapist makes the sound represented by letter and says, "tell me the name of the letter that has this sound. The Patient is expected to give the name of the letter. The letter then written by the therapist and its form is explained to the patient. Then letter is traced, copied, written from memory and then written again by looking at it.

Finally, the therapist makes the sound and instructs the patient to write the letter that has this sound.

d) **For writing:** For improving writing skills, regular practise of writing is required. After each practise session adequate feedback should be given with reinforcements.

Visuospatial Functions

1) **Computerised tasks involving visual scanning and reaction time:** The program uses a light board with 20 coloured lights and a target can be moved around the board at different speeds. With this device the patient can be systematically trained to attend to the neglected visual field. This procedure with addition of other tasks e.g. size estimation and body awareness task improves visual perceptual functioning. In left unilateral neglect syndrome, patients may be made to actively scan left hemisphere by implanting left visual field anchor like bright red light stimulus, response pacing, immediate feedback etc.

2) **Multi-sensory cuing strategy:** It consists of copying sentences using left visual field, auditory cuing to scan left hemi-space and auditory nonverbal stimuli, may be successfully used to direct and orient patients to left hemi-space.

3) **Puzzles and Mazes:** It can be used for improving visuo-spatial planning.

4) **Manipulation of Blocks:** It can be used for visuospatial perception.

5) **Figures, diagrams and matrices:** These are used and practiced for enhancing visuo-spatial skills.

Self Assessment Questions

1) How to improve language and communication?

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2) What are the measures used in the management of reading and writing problems?

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3) How to enhance visuo spatial functions?

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4.7 LET US SUM UP

In this unit we defined neuropsychology. Presented an account of historical review of the development of neuropsychology over the centuries. We then discussed the relationship of neuropsychology to various related fields. Then we had a discussion on the neurons and their functions and roles and this was related to neuropsychology. This was followed by a definition of behavioural neuropsychology. We described the visuo perceptual disorders. Then we put across the many remedial measures to overcome these disorders. We discussed the techniques used in cognitive retraining. Then we dealt in detail the brain behaviour relationship. We defined brain fitness and the various activities one should take up in order to enhance and retain the brain fitness. Following this we defined positive mental health and discussed the ways and means to reduce stress. The next section was on mental stimulation and the various measures used to stimulate the mind and the brain. We put forward the various activities to improve the cognitive domains, and presented measures to improve one's reasoning and planning capabilities. Then a section was devoted to memory and how to enhance the same.

4.8 UNIT END QUESTIONS

1) What is neuropsychology and how it is different from behavioural neuroscience? Discuss the idea of multidisciplinary approach in dealing behavioural problems related to brain impairment.

2) What is behavioural neuropsychology? Describe any five techniques of behavioural neuropsychology for the restoration of memory and language functions.

3) How much is the concept of brain fitness relevant in the present era? What sorts of life style changes are required for achieving brain fitness?

4) Write short notes on the following topics:
   a) Brain behaviour relationship
   b) Improving attention and concentration
   c) Phonetic method
   d) Cognitive neuropsychology
   e) Biofeedback

4.9 SUGGESTED READINGS

Alderman N and Ward A. Behavioural treatment of the dysexecutive syndrome: Reduction of repetitive speech using response cost and cognitive over learning. Neuropsychological Rehabilitation. 1991;3:63-76. As in : Hanlon R. Neuropsychological rehabilitation. In: Zaidel DW (ed). Neuropsychology. Academic Press: New York; 1994: 317-333.

brainfitnessresources.com

Kapur. M, Hinsave. U, Oommen A (2002). *Psychological Assessment of Children in the Clinical Setting*. NIMHANS publications Bangalore.

Kolb B, Whishaw I.Q (1990). *Fundamentals of Human Neuropsychology* (3rd ed). W.H Freeman and company New York.

Walsh K.(1994). *Neuropsychology: A Clinical Approach* (3rd ed). B.I Churchill Livingstone Pvt. Ltd. New Delhi.

References

Cullum.C.M (1998). Neuropsychological assessment of adults. In Bellack A.S, Herson M, Reynolds. C.R (eds) Comprehensive clinical psychology: 4 328-333.

en.wikipedia.org/wiki/Brain_fitness

en.wikipedia.org/wiki/Behaviour_modification

Hanlon RE, Clontz B et al. Management of severe behavioural dyscontrol following subarachnoid haemorrhage. Neuropsychological Rehabilitation. 1993;3:63-76. As in : Hanlon R. Neuropsychological rehabilitation. In: Zaidel DW (ed). Neuropsychology. Academic Press: New York; 1994: 317-333.

Rao.T.A.S (1992); Manual on developing communication skills in mentally retarded persons, Shree Ramana Process, Secundrabad.

Woods RL. Rehabilitation of patients with disorders of attention. Journal of head trauma rehabilitation; 1986; 43-53. As cited in : Hanlon R. Neuropsychological rehabilitation. In: Zaidel DW (ed). Neuropsychology. Academic Press: New York; 1994: 317-333.

UNIT 1 BRAIN SIZE AND DEVALUATION, GENES, BRAIN AND BEHAVIOUR

Structure

1.0 Introduction

1.1 Objectives

1.2 Brain Size

1.2.1 Male Female Brain Differences

1.3 Indicators of Biological Basis of Behaviour

1.3.1 Behaviour often is Species Specific

1.3.2 Behaviour often Breed True

1.3.3 Behaviours Change in Response to Alterations in Biological Structures

1.3.4 Behaviour has an Evolutionary History

1.4 Human Brain and Human Behaviour

1.5 Genes, Brain and Behaviour

1.5.1 Definition of Behavioural Genetics

1.5.2 Definition of a Gene

1.5.3 Description of DNA

1.5.4 Definition of Chromosome

1.6 Genes Influence Behaviour and Attitudes

1.7 Let Us Sum Up

1.8 Unit End Questions

1.9 Suggested Readings

1.0 INTRODUCTION

The brain is the organ that sets us apart from any other species. It is not the strength of our muscles or of our bones that makes us different, it is our brain.— Pasko T. Rakic

Brain is an important part of our various organs. Without brain humans do not exist. In this unit we will be dealing with brain, brain size and how this varies in humans and especially between males and females. Then we discuss the biological indicators of behaviour of humans within which we will show how behaviour is species specific, and how behaviour keeps occurring and how behaviours change in response to alternations in biological structures and processes. Then we trace the evolutionary history of behaviour. This is followed by brain and behaviour and how they are interrelated. What all aspects of behaviours are produced by the activities within the brain etc. Then we deal with genes, brain and behaviour within we will be discussing the definition of behavioural genetics and then we give the definition of gene, DNA and chromosomes. Then we delineate how behaviour and attitudes are influenced by genes.

1.1 OBJECTIVES

After completing this unit, you will be able to:

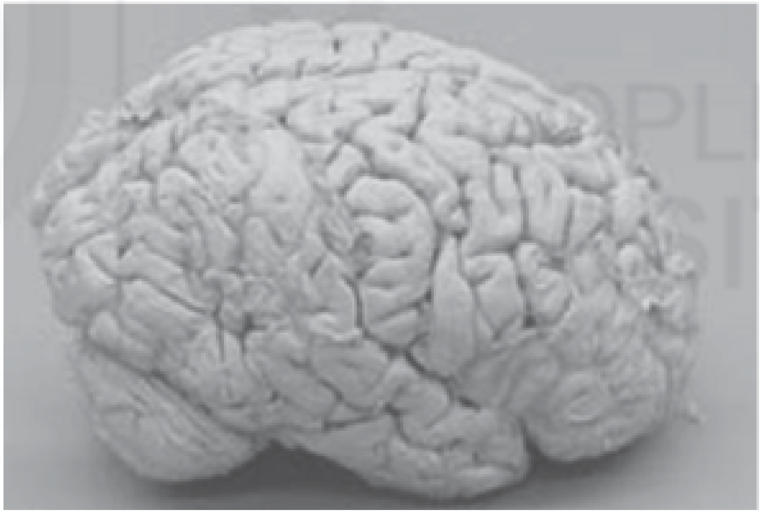
- Elucidate brain and brain size;

- Differentiate between male and female brain size;
- Elucidate the indicators of biological basis of behaviour;
- Explain how behaviour change in response to alternations in biological structures;
- Describe the relationship between brain and behaviour;
- Define genes, behavioural genetics;
- Describe DNA and Chromosomes; and
- Explain how genes influence behaviour and attitudes.

1.2 BRAIN SIZE

The brain is one of the most important organs because it controls so many of the body's functions. The brain makes up only 2% of the total body weight. The volume of a human brain, otherwise known as cranial capacity, varies depending on several factors, such as age, environment, and body size.

Throughout the history of neuroscience certain presumptions have been made. One of these is that the development of increased cognitive capacity is related to increased brain size over evolutionary time. This was the view held by Charles Darwin, who wrote "the difference between man and the higher animals, great as it is, is certainly one of degree and not of kind"



Approx Human brain length=15cm
Approx brain weight=1400g

Brain injury could result in permanent damage or even death. Therefore, it is very important for the brain to be protected.

The brain and spinal cord make up the central nervous system. The skull (cranium), made of bone, protects the brain. The three major sections of the brain are:

i) the forebrain,

ii) the midbrain, and

iii) the hindbrain.

The forebrain

The forebrain includes the cerebrum, the largest part of the brain that takes up about two thirds of the brain.

- The cerebrum is divided into two hemispheres that is the left and the right hemispheres. It controls the interpretation of impulses from sense receptors, memory, learning, and emotions.

The midbrain

- The midbrain carries messages between the forebrain and hindbrain.

The hindbrain

The hindbrain is composed of the cerebellum and the medulla oblongata.

- The cerebellum controls all voluntary and some involuntary movements.
- It maintains balance and coordination.

The medulla oblongata

- This controls many involuntary functions such as breathing and heartbeat.
- If the medulla is destroyed, a person will die.
- The medulla is connected to the spinal cord, which connects the peripheral nervous system with the brain and controls reflexes (automatic responses).

Early humans are known as hominids. *Australopithecus* was the first human like creature, that lived in Africa about 5 million years ago. Their brains were 350 to 450 cubic centimeters, the size of a gorilla. *Homo habilis*, which was more human like, lived two million years ago and was the first to use stone tools. Their brain volume was about 700 cubic centimeter. The Neanderthals, which are more modern humans, are classified in the same species (*Homo sapiens*) as today's humans. However, living humans belong to a different subspecies, *Homo sapiens*. Although the Neanderthal brain was larger than that of humans today, it does not mean that the Neanderthals were more intelligent, because brain size is related to body size and the temperature of the environment.

The volume of a human brain, otherwise known as cranial capacity, varies depending on several factors, such as age, environment, and body size. The volume is usually measured in cubic centimeters (cm^3 or cc). Modern humans have cranial capacities from 950 cm^3 to 1800 cm^3, but the average volume of a modern human brain is 1300 cm^3 to 1500 cm^3.

The brain is a three-dimensional *form*, weighing about 3 pounds in adults less than a pound in newborns. Each of the 100 billion cells, called "neurons", in our brain connects with thousands of other neurons. There are also another 900 billion or so "supporting cells" in the brain. It is believed that there are around 1 quadrillion (10^{15}) connections between neurons, called "synapses", in the entire brain, where activity happens to create the mind.

So the development of the brain is largely a problem of how to connect 100 billion neurons using 1 quadrillion synapses, so that the brain can operate, signals can be processed, memories can form, and responses can be effected.

About 6,000 of our genes seem to be active only in the brain; gene-produced proteins, which induce neurons to grow in specific directions inside the skull, and others that allow them to recognise friendly neurons and cling to them and make a synapse, and then allow signals to be transmitted across those synapses together.

Once neurons have made their specific connections together in the course of their development, those same synapses can be used to send signals from one neuron to other.

Synapses are not truly connections but gaps between neurons into which signaling chemicals are injected. Usually, those chemicals are neurotransmitters, like serotonin, which are used to send signals from one neuron to the next across the synaptic gap. But hormones and other compounds, like anti-depressants, in the bloodstream are also able to influence the signal of many synapses and other receptors at a global level.

The adult human brain weighs on average about 3 lb (1.5 kg) with a size (volume) of around *1130 cubic centimeters* (cm^3) in women and 1260 cm^3 in men, although there is substantial individual variation. Men with the same body height and body surface area as women have on average 100g heavier brains, although these differences do not correlate in any simple way with gray matter neuron counts or with overall measures of cognitive performance. The volume is usually measured in cubic centimeters (cm^3 or cc). Modern humans have cranial capacities from 950 cm^3 to 1800 cm^3, but the average volume of a modern human brain is 1300 cm^3 to 1500 cm^3.

1.2.1 Male Female Brain Differences

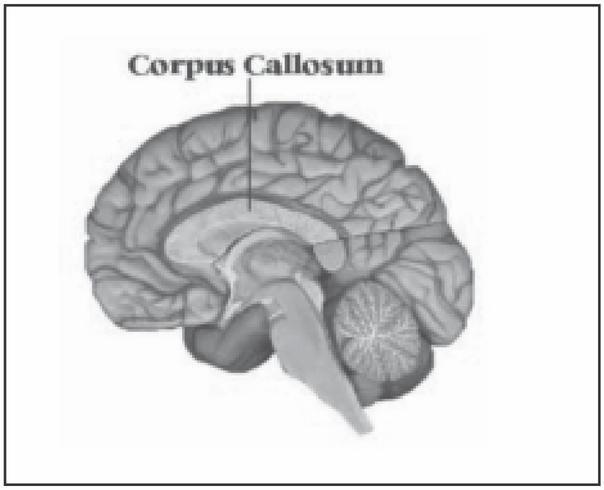
Studies that have looked at differences in the brains of males and females have focused on (i) Total brain size, (ii) Cell number (iii) Cellular connections (iv) corpus callosum (v) hypothalamus (vi) Language etc. These are discussed below:

i) **Total brain size:** In adults, the average brain weight in men is about 11-12% more than the average brain weight in women. Men's heads are also about 2% bigger than women's. This is due to the larger physical stature of men. Male's larger muscle mass, and larger body size require more neurons to control them. This does not suggest that due to the larger brain, males are smarter than females.

ii) **Cell number:** Men have 4% more brain cells than women , and about 100 grams more of brain tissue. This may explain why women are more prone to dementia (such as Alzheimer's disease) than men, because although both may lose the same number of neurons due to the disease, in males, the functional reserve may be greater as a larger number of nerve cells are present, which could prevent some of the functional losses.

iii) **Cellular connections:** While men have more neurons in the cerebral cortex, women have a more developed neuropil, or the space between cell bodies, which contains synapses, dendrites and axons, and allows for communication among neurons .

iv) **Corpus callosum:** It is reported that a woman's brain has a larger corpus callosum which means women can transfer data between the right and left hemisphere faster than men. Men tend to be more left brained, while women have greater access to both sides. Given below is the picture of brain showing corpus callosum



v) **Hypothalamus:** LeVay discovered that the volume of a specific nucleus in the hypothalamus (third cell group of the interstitial nuclei of the anterior hypothalamus) is twice as large in heterosexual men than in women and homosexual men, which may indicate a biological basis for homosexuality.

vi) **Language:** Two areas in the frontal and temporal lobes related to language (the areas of Broca and Wernicke) were significantly larger in women, thus providing a biological reason for women's notorious superiority in language associated thoughts. For men, language is most often just in the dominant hemisphere (usually the left side), but a larger number of women seem to be able to use both sides for language. This gives them a distinct advantage. If a woman has a stroke in the left front side of the brain, she may still retain some language from the right front side. Men who have the same left sided damage are less likely to recover as fully.

vii) **Inferior parietal lobule (IPL)** It is a brain region in the cortex, which is significantly larger in men than in women. This area is bilateral and is located just above the level of the ears (parietal cortex). Furthermore, the left side IPL is larger in men than the right side. In women, this asymmetry is reversed, although the difference between left and right sides is not so large as in men. This is the same area which was shown to be larger in the brain of Albert Einstein, as well as in other physicists and mathematicians. So, it seems that IPL's size correlates highly with mental mathematical abilities. Studies have linked the right IPL with the memory involved in understanding and manipulating spatial relationships and the ability to sense relationships between body parts. It is also related to the perception of our own affects or feelings. The left IPL is involved with perception of time and speed, and the ability to mentally rotate 3-D figures .

viii) **Orbitofrontal to amygdale ratio (OAR):** In one project, they measured the size of the orbitofrontal cortex, a region involved in regulating emotions, and compared it with the size of the amygdala, implicated more in producing emotional reactions. The investigators found that women possess a significantly larger orbitofrontal to amygdala ratio (OAR) than men do.

One can speculate from these findings that women might on average prove more capable of controlling their emotional reactions.

ix) **Limbic size:** Females, on average, have a larger deep limbic system than males. This gives females several advantages and disadvantages. Due to the larger deep limbic brain women are more in touch with their feelings, they are generally better able to express their feelings than men. They have an increased ability to bond and be connected to others. Females have a more acute sense of smell, which is likely to have developed from an evolutionary need for the mother to recognise her young. Having a larger deep limbic system leaves a female somewhat more susceptible to depression, especially at times of significant hormonal changes such as the onset of puberty, before menses, after the birth of a child and at menopause. Women attempt suicide three times more than men. Yet, men kill themselves three times more than women, in part, because they use more violent means of killing themselves. Men are generally less connected to others than are women. Disconnection from others increases the risk of completed suicides.

The average human brain weighs three pounds (1.36 kilograms). The average female brain capacity is 79.3 cubic inches, slightly smaller than the male brain of 88.5 cubic inches. The largest human brains may be twice those of average size, but size has no relevance to brain performance.

Man has been a tribal animal since he first walked erect, more than four million years ago. With the impediment of being bipedal, he could not out climb or outrun his predators. Only through tribal cooperation could he hold his predators at bay.

For two million years, the early hominid was a herd/tribal animal, primarily a herd herbivore. During the next two million years the human was a tribal hunter/warrior. He still is. All of the human's social drives developed long before he developed intellectually. They are, therefore, instinctive. Such instincts as mother-love, compassion, cooperation, curiosity, inventiveness and competitiveness are ancient and embedded in the human. They were all necessary for the survival of the human and pre human. Since human social drives are instinctive (not intellectual), they can not be modified through education. As with all other higher order animals, however, proper behaviour may be obtained through training.

The intellect, the magnitude of which separates the human from all other animals, developed slowly over the entire four million years or more of the human development. The intellect is not unique to the human, it is quite well developed in a number of the other higher animals. The intellect developed as a control over instincts to provide adaptable behaviour. The human is designed by nature (evolution) to modify any behaviour that would normally be instinctive to one that would provide optimum benefit (survivability). This process is called self-control or self-discipline, and is the major difference between the human and the lower order animals, those that apply only instinct to their behavioural decisions. Self-discipline, therefore, is the measuring stick of the human. The more disciplined behaviour (behaviour determined by intellect) displayed by the individual, the more human he becomes. The less disciplined behaviour (behaviour in response to instinct) displayed by an individual, the more he becomes like the lower order animals that are lacking in intellect and are driven by their instincts.

Self Assessment Questions

1) Describe different parts of the brain.

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2) Differentiate between the brain size of male and female humans.

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3) In what way corpus callosum differs in females?

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4) Discuss inferior parietal lobe and its significance.

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5) What is meant by OAR?

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6) How does limbic size vary between males and females?

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1.3 INDICATORS OF BIOLOGICAL BASIS OF BEHAVIOUR

1.3.1 Behaviour often is Species Specific

A chickadee, for example, carries one sunflower seed at a time from a feeder to a nearby branch, secures the seed to the branch between its feet, pecks it open, eats the contents, and repeats the process. Finches, in contrast, stay at the feeder for long periods, opening large numbers of seeds with their thick beaks. Some mating behaviours also are species specific. Prairie chickens, native to the upper Midwest, conduct an elaborate mating ritual, a sort of line dance for birds, with spread wings and synchronised group movements. Some behaviours are so characteristic that biologists use them to help differentiate between closely related species.

1.3.2 Behaviours Often Breed True

We can reproduce behaviours in successive generations of organisms. Consider the instinctive retrieval behaviour of a yellow Labrador or the herding posture of a border collie.

1.3.3 Behaviours Change in Response to Alterations in Biological Structures

For example, a brain injury can turn a polite, mild-mannered person into a foul-mouthed, aggressive boor, and we routinely modify the behavioural manifestations of mental illnesses with drugs that alter brain chemistry. More recently, geneticists have created or extinguished specific mouse behaviours—ranging from nurturing of pups to continuous circling in a strain called "twirler"— by inserting or disabling specific genes. In humans, some behaviours run in families. For example, there is a clear familial aggregation of mental illness.

1.3.4 Behaviour Has an Evolutionary History

Chimpanzees are our closest relatives, separated from us by a mere 2 percent difference in DNA sequence. We and they share behaviours that are characteristic of highly social primates, including nurturing, cooperation, altruism, and even some facial expressions. Genes are evolutionary glue, binding all of life in a single history that dates back some 3.5 billion years. Conserved behaviours are part of that history, which is written in the language of nature's universal information molecule called the DNA.

Self Assessment Questions

1) What are the indicators of biological basis of behaviour?

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2) Describe how behaviour is species specific.

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3) Indicate how behaviour often breeds.

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4) Trace the evolutionary history of behaviour.

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1.4 HUMAN BRAIN AND HUMAN BEHAVIOUR

Human behaviour is influenced both by the genes that we inherit and the environment in which we live. All behaviour is the joint product of heredity and environment, but differences in behaviour can be apportioned between hereditary and environment. The Canadian psychologist Donald Hebb has likened the nature nurture controversy to an argument about whether the area of a rectangle depends more importantly on its width or length. For any given rectangle the area is always a joint product of the two dimensions. However, when comparing two rectangles having different areas, it is meaningful to ask to what extent the different areas can be attributed to differences in either of the dimensions. (Note the corollary: two rectangles can have the same area but different dimensions). Substituting, we can see that any behaviour is always the joint product of heredity and environment, but differences in behaviour can be apportioned between differences in heredity and in environment.

The feeling that brain size or surface complexity is of crucial importance in terms of intelligence or mental capacity and that man excels in both, has plagued anthropological research for almost a hundred years. The actual significance of brain size is being called into question, and so also is its structural form or surface complexity.

Consider these facts. Julian Huxley was satisfied that the evidence demonstrates that a larger brain is a better learning organ than a smaller one, though the learning process may take longer. In a nutshell, his argument is that an *absolutely* larger brain (i.e., not larger relative to the body itself) will have a *relatively* as well as an absolutely larger number of cells in its cortex. A larger number of cortical cells make more elaborate learning possible. The experiments upon which Huxley based this were conducted by the German biologist, Rensch.

1.5 GENES, BRAIN AND BEHAVIOUR

Basically, genes although rarely would directly affect our conscious and subconscious processes of evaluating information and thus determine our behaviour. However, they control the creation of our bodies, including our brains, and thus predetermine how our brains will respond to various stimuli that come to them through our senses.

The traditional differentiation of nature vs. nurture is thus, basically, artificial, that is the behaviour of people is mostly determined by what they learn from their culture. However, what we learn is predetermined by our genes. No single gene determines a particular behaviour. Behaviours are complex traits involving multiple genes that are affected by a variety of other factors a few days in some cases.

About 6,000 of our genes seem to be active only in the brain. Genes (or gene-produced proteins) like Robo which induce neurons to grow in specific directions inside the skull, and others that allow them to recognise friendly neurons and cling to them (making a synapse), and then allow signals to be transmitted across those synapses. Many specialised proteins, such as Reelin, help in the formation of synapses once two neurons find each other and "dock" together. Reelin also helps the brain develop its characteristic six layer structure.

Cadherins are sticky molecules that guide neurons as they migrate inside the skull, to find their permanent position. Think of them like Spiderman climbing a building, using a sticky substance to cling and move against gravity and friction, propelling against other neurons until the right one is found with which to form a more permanent synaptic connection.

The Emx family of genes is involved in establishing the identity of certain regions in the brain. The brain is full of specialised areas such as vision, speech, planning, etc., which are set up in the course of development.

The Eph family of genes helps in lay out of the basic topography map of the brain, by setting up a chemical gradient, which allows migrating neurons to find their homes.

The Hox genes also help to establish basic layouts of the brain and body.

Other examples of "brain genes" include Pax6, important for the formation of the eye, and NMDA receptors which seem to play an important role in establishing memories when the activity of two neurons coincides closely in time.

Since genes largely function to create proteins, genes and proteins can be used interchangeably. However, some genes can code for multiple proteins depending on the context, so it is not as simple as one gene = one protein.

The FGF8 gene (fibroblast growth factor 8), for example, can be sliced and diced in different ways, leading to the production of different proteins , depending on the context. Those proteins are also responsible for laying out some of the gross anatomy of the brain.

Once neurons have made their specific connections together in the course of their development, those same synapses can be used to send signals from one neuron to another. Synapses are not truly connections that is, gaps between neurons into which signaling chemicals are injected. Usually, those chemicals are neurotransmitters such as the serotonin which are used to send signals from one neuron to the next across the synaptic gap. But hormones and other compounds such as the anti depressants in the bloodstream are also able to influence the signal of many synapses at a global level.

Some researchers are attempting to locate specific genes or groups of genes, associated with behavioural traits and to understand the complex relationship between genes and the environment. This is called research in behavioural genetics. In contrast to research into the genetic basis of diseases and disorders, researchers in behavioural genetics investigate aspects of our personalities such as intelligence, sexual orientation, susceptibility to aggression and other anti social conduct, and tendencies towards extraversion and novelty-seeking. If genes that influence particular behavioural traits are identified, it could become possible to test for the presence of variations in these genes in individual people.

Now let us examine what is behavioural genetics.

1.5.1 Definition of Behavioural Genetics

Sir Francis Galton (1822-1911) was the first scientist to study heredity and human behaviour systematically. The term “genetics” did not even appear until 1909, only 2 years before Galton’s death. Human behavioural genetics, a relatively new field, seeks to understand both the genetic and environmental contributions to individual variations in human behaviour. Research in the field of behavioural genetics aims to find out how genes influence our behaviour. Researchers are trying to identify particular genes, or groups of genes, that are associated with behavioural traits, and investigating the role of environmental factors. This is not an easy task, for the following reasons.

It often is difficult to *define* the behaviour in question. Intelligence is a classic example. Is intelligence the ability to solve a certain type of problem? The ability to make one’s way successfully in the world? The ability to score well on an IQ test? During the late summer of 1999, a Princeton molecular biologist published the results of impressive research in which he enhanced the ability of mice to learn by inserting a gene that codes for a protein in brain cells known to be associated with memory. Because the experimental animals performed better than controls on a series of traditional tests of learning, the press dubbed this gene “the smart gene” and the “IQ gene,” as if improved memory were the central, or even sole, criterion for defining intelligence. In reality, there is no universal agreement on the definition of intelligence, even among those who study it for a living.

Having established a definition for research purposes, the investigator still must measure the behaviour with acceptable degrees of validity and reliability. That is especially difficult for basic personality traits such as shyness or assertiveness, which are the subject of much current research. Sometimes there is an interesting conflation of definition and measurement, as in the case of IQ tests, where the test scores itself has come to define the trait it measures. This is a bit like using batting averages to define hitting prowess in cricket. A high average may indicate ability, but it does not define the essence of the trait. Behaviours, like all complex traits, involve *multiple genes*, a reality that complicates the search for genetic contributions.

As with much other research in genetics, studies of genes and behaviour require *analysis of families and populations* for comparison of those who have the trait in question with those who do not. The result often is a statement of "heritability," a statistical construct that estimates the amount of variation in a population that is attributable to genetic factors. The explanatory power of heritability figures is limited, however, applying only to the population studied and only to the environment in place at the time the study was conducted. If the population or the environment changes, the heritability most likely will change as well. Most important, heritability statements provide no basis for predictions about the expression of the trait in question in any given individual.

1.5.2 Definition of a Gene

Genes are sections or segments of DNA that form the individual units of heredity. They are carried on the chromosomes and contain instructions for making molecules called proteins. Each protein enables a cell to perform its own special function. The hemoglobin in red blood cells, for example, is responsible for transporting oxygen throughout your body. Another protein, insulin, helps you metabolise your food. The keratin protein is what helps your hair and nails to grow. If you look at DNA as a recipe for creating a living thing, then genes and proteins are the ingredients which work together to build, repair, and run your body.

The traits which make us each unique are also inherited from our ancestors. Physical characteristics such as curly hair, blue eyes, and a tendency for acne are all determined by our genes. Scientists also believe that many emotional and behavioural traits, at least in part, are influenced by an individual's genetic makeup. Eating habits, intelligence, a penchant for aggressiveness, and even sleeping patterns all have their roots in our DNA.

Because genes are carried on the chromosomes, humans have two copies of each gene, one inherited from the mother and one from the father. The two copies are not necessarily the same, however. Just like snowflakes, genes come in variant forms. These variations are known as alleles. Different alleles are what produce variations in inherited traits. This is why your individual traits such as hair colour or blood type may not match those traits in either of your parents.

1.5.3 Description of DNA

DNA is made up of four chemical bases: Adenine (A), Cytosine (C), Thymine (T), and Guanine (G). These bases are combined into pairs that is adenine with thymine and cytosine with guanine. These make up the "rungs" of the DNA ladder. Each "rung," more accurately called a base pair, is one of three billion such pairs which work together to provide the instructions for building and maintaining a human being, called as the human genome. The exact order in which these base pairs are combined is called the DNA sequence. Much in the way letters of the alphabet are combined to form words and sentences, the sequence of these bases are the "letters" which spell out the genetic code.

DNA, which stands for DeoxyriboNucleic Acid is an extremely (by cellular standards) long macromolecule which forms the main component of chromosomes (a basic component in the genetic determination and development of all known life forms).

DNA, structurally, is composed of two nucleotide 'strands', which coil around each other like a set of spiraling stair cases. It is constructed of two main chains of alternating phosphate and deoxyribose units, bound together chemically with purine and pyrimidine bases (known as adenine, guanine, cytosine and thymine)

DNA is a chemical polymer and is found in the nucleus of the cell. The specific ordering of the chemical bases (mentioned earlier) found within DNA allow it to store and maintain the biological characteristics of all living things. The Laws by which the DNA sequences govern our biological traits are known as the laws of genetics.

DNA is physically capable of self replicating, as well as chemically capable of synthesizing the creation of RNA, a cellular messenger which distributes genetic and cellular information within the cells. This distribution of information facilitates protein synthesis as well as the functionality of genetic determination.

1.5.4 Definition of Chromosome

A chromosome is an organised structure of DNA and protein that is found in cells. It is a single piece of coiled DNA containing many genes, regulatory elements and other nucleotide sequences. Chromosomes also contain DNA bound proteins, which serve to package the DNA and control its functions. Chromosomes are the packaging for our genetic material, or DNA (deoxyribonucleic acid). DNA carries a specific code that gives instructions to our body on how to grow, develop and function. The instructions are organised into units called genes. There are 46 chromosomes in most cells of the human body. The body is made up of many different cells that are the building blocks for the various tissues and organ systems in our body. If we were able to look inside most cells in a person's body we would expect to see 46 chromosomes in each cell.

Self Assessment Questions

1) Discuss the relationship between brain and behaviour of humans.

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2) Define behavioural genetics and bring out the characteristic features.

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3) Define gene. What are their importances?

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4) Describe DNA. How is it important for growth and development of behaviour.

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5) Define chromosome and state its importance.

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1.6 GENES INFLUENCE BEHAVIOUR AND ATTITUDES

Studies of families and twins strongly suggest genetic influences on the development and expression of specific behaviours, but there is no conclusive research demonstrating that genes determine behaviours. In "The Interplay of Nature, Nurture, and Developmental Influences: The Challenge Ahead for Mental Health" (*Archives of General Psychiatry*, vol. 59, no. 11, November 2002), psychiatrist Michael Rutter observed that a range of mental health disorders from autism and schizophrenia to attention deficit hyperactivity disorder (ADHD) involve at least indirect genetic effects, with heritability ranging from 20 to 50%. He further asserted that genetically influenced behaviours also bring about gene-environment correlations.

Genetics influence the environment experienced by individuals, which explains how, for example, children growing up in the same family often experience and interpret their environments differently. This also explains why individuals who share the same genes though living apart show some concordance in selecting or creating similar experiences.

Traditional psychological theory holds that attitudes are learned and most strongly influenced by environment. In "The Heritability of Attitudes: A Study of Twins" (*Journal of Personality and Social Psychology*, vol. 80, no. 6, June 2001), James Olson et al. examined whether there is a genetic basis for attitudes by reviewing earlier studies and conducting original research on monozygotic and dizygotic twins. Olson and his colleagues argued that the premise that attitudes are learned is not incompatible with the idea that biological and genetic factors also influence attitudes. They hypothesized that genes probably influence predispositions or natural inclinations, which then shape environmental experiences in ways that increase the likelihood of the individual developing specific traits and attitudes. For example, children who are small for their age might be teased or taunted by other children more than their larger peers. As a result, these children might develop anxieties about social interaction, with consequences for their personalities such as shyness or low self-esteem discomfort with large groups.

It has been shown in research as mentioned above, that behavioural traits such as intelligence, personality including anxiety, novelty seeking and shyness, antisocial behaviour including aggression and violent behaviour and sexual orientation are all determined to a great extent by genes. It has been also shown that some diseases are caused by changes to a single gene, such as cystic fibrosis and Huntington's disease. In the case of heart disease and diabetes it has been stated that they are likely to be affected by many genes, and the environment may also play a role. The relationship between genes and behaviour is even more complex. It is widely agreed that genes do have some influence on behaviour but it is likely that many genes are involved in influencing behaviours. Environmental factors will also have an effect.

Psychiatrist Michael Rutter explained the mechanism of genetic influence on behaviour—genes affect proteins, and through the effects of these proteins on the functioning of the brain there are resultant effects on behaviour. Rutter viewed environmental influences as comparable to genetic influences in that they are strong and pervasive but do not determine behaviours, and studies of environmental effects show that there are individual differences in response.

There are several reasons as to why it is so difficult to find which genes have an effect on behavioural traits. The following section gives the details.

- More than one gene may contribute to a trait, with many genes each having a small effect;
- A gene may affect more than one trait.
- The action of a gene depends on the presence of other genes.
- Environmental factors may contribute to a trait.
- Genes and the environment interact together in different ways and
- Genes do not have a continuous effect throughout our bodies or for all of our lives.
- The effects of genes are not inevitable.
- Genes, like environmental factors, probably just make a behaviour more or less likely to occur. They are part of the cause, but not the only cause.

One single gene has major consequences for behaviour

A single gene usually makes a single protein or sometimes only a part of a protein as for example, it takes the products of 4 different genes to produce a single acetylcholine receptor/channel. A typical cell expresses 10,000 different gene products. Therefore, if the product of a single gene differs from the prototype for that gene because of a heritable change in the gene, we would expect the following:

- Many cells will be affected, sometimes all the cells in the body.
- Some cells will be affected more than others.
- Consequences for the organism can range from lethality to slightly altered performance.
- Altered performance may at times include an improvement in performance

1.7 LET US SUM UP

We have read till now that everything one does, and experiences is a function of the brain. The brain makes up only 2% of the total body weight. The brain is a three-dimensional *form,* weighing about 3 pounds in adults less than a pound in newborns. The adult human brain weighs on average about 3 lb (1.5 kg) with a *size* (volume) of around 1130 *cubic centimeters* (cm^3) in women and 1260 cm^3 in men, although there is substantial individual variation. Human behaviour is influenced both by the genes that we inherit and the environment in which we live. All behaviour is the joint product of heredity and environment. Basically, genes –although rarely- in that they would directly affect our conscious and subconscious processes of evaluating information and thus determine our behaviour. However, they controlled the creation of our bodies, including our brains, and thus predetermined how our brains will respond to various stimuli that come to them through our senses.

1.8 UNIT END QUESTIONS

1) Describe different parts of the brain and state their importance.
2) Discuss the various indicators of biological basis of behaviour.
3) Elucidate the relationship between human brain and behaviour.
4) How are genes, brain and behaviour inter related? Discuss in detail.
5) How do genes influence behaviour and attitudes of humans?

1.9 SUGGESTED READINGS

Neil R. Carlson (1995). *Foundations of Physiological Psychology* (6th edition). Allyn and Bacon, NY

Levinthal, C.F. (1990). *Introduction ot Physiological Psychology* (3rd edition). Prentice Hall of India, New Delhi.

Thompson, R.E. (1975). *Introduction to Physiological Psychology*. Harper and Row Publishers, NY.

Morgan, C.T. and King, R.A. (2010). (11th edition). *Introduction to Psychology*. McGraw Hill Book Company, New Delhi.

UNIT 2 THE BRAIN

Structure

2.0 Introduction

2.1 Objectives

2.2 The Brain

- 2.2.1 The Cerebrum
- 2.2.2 The Cerebellum
- 2.2.3 The Pituitary Gland
- 2.2.4 The Hypothalamus
- 2.2.5 The Brain Stem

2.3 The Forebrain

- 2.3.1 The Cerebral Cortex
- 2.3.2 The Lobes
- 2.3.3 The Limbic System
- 2.3.4 Basal Ganglia
- 2.3.5 Thalamus

2.4 The Midbrain

- 2.4.1 The Brain Stem
- 2.4.2 Colliculi

2.5 The Hindbrain

- 2.5.1 Cerebellum
- 2.5.2 The Pons
- 2.5.3 Medulla

2.6 The Neurons or the Brain Cells

- 2.6.1 Different Types of Neurons
- 2.6.2 The Lifespan of Neurons
- 2.6.3 Protection of the Brain

2.7 Functions of the Brain

2.8 Let Us Sum Up

2.9 Unit End Questions

2.10 Suggested Readings

2.0 INTRODUCTION

In this unit we give a very elaborate description of the brain and its various parts. We start with the brain itself and its parts briefly with the cerebrum, cerebellum, pituitary gland, the hypothalamus and the brain stem. Then we move on to the forebrain and the cerebral cortex followed by the four lobes, that is the frontal, temporal, occipital and the parietal lobe and their functions. This is followed by the description of the limbic system, the basal gangliaand the thalamus. Then we discuss the parts of the midbrain in which we discuss in detail the brain stem and the colliculi. The hindbrain is the last part which we discuss in which we describe the cerebellum, the pons and the medulla. Then we take on the very important brain nerve cells called the neurons and discuss their different types, the lifespan of the neurons and how the brain as a whole is protected. Then we present the functions of the brain.

2.1 OBJECTIVES

After completing this unit, you will be able to:

- Define and describe brain and its five different parts;
- Describe the forebrain and the cerebral cortex and their functions;
- Explain the four different lobes and their functions;
- Describe the limbic system and the basal ganglia;
- Explain the parts of the midbrain;
- Describe the brain stem and its functions;
- Explain the hindbrain and its parts;
- Define neurons and their functions;
- Analyse the different types of neurons; and
- Elucidate the functions of the brain.

2.2 THE BRAIN

The brain is probably the most complex structure in the known universe. The human brain is the center of the human nervous system and is a highly complex organ. This nervous system is composed of billions of cells, the most essential being the nerve cells or neurons. There are estimated to be as many as 100 billion neurons in our nervous system. Enclosed in the cranium, brain has the same general structure as the brains of other mammals, but is over three times as large as the brain of a typical mammal with an equivalent body size (Johanson, D. C.1996). The human brain is an organ that controls an individual's ability to breathe, think, move and interact with the world around the individual. This organ consists of more than 15 billion cells used to receive, interpret and transmit information throughout the body. These cells, which are known as neurons, form a series of parts that each control a different set of body functions. It continuously receives sensory information, and rapidly analyses this data and then responds, control bodily actions and functions.

In humans, the brain weighs about 3 pounds. Differences in weight and size do not correlate with differences in mental ability. The brain is the control center for movement, sleep, hunger, thirst, and virtually every other vital activity necessary to survive. It is a pinkish gray mass that is composed of about 10 billion nerve cells. The nerve cells, called neurons, are linked to each other and together are responsible for the control of all mental functions.

The nervous system consists of the brain, the spinal cord and the network of nerves that extend to every part of the body. The brain weighs about three pounds; there are about 45 miles of nerves in the human body. It has right and left hemispheres. (See figure below)

The brain has five major parts:

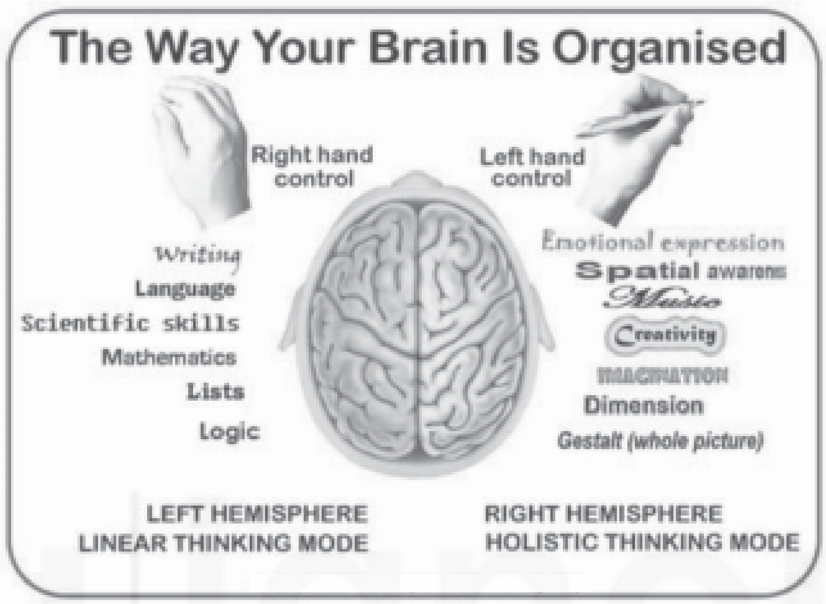
1) the cerebrum,
2) cerebellum,

3) brain stem,

4) pituitary gland and

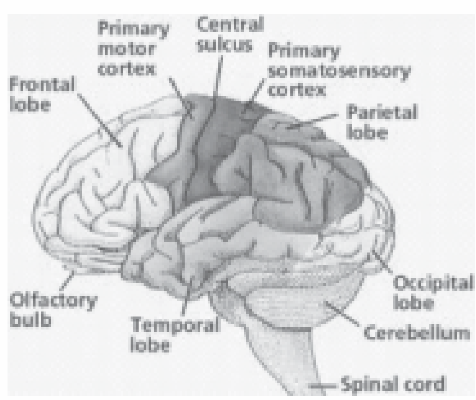
5) the hypothalamus.

The two halves of the brain (Cerebrum)



2.2.1 The Cerebrum (See Sigure Below)

The cerebrum has two halves, the right and left, and is the largest part. It is responsible for thinking, reasoning, both short and long term memory, and for voluntary muscle movement. The right side of the cerebrum controls the left side of the body and is related to abstract thought, colours, shapes, music and creative endeavors. The left side of the cerebrum controls the right side of the body and is associated with logical, analytical and mathematical thought, and speech. The cerebrum contains the information that essentially makes us who we are: our intelligence, memory, personality, emotion, speech, and ability to feel and move. Specific areas of the cerebrum are in charge of processing these different types of information. These are called lobes, and there are four of them: the frontal, parietal, temporal, and occipital.



The cerebrum has right and left halves, called hemispheres, which are connected in the middle by a band of nerve fibers (the corpus collosum) that enables the two sides to communicate. Though these halves may look like mirror images of each other, many scientists believe they have different functions. The left side is considered the logical, analytical, objective side. The right side is thought to be more intuitive, creative, and subjective. So when you're balancing the checkbook, you're using the left side; when you're listening to music, you're using the right side. It's believed that some people are more "right-brained" or "left-brained" while others are more "whole-brained," meaning they use both halves of their brain to the same degree.

2.2.2 The Cerebellum

The cerebellum controls and coordinates movements of the muscles, like walking or swinging the arms. This means that the movement is smooth and controlled and you do not fall over when you turn around

2.2.3 The Pituitary Gland

The pituitary gland is a pea size structure in the center of the brain under the cerebrum which controls hormone production, metabolism and growth. It is in many ways the extension of the hypothalamus. The posterior part of the pituitary gland contains hormone-secreting terminal buttons of axons whose cell bodies lie within the hypothalamus.

2.2.4 The Hypothalamus

This is a very small structure also under the cerebrum, which controls the body's temperature and helps it respond to the environment by shivering or sweating in order to maintain a steady body temperature. It is a part of the diencephalon, ventral to the thalamus. The structure is involved in functions including homeostasis, emotion, thirst, hunger, circadian rhythms, and control of the autonomic nervous system. The hypothalamus controls the pulse, thirst, appetite, sleep patterns, and other processes in our bodies that happen automatically. It also controls the pituitary gland, which makes the hormones that control our growth, metabolism, digestion, sexual maturity, and response to stress.

The cerebellum is smaller than the cerebrum and located below it at the back of the brain. It controls balance, movement and coordination. We could not move around without it.

2.2.5 The Brain Stem

The brain stem is at the back of the brain and connects the brain to the spinal cord. It regulates involuntary movement such as breathing, digestion, and blood circulation. It also sorts out millions of messages going back and forth to the rest of the body.

The spinal cord is about 18 inches long and three-quarters of an inch wide and acts as a conduit for all impulses to and from every body part and the brain. It is protected from harm by the bones of the spinal column.

Our nerves are intimately linked with our senses and our emotions, which are also seated in the brain. They relay information to and from the brain so that it can function as "executive", controlling responses to stimuli and keeping things going.

Damage to the brain can result in altered functioning. Because the brain is so complex, it is sometimes impossible to determine cause and effect accurately. Human traits like mood, preferences, and character are somewhat of a mystery, probably due to the relationship of our spiritual selves with the physical, social and emotional.

The brain is wrapped in 3 layers of tissue and floats in a special shock proof fluid to stop it from getting bumped on the inside of your skull as your body moves around.

Parts of the Brain

The brain is made of three main parts: the forebrain, midbrain, and hindbrain. The forebrain consists of the cerebrum, thalamus, and hypothalamus (part of the limbic system). The midbrain consists of the tectum and tegmentum. The hindbrain is made of the cerebellum, pons and medulla. Often the midbrain, pons, and medulla are referred to together as the brainstem.

The Forebrain ——- The Midbrain ——— The Hindbrain

Self Assessment Questions

1) What are the parts of the brain?

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2) Describe the cerebrum and the cerebellum.

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3) What is the role of the pituitary gland?

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4) What is the role of hypothalamus?

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5) Describe the brain stem and its functions.

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2.3 THE FOREBRAIN

The forebrain is the largest and most complex part of the brain. It surrounds the rostal end of the neural tube. Its two major components are the Telencephalon and the Diencephalon.

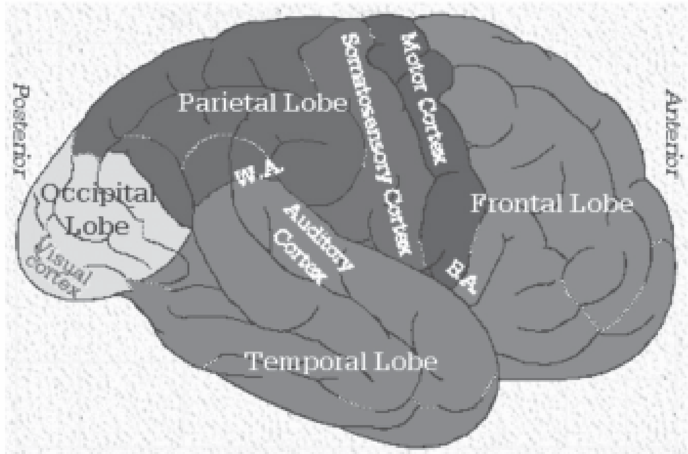
Telencephalon: It includes most of the two symmetrical cerebral hemispheres that make up the cerebrum. The cerebral hemispheres are covered by the cerebral cortex and contain the limbic system and the basal ganglia. The latter two set of structures are primarily in the subcortical regions of the brain.

2.3.1 The Cerebral Cortex

The outer layer of the cerebrum is called the cortex (also known as “gray matter”). It encompasses about two-thirds of the brain mass and lies over and around most of the structures of the brain. It is the most highly developed part of the human brain and is responsible for thinking, perceiving, producing and understanding language. It is also the most recent structure in the history of brain evolution. Most of the actual information processing in the brain takes place in the cerebral cortex. Information collected by the five senses comes into the brain from the spinal cord to the cortex. This information is then directed to other parts of the nervous system for further processing. For example, when you touch the hot stove, not only does a message go out to move your hand but one also goes to another part of the brain to help.

The cerebral cortex is divided into four sections, called “lobes”: the frontal lobe, parietal lobe, occipital lobe, and temporal lobe. Each has a specific function. For example, there are specific areas involved in vision, hearing, touch, movement, and smell. Other areas are critical for thinking and reasoning. Although many functions, such as touch, are found in both the right and left cerebral hemispheres, some functions are found in only one cerebral hemisphere. For example, in most people, language abilities are found in the left hemisphere.

2.3.2 The Lobes: (see picture below)



i) **Frontal Lobe:** This Lobe is located deep to the Frontal Bone of the skull. It plays an integral role in the following functions/actions such as reasoning, planning, parts of speech, movement, emotions, and problem solving.

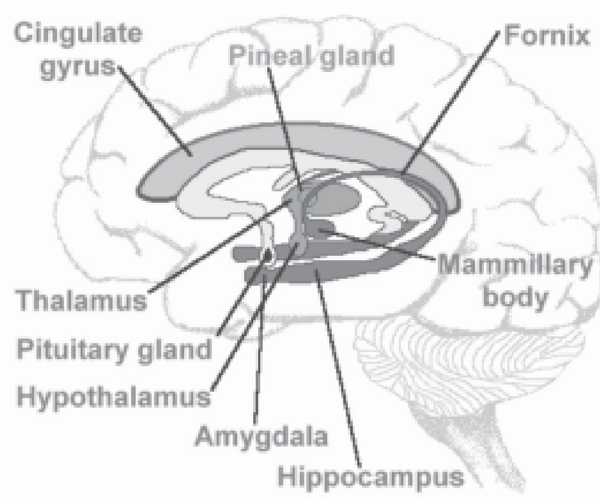
ii) **Parietal Lobe:** This Lobe is located deep to the Parietal Bone of the skull. It is associated with movement, orientation, recognition, perception of stimuli.

iii) **Occipital Lobe:** The Occipital Lobe is located deep to the Occipital Bone of the Skull. Its primary function is the processing, integration, interpretation, etc. of vision and visual stimuli.

iv) **Temporal Lobe:** These Lobes are located on the sides of the brain, deep to the temporal Bones of the skull and associated with perception and recognition of auditory stimuli, memory, and speech.

2.3.3 The Limbic System

A group of brain regions including the anterior thalamic nuclei, amygdala, hippocampus, limbic cortex, and parts of the hypothalamus as well as their interconnecting fibre bundles is called limbic system. Hippocampus is a structure of the temporal lobe, includes the hippocampus proper, dentate gyrus and subiculum. Amygdala is located in the temporal lobe is involved in memory, emotion, and fear. The amygdala is just beneath the surface of the front, medial part of the temporal lobe where it causes the bulge on the surface called the uncus. (See picture of limbic system below)



The Limbic System

2.3.4 Basal Ganglia

The basal ganglia are a collection of subcortical nuclei in the forebrain that lie beneath the anterior portion of the lateral ventrical. Nuclei are group of neurons of the same shape.

Diencephalon: The diencephalon, the inner part of the forebrain, consists of the thalamus, hypothalamus, and pituitary gland.

2.3.5 Thalamus

A large mass of gray matter deeply situated in the forebrain at the topmost portion of the diencephalon. The structure has sensory and motor functions. Almost all sensory information enters this structure where neurons send that information to the overlying cortex. Axons from every sensory system (except olfaction) synapse here as the last relay site before the information reaches the cerebral cortex. The thalamus carries messages from the sensory organs like the eyes, ears, nose, and fingers to the cortex.

Self Assessment Questions

1) Describe the forebrain and its functions.

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2) Discuss the role of cerebral cortex.

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3) Describe the four lobes and their functions.

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4) What are the functions of the limbic system?

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5) Describe the basal ganglia and the thalamus in terms of their functions.

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2.4 THE MIDBRAIN (MESENCEPHALON)

The midbrain is located between the two developmental regions of the brain known as the forebrain and hindbrain. It acts as a master coordinator for all the messages going in and out of the brain to the spinal cord. The midbrain and the hindbrain together make up the brainstem.

2.4.1 The Brain Stem

This is the lower extension of the brain where it connects to the spinal cord. Neurological functions located in the brainstem include those necessary for survival (breathing, digestion, heart rate, blood pressure) and for arousal (being awake and alert).

It consists of two major parts: (i) Tectum and (ii) Tegmentum. Tectum is the dorsal part of the midbrain and includes the inferior colliculi and the superior colliculi. Tegmentum is the ventral part of the midbrain which includes the periacquductal grey matter, reticular formation, red nuclei and substantia nigra.

Most of the cranial nerves come from the brainstem. The brainstem is the pathway for all fiber tracts passing up and down from peripheral nerves and spinal cord to the highest parts of the brain.

This region of the brain is involved in auditory and visual responses as well as motor function. The reticular formation influences motor functions. The *tegmentum* is a general area within the brainstem. It is located between the ventricular system and distinctive basal or ventral structures at each level. It forms the floor of the midbrain whereas the tectum forms the ceiling. It is a multisynaptic network of neurons that is involved in many unconscious homeostatic and reflective pathways. The *tectum* (Latin: *roof*) is a region of the brain, specifically the dorsal part of the mesencephalon (midbrain). This is contrasted with the tegmentum, which refers to the region ventral to the ventricular system. It is responsible for auditory and visual reflexes.

The midbrain also contains the crus cerebri, which is made up of nerve fibres connecting the cerebral hemispheres to the cerebellum, and a large pigmented nucleus called the substantia nigra. The substantia nigra consists of two parts, the pars reticulata and the pars compacta. Cells of the pars compacta contain the dark pigment melanin; these cells synthesize dopamine and project to either the caudate nucleus or the putamen, both of which are structures of the basal ganglia and are involved in mediating movement and coordination. The roof plate of the midbrain is formed by two paired rounded swellings, the superior and inferior colliculi.

2.4.2 Colliculi

In adult humans it is present only in the mesencephalon as the inferior and the superior colliculi.

The superior colliculus is involved in preliminary visual processing and control of eye movements. In non-mammalian vertebrates it serves as the main visual area of the brain, functionally analogous to the visual areas of the cerebral cortex in mammals.

The inferior colliculus is involved in auditory processing. It receives input from various brain stem nuclei and projects to the medical geniculate nucleus of the thalamus, which relays auditory information to the primary auditory cortex.

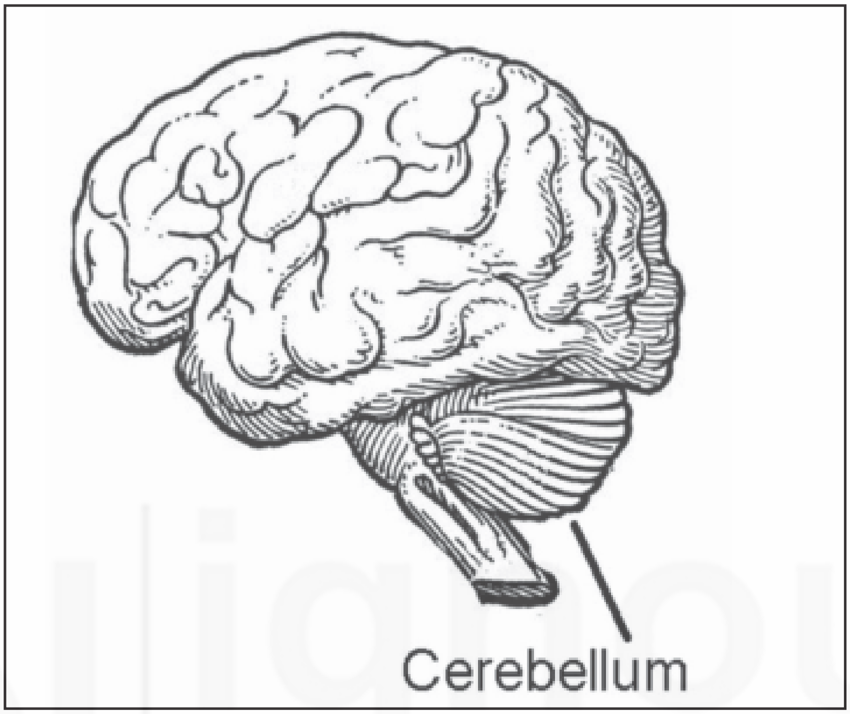
Both colliculi also have descending projections to the paramedian pontine reticular formation and spinal cord, and thus can be involved in responses to stimuli faster than cortical processing would allow. Collectively the colliculi are referred to as the corpora quadrigemina.

At the caudal (rear) midbrain, crossed fibres of the superior cerebellar peduncle (the major output system of the cerebellum) surround and partially terminate in a large centrally located structure known as the red nucleus. Most crossed ascending fibres of this bundle project to thalamic nuclei, which have access to the primary motor cortex. A smaller number of fibres synapse on large cells in caudal regions of the red nucleus; these give rise to the crossed fibres of the rubrospinal tract, which runs to the spinal cord and is influenced by the motor cortex.

The second segment appears as a slight swelling in lower vertebrates and enlarges in the higher primates and ourselves into the midbrain. The structures contained here link the lower brain stem to the thalamus (for information relay) and to the hypothalamus (which is instrumental in regulating drives and actions). The latter is part of the limbic system.

2. 5 THE HINDBRAIN

The hindbrain sits underneath the back end of the cerebrum, and it consists of the cerebellum, pons, and medulla. (Picture of cerebellum. The small portion indicated is cerebellum)



2.5.1 Cerebellum

It is also called the "little brain" because it looks like a small version of the cerebrum — is responsible for balance, movement, and coordination. The cerebellum, or "little brain", is similar to the cerebrum in that it has two hemispheres and has a highly folded surface or cortex. This structure is associated with regulation and coordination of movement, posture, and balance. The cerebellum is assumed to be much older than the cerebrum, evolutionarily. The pons and the medulla, along with the midbrain, are often called the brainstem.

2.5.2 The Pons

The pons (Latin for "bridge") is a structure located on the brain stem. It is superior to (up from) the medulla oblongata, inferior, to (down from) the midbrain, and rostral to (in front of) the cerebellum. The pons (see the picture below)

The pons measures about 2.5 cm in length. It contains nuclei that relay signals from the cerebrum to the cerebellum, along with nuclei that deal primarily with sleep, respiration, swallowing, bladder control, hearing, equilibrium, taste, eye movement, facial expressions, facial sensation, and posture. It is a part of the metencephalon in the hindbrain. It is involved in motor control and sensory analysis, for example, information from the ear first enters the brain in the pons. It has parts that are important for the level of consciousness and for sleep. Some structures within the pons are linked to the cerebellum, thus are involved in movement and posture.

2.5.3 Medulla

This structure is the caudal-most part of the brain stem, between the pons and spinal cord. It is responsible for maintaining vital body functions, such as breathing and heart rate. The brainstem takes in, sends out, and coordinates all of the brain's messages. It also controls many of the body's automatic functions, like breathing, heart rate, blood pressure, swallowing, digestion, and blinking.

Self Assessment Questions

1) Describe the parts of the midbrain and the hindbrain.

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2) What is the role of brainstem and colliculi?

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3) Describe cerebellum and its contribution.

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4) Where are the Pons located and what are their functions?

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5) What is the role of medulla?

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Overview of Anatomical Sub-divisions of Brain

Part	Location	Functions	Other Facts
The Cerebral Cortex	This newspaper sized "white matter" is the 1/4" outside covering of both brain hemispheres.	The cerebral cortex controls your thinking, voluntary movements, language, reasoning, and perception.	In higher mammals the cortex looks like it has lots of wrinkles, grooves and bumps. Grooves and bumps are also called "gyros." Cortex is the Latin word for "bark."
Cerebellum	The cerebellum is a cauliflower-shaped structure located in the lower part of the brain next to the occipital area and the brain stem.	The cerebellum controls your movement, balance, posture, and coordination. New research has also linked it to thinking, novelty, and emotions.	The very word cerebellum comes from the Latin word "little brain."
Hypothalamus	The hypothalamus is part of the limbic system. It is located in the internal portion of the brain under the thalamus.	The hypothalamus controls your body temperature, emotions, hunger, thirst, appetite, digestion and sleep.	The hypothalamus is composed of several different areas and is located at the base of the brain. It is only the size of a pea (about 1/300 of the total brain weight), but is responsible for some very important behaviours.

Thalamus	The thalamus is part of the limbic system so it is located in the internal portion of the brain or the center of the brain.	The thalamus controls your sensory integration and motor integration.	The thalamus recieves sensory information and relays it to the cerebral cortex. The cerebral cortex also sends information to the thalamus which then transmits this information to other parts of the brain and the brain stem.
Pituitary Gland	The pituitary gland is part of the limbic system although it hangs below the rest of the limbic system.	The pituitary gland controls your hormones and it helps to turn food to energy.	Without your pituitary gland, you could eat but you wouldn't get any energy from the food.
Pineal Gland	The pineal gland is part of the limbic system so it is located in the internal portion of the brain.	The pineal gland controls your growing and maturing.	I bet you didn't know that your pineal gland is activated by light so if you were born and lived all your life in a place without a trace of light your pineal gland would never start to work.
Amygdala	The almond shaped amygdala is part of the limbic system so it is located in the internal portion of the brain.	The amygdala (there are two of them) control your emotions such as regulating when you're happy or mad.	Your amygdala is very important. Without it you could win the lottery and feel nothing. You wouldn't be happy.
Hippocam-pus	The crescent shaped hippocampus is found deep in the temporal lobe, in the front of the limbic system.	The hippocampas forms and stores your memories (scientists think there are other things unknown about the hippo-campus) and is involved in learning.	Your hippocampus is one of the most important parts of your brain. If you didn't have it, you wouldn't be able to remember anything. People with Alzheimer's Disease loose the functioning of their hippocampus.
Mid-brain	The mid-brain is an area located in the middle of the brain behind the frontal lobes.	The mid-brain controls your breathing, reflexes, and your swallowing reflexes.	The mid-brain includes the thalamus, hippocampus, and amygdala. Every living thing has to have a mid-brain.

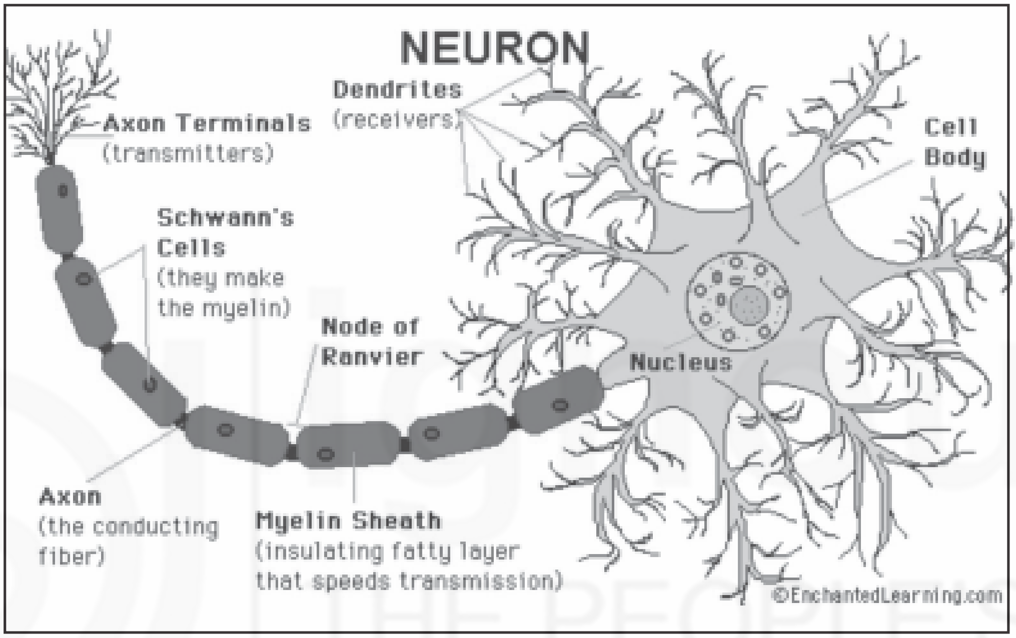
2.6 THE NEURONS OR THE BRAIN CELLS

The brain cells are called the neurons

(Source:http://www.enchantedlearning.com/subjects/anatomy/brain/Neuron.shtml)

The word "neuron" was coined by the German scientist Heinrich Wilhelm Gottfried von Waldeyer-Hartz in 1891 (he also coined the term "chromosome").

There is much type of neurons. They vary in size from 4 microns (.004 mm) to 100 microns (.1 mm) in diameter. Their length varies from a fraction of an inch to several feet.



Neurons are nerve cells that transmit nerve signals to and from the brain at up to 200 miles per hour. A typical neuron has about 1,000 to 10,000 synapses

i) a cell body (or soma) . The **cell body (soma)** contains the neuron's nucleus (with DNA and typical nuclear organelles). Dendrites branch from the cell body and receive messages.

ii) Dendrites branch from the cell body. They are the signal receivers. Dendrites bring information to the cell body.

iii) A projection called an axon, which conduct the nerve signal. Axon is a long extension of a nerve cell which take information away from the cell body. Bundles of axons are known as nerves. Within the Central Nervous System these are known as nerve tracts or pathways.

At the other end of the axon, the axon terminals transmit the electro-chemical signal across a synapse (the gap between the axon terminal and the receiving cell).

The axons are protected by myelin coats and insulates the axon, increasing transmission speed along the axon. Myelin is manufactured by Schwann's cells, and consists of 70-80% lipids (fat) and 20-30% protein.

2.6.1 Different Types of Neurons

There are different types of neurons. They all carry electro chemical nerve signals, but differ in structure (the number of processes, or axons, emanating from the cell body) and are found in different parts of the body.

Sensory neurons or Bipolar neurons carry messages from the body's sense receptors (eyes, ears, etc.) to the CNS. These neurons have two processes. Sensory neuron account for 0.9% of all neurons. (Examples are retinal cells, olfactory epithelium cells.). are sensitive to various non-neural stimuli. There are sensory neurons in the skin, muscles, joints, and organs that indicate pressure, temperature, and pain. There are more specialised neurons in the nose and tongue that are sensitive to the molecular shapes we perceive as tastes and smells. Neurons in the inner ear are sensitive to vibration, and provide us with information about sound. And the rods and cones of the retina are sensitive to light, and allow us to see.

Motor neurons or Multipolar neurons carry signals from the CNS to the muscles and glands. These neurons have many processes originating from the cell body. Motoneurons account for 9% of all neurons. (Examples are spinal motor neurons, pyramidal neurons, Purkinje cells.). are able to stimulate muscle cells throughout the body, including the muscles of the heart, diaphragm, intestines, bladder, and glands.

Inter neurons or Pseudopolare (Spelling) cells form all the neural wiring within the CNS. These have two axons (instead of an axon and a dendrite). One axon communicates with the spinal cord; one with either the skin or muscle. These neurons have two processes (Examples are dorsal root ganglia cells.) are the neurons that provide connections between sensory and motor neurons, as well as between themselves. The neurons of the central nervous system, including the brain, are all inter-neurons.

2.6.2 The Life Span of Neurons

Unlike most other cells, neurons cannot regrow after damage (except neurons from the hippocampus). Fortunately, there are about 100 billion neurons in the brain.

2.6.3 Protection of the Brain

As mentioned earlier, the entire brain is enveloped in three protective sheets known as the meninges, continuations of the membranes that wrap the spinal cord. The two inner sheets enclose a shock-absorbing cushion of cerebrospinal fluid. Nerve fibers in the brain are covered in a near-white substance called myelin and form the white matter of the brain. Nerve cell bodies, which are not covered by myelin sheaths, form the gray matter. The cerebral cortex is the layer of the brain often referred to as gray matter. The cortex (thin layer of tissue) is gray because nerves in this area lack the insulation that makes most other parts of the brain appear to be white. The cortex covers the outer portion (1.5mm to 5mm) of the cerebrum and cerbellum. The portion of the cortex that covers the cerebrum is called the cerebral cortex. The cerebral cortex consists of folded bulges called gyri that create deep furrows or fissures called sulci. The folds in the brain add to its surface area and therefore increase the amount of gray matter and the quantity of information that can be processed.

Most of the actual information processing in the brain takes place in the cerebral cortex. The cerebral cortex is divided into lobes that each has a specific function. For example, there are specific areas involved in vision, hearing, touch, movement, and smell. Other areas are critical for thinking and reasoning. Although many functions, such as touch, are found in both the right and left cerebral hemispheres, some functions are found in only one cerebral hemisphere. For example, in most people, language abilities are found in the left hemisphere.

Self Assessment Questions

1) Define Neurons.

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2) Describe the different types of neurons and their functions.

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3) What is the lifespan of neurons?

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4) How is the brain protected?

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2.7 FUNCTIONS OF THE BRAIN

Human brain is more powerful, more complex and more clever than any computer ever built.

It is constantly dealing with hundreds of messages from the world around , and from the individual's body, and telling the body what to do.

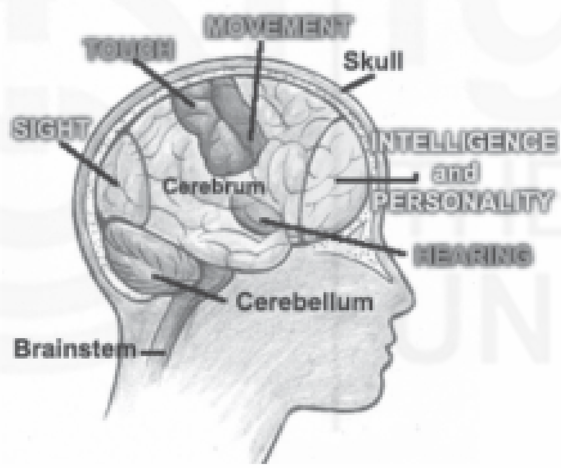
It gets the messages from the person's senses that is seeing, hearing, tasting, smelling, touching and moving. The messages travel from nerve cells all over the body. They travel along nerve fibres to nerve cells in the brain.

Cranial nerves carry messages to and from the ears, eyes, throat, tongue and skin on one's face and scalp.

The spinal cord carries messages from and to the arms, legs and trunk of the body.

Sensory nerves collect the information and send it to the brain along one network. Then the motor nerves take the brain's orders back along another network.

As for the control centers of the brain, the different parts of the brain are in charge of different things. Look at the diagram for an easy way to understand.



The outside layer of the cerebrum has special areas which receive messages about sight, touch, hearing and taste. Other areas control movement, speech, learning, intelligence and personality.

The brain stem is in charge of keeping the automatic systems of the body working, such as breathing,

The human brain has 100 billion nerve cells. It also has 1000 billion other cells, which cover the nerve cells and the parts of the nerve cells which form the links between one cell and another, feed them and keep them healthy.

The left side of the brain is better at problem solving, maths and writing.

The right side of the brain is creative and helps the person to be good at art and music.

The brain stores in memory facts and figures and all the smells, tastes and things the person has seen, heard or touched.

The brain can also find things that one has remembered such as how to spell a word etc.

Each area of the brain has an associated function, although many functions may involve a number of different areas.

The cerebellum is the hind part of the brain. It is made up of gray, unmyelinated cells on the exterior and white, myelinated cells in the interior. The cerebellum coordinates muscular movements and, along with the midbrain, monitors posture. It is essential to the control of movement of the human body in space. The brain stem, which incorporates the medulla and the pons, monitors involuntary activities such as breathing and vomiting.

The thalamus, which forms the major part of the diencephalon, receives incoming sensory impulses and routes them to the appropriate higher centers. The hypothalamus, occupying the rest of the diencephalon, regulates heartbeat, body temperature, and fluid balance. Above the thalamus extends the corpus callosum, a neuron-rich membrane connecting the two hemispheres of the cerebrum.

The cerebrum occupies the topmost portion of the skull. It is by far the largest part of the brain. It makes up about 85% of the brain's weight. The cerebrum is split vertically into left and right hemispheres. it appears deeply fissured and grooved. Its upper surface, the cerebral cortex, contains most of the master controls of the body. In the cerebral cortex ultimate analysis of sensory data occurs, and motor impulses originate that initiate, reinforce, or inhibit the entire spectrum of muscle and gland activity. The left half of the cerebrum controls the right side of the body; the right half controls the left side.

Other important parts of the brain are the pituitary gland, the basal ganglia, and the reticular activating system (RAS). The pituitary participates in growth regulation. The basal ganglia, located just above the diencephalon in each cerebral hemisphere, handle coordination and habitual but acquired skills like chewing and playing the piano. The RAS forms a special system of nerve cells linking the medulla, pons, midbrain, and cerebral cortex. The RAS functions as a sentry. In a noisy crowd, for example, the RAS alerts a person when a friend speaks and enables that person to ignore other sounds.

2.8 LET US SUM UP

Brain, a part of the central nervous system, is located in the skull. It controls mental and physical actions of the organism. The brain, with the spinal cord and network of nerves, controls information flow throughout the body, voluntary actions. The human nervous system, with its billions of nerve cells, is often described as "the most complex system in the known universe." It starts as a tube of cells in the embryo, rapidly developing three distinct parts called the forebrain, midbrain, and hindbrain. As the forebrain develops, it folds into wrinkles called convolutions. This allows a great surface area to be packed into the limited space of the skull. Human brains have noticeably more convolutions than brains of other species.

The cerebrum is the large, topmost part of the brain. The cerebral cortex is the outer layer of the cerebrum, where most of the cell bodies are packed. This layer is visible as a dark layer of gray matter when a preserved brain is sliced. Deep folds in the cerebral cortex, called fissures, are found in the same location on each brain. They can be used to define major areas on the cerebral cortex called lobes. The temporal lobe is at the side of the brain, below the lateral fissure. The parietal lobe is above the lateral fissure. The frontal lobe is farthest forward in the brain. It is more developed in humans than in other animals. It contains the prefrontal areas, farthest in front, which are involved in complex mental processes such as planning and creativity.

The two hemispheres of the brain are somewhat specialised for different activities, with language depending upon areas on the left, spatial processing upon areas on the right. Emotional processing is also lateralised. However, expert neuroscientists feel that the idea of "right brain thinking" and "left brain thinking" has been overdone, and most complex mental activity involves a mix of areas on the two sides.

2.9 UNIT END QUESTIONS

1) Describe the brain and its parts briefly. Why is brain so important for humans?
2) Describe the lobes highlighting the functions of each lobe.
3) Describe with a diagram the forebrain, the midbrain and the hind brain. What are their parts? Describe the functions of each part.
4) Describe the neurons and their functions and their importance for the brain.
5) What are the functions of the brain? Give in detail.

2.10 SUGGESTED READINGS

Singh, Inderbir (2008) (2nd edition). *Anatomy and Physiology for Nurses*. Anshan Ltd., New Delhi

Pearce, Evelyn (2008)(16th edition). *Anatomy and Physiology for Nurses*. Faber Publications, London.

UNIT 3 THE CEREBRUM AND THE CEREBRAL HEMISPHERES AND THEIR FUNCTIONS

Structure

3.0 Introduction
3.1 Objectives
3.2 The Cerebrum and the Cerebellum
3.3 The Brain Stem
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3.5 The Cerebrum
   3.5.1 The Cerebral Cortex
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3.8 Cerebral Hemisphreres
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3.0 INTRODUCTION

This unit discusses the two main aspects of the brain namely the cerebrum and the cerebral hemispheres and their functions. The first section starts with the cerebrum and the cerebellum followed by a discussion on the brain stem and its various functions. This is followed by a description of the diencephalon and its functions. The next topic to be taken up is the cerebrum within which we discuss the cerebral cortex and the functional areas of the cerebral cortex. We then take up the description of the cerebellum and bring out the differences between the cerebrum and the cerebellum. How to learn about the brain and what are the various methods available to us to learn about the brain is discussed next which includes the MRI, PET and other such equipments which help to understand what goes on within the brain. Then the two hemispheres are discussed of the brain and we take up the description of the left and the right brain followed by the how the two hands are controlled and managed by the two hemispheres. Then we discuss about the cerebral dominance and the functions of the right and left hemispheres. Then we discuss the limbic system, the forebrain and the four lobes of the brain.

3.1 OBJECTIVES

After completing this unit, you will be able to:

- Define and describe cerebrum and the cerebellum;
- Differentiate between the cerebrum and the cerebellum;
- Describe the diencephalon, and the brain stem;
- Explain the cerebral cortex and its functions;
- Describe the two hemispheres of the brain;
- Explain how the right and left hands are controlled by the two sides of the brain;
- Define the limbic system and its functions;
- Eklucidate the role of the forebrain; and
- Analyse the functions of the four lobes of the brain.

3.2 THE CEREBRUM AND THE CEREBELLUM

The brain, with the spinal cord and network of nerves, controls information flow throughout the body, voluntary actions, such as walking, reading, and talking, and involuntary reactions, such as breathing and heartbeat.

The human brain is a soft, shiny, grayish white, mushroom shaped structure. Encased within the skull, the brain of an average adult weighs about 3 lb (1.4 kg).

At birth, the average human infant's brain weighs 13.7 oz (390 g); by age 15, the brain has nearly reached full adult size. The brain is protected by the skull and by a three layer membrane called the meninges.

Many bright red arteries and bluish veins on the surface of the brain penetrate inward. Glucose, oxygen, and certain ions pass easily from the blood into the brain, whereas other substances, such as antibiotics, do not.

The four principal sections of the human brain are:

- the brain stem,
- the diencephalon,
- the cerebrum, and
- the cerebellum.

3.3 THE BRAIN STEM

Underneath the limbic system is the brain stem. This structure is responsible for basic vital life functions such as breathing, heartbeat, and blood pressure. Scientists say that this is the "simplest" part of human brains because animals' entire brains, such as reptiles (who appear early on the evolutionary scale) resemble our brain stem.

The brain stem connects the brain with the spinal cord. All the messages that are transmitted between the brain and spinal cord pass through the medulla, which is a part of the brain stem. This it does through fibers. The fibers on the right side of the medulla cross to the left and those on the left cross to the right.

As a result, each side of the brain controls the opposite side of the body. The medulla also controls the heartbeat, the rate of breathing, and the diameter of the blood vessels and helps to coordinate swallowing, vomiting, hiccupping, coughing, and sneezing.

Another component of the brain stem is the pons (meaning bridge). The pons conducts messages between the spinal cord and the rest of the brain, and between the different parts of the brain. They convey impulses between the cerebral cortex. The pons, and the spinal cord is a section of the brain stem known as the midbrain, which also contains visual and audio reflex centers involving the movement of the eyeballs and head.

The brain stem is made of the midbrain, pons, and medulla. Let us see what these structures do:

i) **Midbrain:** The midbrain is the smallest region of the brain that acts as a sort of relay station for auditory and visual information.

   The midbrain controls many important functions such as the visual and auditory systems as well as eye movement. Portions of the midbrain called the red nucleus and the substantia nigra are involved in the control of body movement. The darkly pigmented substantia nigra contains a large number of dopamine-producing neurons are located. The degeneration of neurons in the substantia nigra is associated with Parkinson's disease.

ii) **Pons:** In Latin, the word pons literally means bridge. The pons is a portion of the hindbrain that connects the cerebral cortex with the medulla oblongata. It also serves as a communications and coordination center between the two hemispheres of the brain. As a part of the brainstem, the pons helps in the transferring of messages between various parts of the brain and the spinal cord.

iii) **Medulla:** This structure is the caudal most part of the brain stem, between the pons and spinal cord. It is responsible for maintaining vital body functions, such as breathing and heartrate

iv) **Cranial nerves:** Twelve pairs of cranial nerves originate in the underside of the brain, mostly from the brain stem. They leave the skull through openings and extend as peripheral nerves to their destinations. Among these cranial nerves are the olfactory nerves that bring messages about smell and the optic nerves that conduct visual information.

3.4 THE DIENCEPHALON

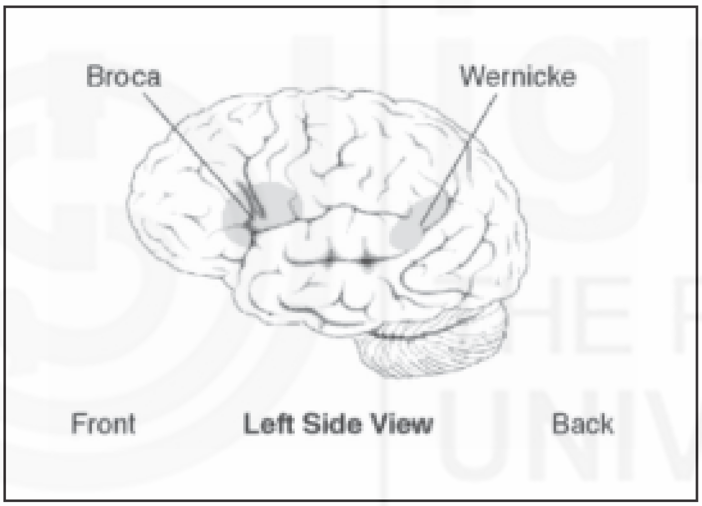
The diencephalon lies above the brain stem and embodies the thalamus and hypothalamus. The thalamus is an important relay station for sensory information, interpreting sensations of sound, smell, taste, pain, pressure, temperature, and touch.

The thalamus also regulates some emotions and memory.

The hypothalamus controls a number of body functions, such as heartbeat rate and digestion, and helps regulate the endocrine system and normal body temperature. The hypothalamus interprets hunger and thirst, and it helps regulate sleep, anger, and aggression.

3.5 THE CEREBRUM

The cerebrum constitutes nearly 90% of the brain's weight. Specific areas of the cerebrum interpret sensory impulses. For example, spoken and written language are transmitted to a part of the cerebrum called Wernicke's area.



Wernicke's area is the region of the brain that is important in language development. The Wernicke's Area is located on the temporal lobe on the left side of the brain and is responsible for the comprehension of speech (Broca's area is related to the production of speech). Language development or usage can be seriously impaired by damage to the Wernicke's Area.

Broca studied patients with language deficits. Later after their death when he autopsied, he found a sizable lesion in the left inferior frontal cortex. Subsequently, Broca studied eight other patients, all of whom had similar language deficits along with lesions in their left frontal hemisphere. This led him to make his famous statement that "we speak with the left hemisphere" and to identify, for the first time, the existence of a "language centre" in the posterior portion of the frontal lobe of this hemisphere. Now known as Broca's area, this was in fact the first area of the brain to be associated with a specific function that is in this case language.

Ten years later, Carl Wernicke, a German neurologist, discovered another part of the brain, this one involved in understanding language, in the posterior portion of the left temporal lobe. People who had a lesion at this location, could speak, but their speech was often incoherent and made no sense.

Wernicke's observations have been confirmed many times since. Neuroscientists now agree that there is a sort of neural loop that is involved both in understanding and in producing spoken language. At the frontal end of this loop lies Broca's area, which is usually associated with the production of language, or language outputs . At the other end (more specifically, in the superior posterior temporal lobe), lies Wernicke's area**,** which is associated with the processing of words that we hear being spoken, or language inputs. Broca's area and Wernicke's area are connected by a large bundle of nerve fibres called the arcuate fasciculus**.**

Broca's area translates thoughts into speech, and coordinates the muscles needed for speaking. Impulses from other motor areas direct hand muscles for writing and eye muscles for physical movement necessary for reading.

The cerebrum is divided into two hemispheres, that is, left and right.

In general, the left half of the brain controls the right side of the body, and vice versa.

For most right-handed people (and many left-handed people as well), the left half of the brain is dominant.

By studying patients whose corpus callosum had been destroyed, scientists realised that differences existed between the left and right sides of the cerebral cortex.

The left side of the brain functions mainly in speech, logic, writing, and arithmetic.

The right side of the brain, on the other hand, is more concerned with imagination, art, symbols, and spatial relations.

3.5.1 The Cerebral Cortex

The cerebrum's outer layer, the cerebral cortex, is composed of gray matter made up of nerve cell bodies.

The cerebral cortex is about 0.08 in (2 mm) thick and its surface area is about 5 sq ft (0.5 sq m)—around half the size of an office desk.

White matter, composed of nerve fibers covered with myelin sheaths, lies beneath the gray matter.

During embryonic development, the gray matter grows faster than the white matter and folds on itself, giving the brain its characteristic wrinkly appearance.

The folds are called convolutions or gyri, and the grooves between them are known as sulci.

A deep fissure separates the cerebrum into a left and right hemisphere, with the corpus callosum, a large bundle of fibers, connecting the two.

3.5.2 Functional Areas of the Cerebral Cortex

Considerable knowledge of cortical function has come from patients with damage to specific cortical areas, and from electrical stimulation and recording from the cortex, often as a necessary prelude to neurosurgery. Imaging procedures developed in the 1980s and 1990s, such as positron emission tomography (PET), enable neuroscientists to follow changes in cortical activity over time. PET scans can show sequential changes in brain activity during such tasks as planning and executing movement and learning and storing information.

Motor Areas: Four motor areas collectively occupy almost half of the frontal lobe. One of these, the primary motor cortex, is the precentral gyrus just anterior to the central sulcus. The motor areas are extensively connected to the basal ganglia and cerebellum. Working together in complex feedback loops, these areas are essential for motor coordination, postural stability and balance, learned movements, and the planning and execution of voluntary movement.

Sensory Areas: Primary sensory areas receive incoming sensory information. One of these, the primary somatosensory cortex, receives input for pain, temperature, touch, and pressure. It is located in the postcentral gyrus, the first gyrus of the parietal lobe posterior to the central sulcus. The primary auditory cortex, for hearing, is on the super (upper) margin of the temporal lobe, deep in the lateral fissure. The primary visual cortex, for sight, is in the occipital lobe, especially the medial surface.

Primary sensory areas are organised into precise sensory maps of the body. The primary somatosensory cortex, for example, has a point-for-point correspondence with the opposite (contralateral) side of the body, so that, for instance, the first and second fingers of the left hand send sensory information to adjacent areas of the right primary somatosensory cortex. Similarly, the primary visual cortex has a point-for-point map of the contralateral visual field. The primary auditory cortex has a tonotopic map of the cochlea of the inner ear, with different points in the cortex representing different sound frequencies.

Association Areas: Once received by a primary sensory area, information is sorted and relayed to adjacent sensory association areas for processing. Association areas identify specific qualities of a stimulus and integrate stimulus information with memory and other input. To hear a piece of music, for example, involves the primary auditory cortex, but to recognise that music as Mozart or Elvis Presley involves the auditory association area just below the primary auditory cortex.

The human brain differs from that of other primates in its large amount of association cortex. Association areas not only integrate immediate sensory data with other information, but are also responsible for human ingenuity, personality, judgment, and decision making.

Self Assessment Questions

1) Describe cerebrum and cerebellum and bring out the differences.

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2) Define brain stem and states its functions.

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3) What is Diencephalon and what role does it play?

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4) Describe the cerebral cortex and indicate the functional areas of the cerebral cortex.

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3.6 THE CEREBELLUM

The cerebellum is located below the cerebrum and behind the brain stem. It is butterfly-shaped, with the "wings" known as the cerebellar hemispheres. The cerebellum controls many subconscious activities, such as balance and muscular coordination.

Disorders related to damage of the cerebellum are ataxia (problems with coordination), dysarthria (unclear speech resulting from problems controlling the muscles used in speaking), and nystagmus (uncontrollable jerking of the eyeballs). A brain tumor that is relatively common in children known as medullablastoma grows in the cerebellum.

3.6.1 Difference between Cerebrum and Cerebellum

- One of the basic anatomical difference between these two structures is in there numbers of layers of grey matter. cerebrum has 6 layers of distinct cells in its cortex where as cerebellum has only 3 layers of neuronal cells in its cortex.

- Other difference is that they both have difference in their vasculature. cerebellum has a very high vasculature as compared to cerebrum.

- The next difference is that Cerebrum has sensory areas that interpret sensory activities, association areas that are concerned with emotional and intellectual processes like will, judgement, memory etc. It controls all voluntary activities. Cerebellum coordinates muscular activities and maintains body posture and balance.

3.7 STUDY OF THE BRAIN

Researchers have discovered that neurons carry information through the nervous system in the form of brief electrical impulses called action potentials. When an impulse reaches the end of an axon, neurotransmitters are released at junctions called synapses. The neurotransmitters are chemicals that bind to receptors on the receiving neurons, triggering the continuation of the impulse.

Fifty different neurotransmitters have been discovered since the first one was identified in 1920. By studying the chemical effects of neurotransmitters in the brain, scientists are developing treatments for mental disorders and are learning more about how drugs affect the brain.

Scientists once believed that brain cells do not regenerate, thereby making brain injuries and brain diseases untreatable. Since the late 1990s, researchers have been testing treatment for such patients with neuron transplants, introducing nerve tissue into the brain. They have also been studying substances, such as nerve growth factor (NGF), that someday could be used to help regrow nerve tissue.

Technology provides useful tools for researching the brain and helping patients with brain disorders. An electroencephalogram (EEG) is a record of brain waves, electrical activity generated in the brain. An EEG is obtained by positioning electrodes on the head and amplifying the waves with an electroencephalograph and is valuable in diagnosing brain diseases such as epilepsy and tumors.

Scientists use three other techniques to study and understand the brain and diagnose disorders:

1) Magnetic resonance imaging (MRI) uses a magnetic field to display the living brain at various depths as if in slices.

2) Positron emission tomography (PET) results in color images of the brain displayed on the screen of a monitor. During this test, a technician injects a small amount of a substance, such as glucose, that is marked with a radioactive tag. The marked substance shows where glucose is consumed in the brain. PET is used to study the chemistry and activity of the normal brain and to diagnose abnormalities such as tumors.

3) Magnetoencephalography (MEG) measures the electromagnetic fields created between neurons as electrochemical information is passed along. When under the machine, if the subject is told, “wiggle your toes,” the readout is an instant picture of the brain at work. Concentric colored rings appear on the computer screen that pinpoint the brain signals even before the toes are actually wiggled.

Using an MRI along with MEG, physicians and scientists can look into the brain without using surgery. They foresee that these techniques could help paralysis victims move by supplying information on how to stimulate their muscles or indicating the signals needed to control an artificial limb.

Self Assessment Questions

1) Define and describe cerebellum.

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2) What are the various parts of the cerebellum?

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3) What are the importances of studying the brain?

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4) What are the various methods available to scientists to study the brain?

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3.8 CEREBRAL HEMISPHERES

By means of a prominent groove, called the longitudinal fissure, the brain is divided into two halves called hemispheres. At the base of this fissure lies a thick bundle of nerve fibers, called the corpus callosum, which provides a communication link between the hemispheres. The left hemisphere controls the right half of the body, and the right hemisphere controls the left half of the body, because of a crossing of the nerve fibers in the medulla.

A cerebral hemisphere (*hemispherium cerebrale*) is one of the two regions of the eutherian brain that are delineated by the median plane, (medial longitudinal fissure). The brain can thus be described as being divided into *left* and *right cerebral hemispheres*. Each of these hemispheres has an outer layer of grey matter called the cerebral cortex that is supported by an inner layer of white matter. The hemispheres are linked by the corpus callosum, a very large bundle of nerve fibers, and also by other smaller commissures, including the anterior commissure, posterior commissure, and hippocampal commissure.

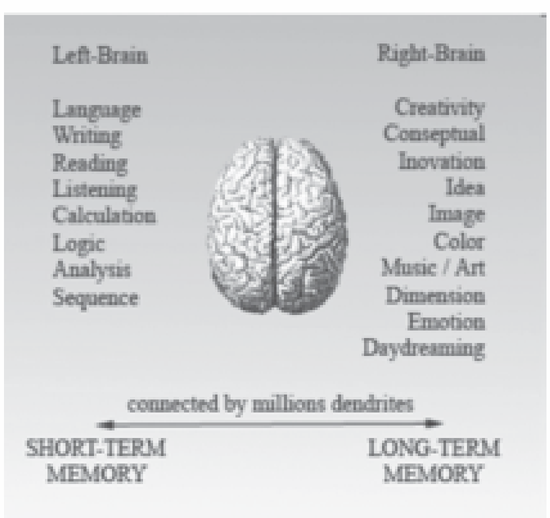
These commissures transfer information between the two hemispheres to coordinate localised functions. The architecture, types of cells, types of neurotransmitters and receptor subtypes are all distributed among the two hemispheres in a markedly asymmetric fashion. However, while some of these hemispheric distribution differences are consistent across human beings, or even across some species, many observable distribution differences vary from individual to individual within a given species.

Although the right and left hemispheres seem to be a mirror image of one another, there are important functional distinctions. In most people, for example, the areas that control speech are located in the left hemisphere, while areas that govern spatial perceptions reside in the right hemisphere.

3.8.1 Left Brain and Right Brain

The two cerebral hemispheres are neither anatomically nor functionally identical. Cortical functions are said to be lateralised when one hemisphere is dominant over the other for a particular function. The side containing the speech centers is called the dominant hemisphere, and is usually the left hemisphere. Most people are highly lateralised for language skills, and lesions in the dominant cortex can cause complete loss of specific language functions. The posterior, superior part of the dominant temporal lobe is important for understanding spoken and written language. Lesions in the language centers produce various forms of aphasia, difficulty understanding or using written or spoken language. The language-dominant hemisphere is also a site of mathematical skills, and intellectual decision making and problem solving using rational, symbolic thought processes.

The non-dominant hemisphere is more adept at recognition of complex, three-dimensional structures and patterns of both visual and tactile kinds. It is also the site for recognition of faces and other images, and for non-verbal, intuitive thought processes. Creative and artistic abilities reside in the non-dominant hemisphere. Thus, the dominant hemisphere tends to be the more analytical one, and the non-dominant hemisphere more intuitive. (See the figure below)



Left and Right Hemispheres

Left Hemisphere Functions	Right Hemisphere Functions
numerical computation (exact calculation, numerical comparison, estimation) left hemisphere only: direct fact retrieval (Dehaene, et. al.1999)	numerical computation (approximate calculation, numerical comparison, estimation) (Dehaene, et.al 1999)
language: grammar/vocabulary, literal(Taylor,1990)	language: intonation/accentuation, prosody, pragmatic, contextual (Taylor,1990)

3.8.2 The Hands and Two Hemispheres

The advantage of the popular right and left-brain speculations is that most people know they have two cerebral hemispheres. The left hemisphere controls the right half of the body and visa versa. The crossed innervation of the body is one of those curious facts that has no particular explanation. It just happens to be the case.

Damage or disease in the left hemisphere shows up in the right side of the body and visa versa. The left hemisphere tends to be dominant in terms of hand use and language storage in about 92% of humans. You determine dominance by watching which hand holds a pen and does more of the fine motor skills. The dominant side of the body also tends to be larger than the non-dominant side. About 4% of humans have right hemisphere dominance and another 4% are in the middle with more or less symmetrical hemispheric function.

The human hand is remarkably adaptable and the brain systems that control hand movements are more remarkable. Human hands hold tools, gesture, express feelings and meanings. Two hands work together in most tasks. This means that the two hemispheres work together by sending signals back and forth through a massive bundle of wires, the corpus callosum. In normal people, the left and right hemispheres form integrated operating systems that are often tightly coordinated as in walking, running, and tool use. Clumsy people are less coordinated and some have distinct difficulty achieving left and right cooperation.

The dominant hand leads the nondominant hand by 15 to 30 milli-seconds when coordinated movements are performed. This suggests that the left hemisphere initiates the movement and sends signals to the right. This asymmetric activation of the hemispheres may come from below the cerebral cortex (from the thalamus, for example) and may have implications about how all volitional activity is organised.

A popular notion, that the dominant left hemisphere is “analytic” and the right hemisphere is “synthetic or artistic,” makes little sense and is not a good way to try to understand how the human brain works. Roger Sperry and other surgeons launched the right-left theories by cutting the corpus callosum in patients with epilepsy. Studies of cognitive function revealed some interesting features of these “split-brain” patients who could not send signals back and forth between their hemispheres. These were distinctly abnormal people and their peculiarities did not reveal how normal people work.

As one would expect, the split-brain patients had disconnected cognitive functions because their hemispheres could not share information. In contrived experiments, information could be supplied to only one hemisphere and would not be available to the other. Each hemisphere revealed a separate consciousness in terms of responses to stimuli and reportable contents. Usually, only the left hemisphere could speak and could only report on information received on the left. The right hemisphere could not speak, but communicated with nonverbal vocalisations and in other ways.

The coordination of left and right hand and arm movements is critically important to human survival. Both hands are needed to perform most tasks and although the hands may do different tasks, both hands cooperate and work toward the same goal. The right-left linkage shows up clearly whenever you try to perform distinctly different tasks with each hand. Even with sustained practice, the hands want to do similar things or perform linked movements as you do when you play the bongo drums or knit sweaters.

The central sulcus and the lateral sulcus, divide each cerebral hemisphere into four sections, called lobes (see Division of the Cortex Into Lobes). The central sulcus, also called fissure of Rolando, also separates the cortical motor area (which is anterior to the fissure).

Central Sulcus is an important landmark because it forms the boundary between the frontal and parietal lobes and also separates the primary sensory cortex (posterior) from the primary motor cortex (anterior).

Starting from the top of the hemisphere, the upper regions of the motor and sensory areas control the lower parts of the body.

3.8.3 Cerebral Dominance

This term refers to the fact that one of the cerebral hemispheres is “leading” the other one in certain functions. The difference is most realised in language and manual skills. Although there is an individual and cultural variability, language is mostly represented on the left hemisphere, while non-verbal skills tend to be represented on the right hemisphere. Broca’s area and Wernick’s area refers to language function and lie on the left hemisphere.

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3.8.4 Functions of the Left Hemisphere

Considered the "dominant half of the brain" in most people due to the verbal and analytical skills contained, the left hemisphere is the logical, rational hemisphere of the brain, as Enspire Press states. It controls all communication such as talking, reading and verbal awareness. The processing of information in logic and spatial perceptions—such as multiplying, using reason, typing and analysing situations is made possible within the left hemisphere. The left hemisphere also controls the right half of the body.

3.8.5 Functions of the Right Hemisphere

The right hemisphere, explains Alz Online, "is associated with 'unconscious' awareness (in the sense it is not linguistically based)." Recognition of faces, understanding of social interaction, artistic creativity, intuition and emotion are controlled by your brain's right hemisphere. However, although either hemisphere has its own specialty, communication between both occurs across the corpus callosum—the dividing matter. But, "this is not an equal partnership ... one hemisphere usually dominates over the other," as Bryn Mawr explains. Evidence of this is in people who are either left or right handed. Additionally, women have a thicker corpus callosum, explains Enspire Press, "likely giving rise to women's intuition." Even the differences between men's and women's thoughts and emotions are thought to arise from differences in the right and left hemispheres.

3.8.6 Hemispheric Lobe Functions

Both of the hemispheres, right and left, contain specialised areas called lobes. The lobes are named to correspond to the section of skull plate protecting them: frontal, parietal, temporal, and occipital. Most important of these, the frontal lobe, contained in both left and right hemispheres, is associated "with what it means to be human," as Enspire Press explains. Whether in the right or left hemisphere, any damage results "in a person who is deemed emotionally shallow, listless, apathetic, and insensitive to social norms," Enspire continues. In contrast, the parietal, temporal and occipital lobes within the hemispheres regulate perception. The parietal regulates touch, pressure, pain, even temperature. The occipital processes visual information, and hearing is controlled by the temporal lobe. Thus, it is not the hemispheres at all that control emotional and physical function—but the lobes located in the hemispheres.

3.8.7 Lateralisation or Plasticity of Hemispheric Function

It can prove unclear which predominates, that is the specialisation of a hemisphere and its lobes, called lateralisation or the interaction and cooperation of hemispheric regions. In the early years of psychology, the discovery of Broca's area a small region of the right hemisphere without which speech is impossible led psychologists to speculate that hemispheric power is all or nothing. Each hemisphere has localised function, they believed, which led to a very stereotyped understanding of the two hemispheres. In reality in most instances, hemispheres do not work alone. The functions of the major cerebral hemispheres and their lobes work together, and for function to be completely lost, both hemispheres must be damaged.

Self Assessment Questions

1) With the help of a diagram show the two hemispheres of the brain and discuss their functions.

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2) Discuss the role of right and left hemispheres in regard to hand dominance.

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3) What is meant by cerebral dominance?

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4) What are the functions of left and right hemispheres?

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5) What do you understand by lateralisation or plasticity of hemispheric function?

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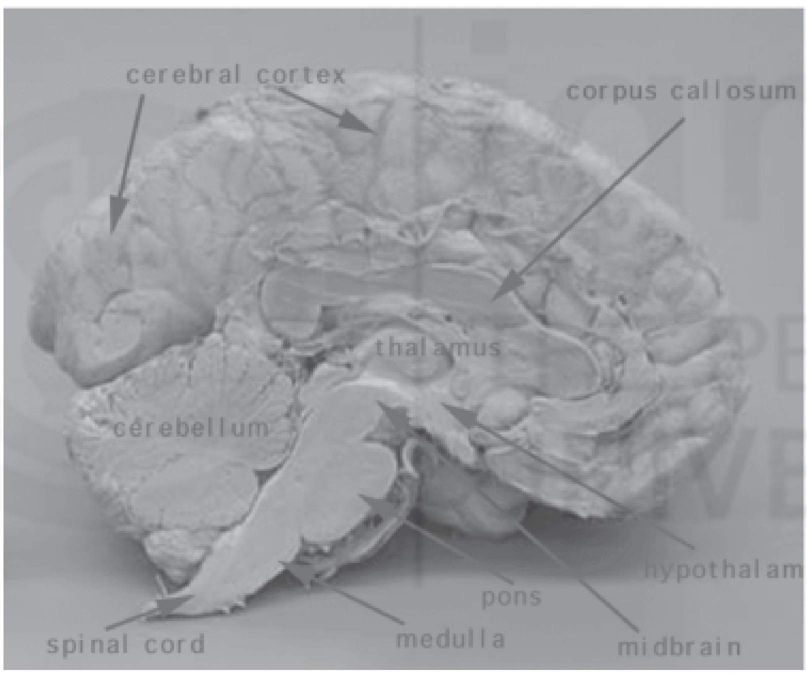
3.9 THE LIMBIC SYSTEM

The limbic system is a ring of tissue on the medial surface of each hemisphere, surrounding the corpus callosum and diencephalon and incorporating parts of the frontal, parietal, and temporal lobes. Corpus callosum is the main "bridge" between the left and right cerebral hemispheres; a broad bundle of myelinated fibers (white matter) carrying information from regions in one lobe to similarly placed regions in the opposing lobe. There are some 300 million fibers in the average corpus callosum. Cutting the corpus callosum prevents communication between the hemispheres (creating the well-known "split-brain" cases), and is used in severe cases of epilepsy. A major component of this system is the hippocampal formation, deep in the temporal lobe.

This is often referred to as the "emotional brain", and is found buried within the cerebrum. Like the cerebellum, evolutionarily the structure is rather old.

This system contains the thalamus, hypothalamus, amygdala, and hippocampus. Here is a visual representation of this system.



1) Thalamus
2) Hypothalamus
3) Amygdala
4) Hippocampus

Let us see what these structures do.

1) **The thalamus:** The thalamus is part of the limbic system so it is located in the internal portion of the brain or the center of the brain. The thalamus controls your sensory integration and motor integration. The thalamus recieves sensory information and relays it to the cerebral cortex. The cerebral cortex also sends information to the thalamus which then transmits this information to other parts of the brain and the brain stem.

2) **The Hypothalamus:** The hypothalamus is part of the limbic system. It is located in the internal portion of the brain under the thalamus. The hypothalamus controls your body temperature, emotions, hunger, thirst, appetite, digestion and sleep. The hypothalamus is composed of several different areas and is located at the base of the brain. It is only the size of a pea (about 1/300 of the total brain weight), but is responsible for some very important behaviours.

3) **Amygdala:** The almond shaped amygdala is part of the limbic system so it is located in the internal portion of the brain. The amygdala (there are two of them) control your emotions such as regulating when you're happy or mad. Your amygdala is very important. Without it you could win the lottery and feel nothing. You wouldn't be happy.

4) **Hyppocampus:** The crescent shaped hippocampus is found deep in the temporal lobe, in the front of the limbic system. The hippocampas forms and stores your memories (scientists think there are other things unknown about the hippocampas) and is involved in learning. Your hippocampus is one of the most important parts of your brain. If you didn't have it, you wouldn't be able to remember anything. People with Alzheimer's Disease loose the functioning of their hippocampus

3.10 THE FOREBRAIN

The cerebrum or telencephalon, the largest subdivision of the human brain, together with the diencephalon, constitutes the forebrain. It is the most anterior or, especially in humans, most superior region of the vertebrate central nervous system.

"Telencephalon" refers to the embryonic structure, from which the mature "cerebrum" develops. It consists of a pair of cerebral hemispheres.

The dorsal telencephalon, or pallium, develops into the cerebral cortex, and the ventral telencephalon, or subpallium, becomes the basal ganglia.

Each hemisphere consists of an outer mantle of gray matter (the cerebral cortex), an extensive underlying of white matter, and deep aggregations of gray matter, the basal nuclei, or ganglia.

It, with the assistance of the cerebellum, controls all voluntary actions in the body.

Basal ganglia are large "knots" (ganglion means knot) of nerve cells deep in the cerebrum. They are thought to be involved in various aspects of motor behaviour (Parkinson's disease, for example, is an affliction of the basal ganglia).

Structures contained in the basal ganglia include the amygdala, globus pallidus, and striatum (containing the caudate nucleus and the putamen).

As the cortex continues to grow, it is thrown into folds called gyri (singular, gyrus), separated by shallow grooves called sulci (singular, sulcus).

Sulcus is a cleft or fissure in the cerebrum. A few especially prominent sulci appear early in development and are consistent from brain to brain. They serve as landmarks to divide the cortex into areas called lobes.

Self Assessment Questions

1) Describe the limbic system.

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2) What are the various parts of the limbic system? Describe each of them.

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3) Where is forebrain located and what is its importance?

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4) What are the parts of the forebrain? Discuss each of them in detail.

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3.11 LOBES OF THE BRAIN

The frontal, parietal, temporal, and occipital lobes

The frontal, parietal, temporal, and occipital lobes are visible on the surface of the brain. The frontal lobe extends from the region of the forehead to a groove called the central sulcus at the top of the head.

The parietal lobe begins there and progresses posteriorly as far as the parieto-occipital sulcus, which is visible only on the medial surface of the brain.

The occipital lobe extends from there to the rear of the head.

A conspicuous lateral fissure separates the temporal lobe, in the region of the ear, from the frontal and parietal lobes above it.

The insula is a fifth lobe of the cerebrum not visible from the surface. It lies deep to the lateral fissure between portions of the frontal, parietal, and temporal lobes.

Let us study these lobes in detail.

3.11.1 Frontal Lobe

The frontal lobes are anterior to the central sulcus. They are essential for planning and executing learned and purposeful behaviours; they are also the site of many inhibitory functions. There are several functionally distinct areas in the frontal lobes:

The primary motor cortex is the most posterior part of the precentral gyrus. The primary motor cortex on one side controls all moving parts on the contralateral side of the body. 90% of motor fibers from each hemisphere cross the midline in the brain stem. Thus, damage to the motor cortex of one hemisphere causes weakness or paralysis mainly on the contralateral side of the body.

The medial frontal cortex (sometimes called the medial prefrontal area) is important in arousal and motivation. If lesions in this area are large and extend to the most anterior part of the cortex (frontal pole), patients sometimes become abulic (apathetic, inattentive, and markedly slow to respond).

The orbital frontal cortex (sometimes called the orbital prefrontal area, helps modulate social behaviours. Patients with orbital frontal lesions can become emotionally labile, indifferent to the implications of their actions, or both. They may be alternately euphoric, facetious, vulgar, and indifferent to social nuances. Bilateral acute trauma to this area may make patients boisterously talkative, restless, and socially intrusive. With aging and in many types of dementia, disinhibition and abnormal behaviours can develop; these changes probably result from degeneration of the frontal lobe, particularly the orbital frontal cortex.

The left posteroinferior frontal cortex (sometimes called Broca’s area or the posteroinferior prefrontal area controls expressive language function. Lesions in this area cause expressive aphasia (impaired expression of words).

The dorsolateral frontal cortex (sometimes called the dorsolateral prefrontal area) manipulates very recently acquired information—a function called working memory. Lesions in this area can impair the ability to retain information and process it in real time (e.g, to spell words backwards or to alternate between letters and numbers sequentially).

3.11.2 Parietal Lobe

Several areas in the parietal lobes have specific functions.

The primary somatosensory cortex, located in the postrolandic area (postcentral gyrus) in the anterior parietal lobes, integrates somesthetic stimuli for recognition and recall of form, texture, and weight. The primary somatosensory cortex on one side receives all somatosensory input from the contralateral side of the body. Lesions of the anterior parietal lobe can cause difficulty recognising objects by touch (astereognosis).

Areas posterolateral to the postcentral gyrus generate visual-spatial relationships and integrate these perceptions with other sensations to create awareness of trajectories of moving objects. These areas also mediate proprioception (awareness of the position of body parts in space).

Parts of the midparietal lobe of the dominant hemisphere are involved in abilities such as calculation, writing, left-right orientation, and finger recognition. Lesions in the angular gyrus can cause deficits in writing, calculating, left-right disorientation, and finger-naming (Gerstmann's syndrome).

The nondominant parietal lobe integrates the contralateral side of the body with its environment, enabling people to be aware of this environmental space, and is important for abilities such as drawing. Acute injury to the nondominant parietal lobe may cause neglect of the contralateral side (usually the left), resulting in decreased awareness of that part of the body, its environment, and any associated injury to that side (anosognosia). For example, patients with large right parietal lesions may deny the existence of left-sided paralysis. Patients with smaller lesions may lose the ability to do learned motor tasks (e.g, dressing, other well-learned activities)—a spatial-manual deficit called apraxia.

3.11.3 Temporal Lobe

The temporal lobes are integral to auditory perception, receptive components of language, visual memory, declarative (factual) memory, and emotion. Patients with right temporal lobe lesions commonly lose the ability to interpret nonverbal auditory stimuli (eg, music). Left temporal lobe lesions interfere greatly with the recognition, memory, and formation of language.

Patients with epileptogenic foci in the medial limbic-emotional parts of the temporal lobe commonly have complex partial seizures, characterised by uncontrollable feelings and autonomic, cognitive, or emotional dysfunction. Occasionally, such patients have personality changes, characterised by humorlessness, philosophic religiosity, and obsessiveness.

3.11.4 Occipital Lobe

The occipital lobes contain the primary visual cortex and visual association areas. Lesions in the primary visual cortex lead to a form of central blindness called Anton's syndrome; patients become unable to recognise objects by sight and are generally unaware of their deficits. Seizures in the occipital lobe can cause visual hallucinations, often consisting of lines or meshes of color superimposed on the contralateral visual field.

3.12 LET US SUM UP

The cerebral cortex is the layer of the brain often referred to as gray matter. The cortex (thin layer of tissue) is gray because nerves in this area lack the insulation that makes most other parts of the brain appear to be white. The cortex covers the outer portion of the cerebrum and cerebellum. The portion of the cortex that covers the cerebrum is called the cerebral cortex. The cerebral cortex consists of folded bulges called gyri that create deep furrows or fissures called sulci. The folds in the brain add to its surface area and therefore increase the amount of gray matter and the quantity of information that can be processed.

The cerebral cortex is divided into right and left hemispheres. It encompasses about two-thirds of the brain mass and lies over and around most of the structures of the brain. It is the most highly developed part of the human brain and is responsible for thinking, perceiving, producing and understanding language. It is also the most recent structure in the history of brain evolution. Most of the actual information processing in the brain takes place in the cerebral cortex.

The cerebral cortex is divided into lobes that each has a specific function. For example, there are specific areas involved in vision, hearing, touch, movement, and smell. Other areas are critical for thinking and reasoning. Although many functions, such as touch, are found in both the right and left cerebral hemispheres, some functions are found in only one cerebral hemisphere. For example, in most people, language abilities are found in the left hemisphere. The cerebral cortex is responsible for sensing and interpreting input from various sources and maintaining cognitive function. Sensory functions interpreted by the cerebral cortex include hearing, touch, and vision. Cognitive functions include thinking, perceiving, and understanding language.

3.13 UNIT END QUESTIONS

1) Discuss the cerebrum and cerebellum in detail.

2) Discuss in detail all aspects related to the two hemispheres of the brain.

3) What is the importance of the forebrain? Discuss its parts and their functions.

4) Discuss the temporal lobe and the occipital lobe in terms of their location and their functions.

5) Discuss the functions of the frontal and parietal lobes of the brain.

3.14 SUGGESTED READINGS

Mark E. Bear, Barry W. Connors & Michael A.Paradiso (2001) (2nd edition). *Neuroscience. Exploring the Brain*. Lippincott Williams & Wilkins, New York.

Restack, Richard (19096). *Brainscapes: An Introduction to what neuroscience has Learned about the Structure, Function and Abilities of the Brain*. Discover books, NY.

UNIT 4 CEREBRAL LOBES AND THE LIMBIC SYSTEM

Structure

4.0 Introduction

4.1 Objectives

4.2 The Lobes of the Brain

4.3 The Frontal Lobe

- 4.3.1 The Location of the Frontal Lobe
- 4.3.2 Anatomy of Frontal Lobe
- 4.3.3 Different Functions of Frontal Lobes
- 4.3.4 Frontal Lobe Damage

4.4 The Occipital Lobe

- 4.4.1 Occipital Lobe Anatomy
- 4.4.2 Location of the Occipital Lobe
- 4.4.3 Functions of the Occipital Lobe
- 4.4.4 Occipital Lobe Damage and Its Effects

4.5 The Parietal Lobe

- 4.5.1 Location of Parietal Lobe
- 4.5.2 Anatomy of Parietal Lobe
- 4.5.3 Functions of Parietal Lobe
- 4.5.4 Damage to Parietal Lobe and Its Effects

4.6 The Temporal Lobe

- 4.6.1 Location of Temporal Lobe
- 4.6.2 Anatomy of Temporal Lobe
- 4.6.3 The Functions of Temporal Lobe
- 4.6.4 Temporal Lobe Damage and Its Effects

4.7 The Limbic System

4.8 The Amygdala

4.9 Let Us Sum Up

4.10 Unit End Questions

4.11 Suggested Readings

4.0 INTRODUCTION

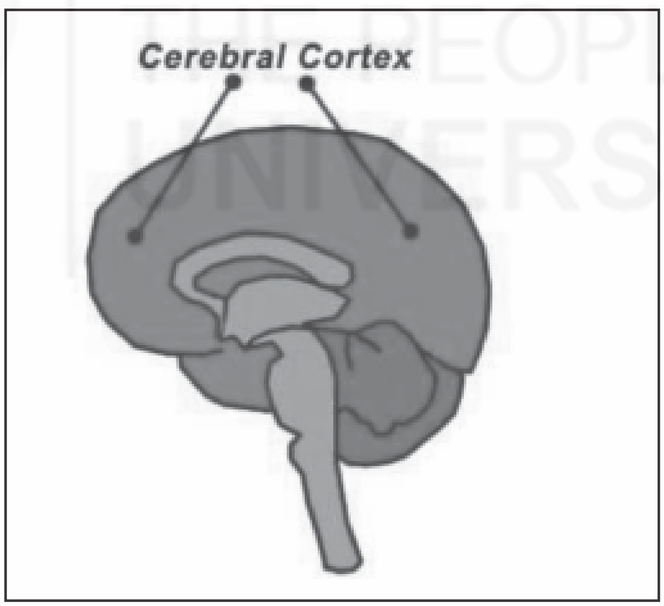
In this unit we will be dealing with the lobes of the brain. This consists of the frontal, occipital, parietal and temporal lobes. Then we take up in detail the frontal lobe and discuss its anatomy, location and functions. Then we deal with the damage caused to the frontal lobe and what are the effects of the same. This section is followed by the section on Occipital lobe. We take up the anatomy, location and functions of occipital lobe, and discuss the consequences of any damage to any part of the occipital lobe. Then we take up the issue of parietal lobe and discuss its location, anatomy and functions. We also mention about the damages caused to the parietal lobe and the consequences of the same. This is followed by a section on temporal lobe in which we discuss then location, anatomy and functions of the temporal lobe and point out how damage to this lobe ma cause myriads of problems. Then we present the limbic system and amygdala and their effects on behaviour.

4.1 OBJECTIVES

After completing this unit, you will be able to:

- Define lobes of the brain;
- Categorize the structural divisions of the brain;
- Describe the general structure of the frontal lobe;
- Describe the primary functions of the frontal lobe;
- Explain what would happen if the frontal lobe is damaged;
- Describe the location, anatomy and functions of the occipital lobe;
- Analyse the problems that may arise as a result of damage to the occipital lob;
- Elucidate the functions, location and anatomy of temporal lobe; and
- Explain the behaviours that may be affected as a result of damage to the lobe.

4.2 THE LOBES OF THE BRAIN

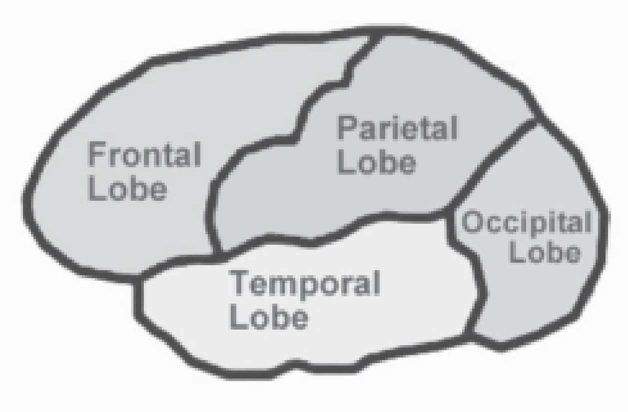


The human brain is not only one of the most important organs in the human body but it is also the most complex. In the following sections, We will discuss the basic structures that make up the brain as well as how the brain works.

The cerebral cortex is a part of the brain that functions to make human beings unique. Distinctly human traits including higher thought, language, human consciousness, as well as the ability to think, reason, and imagine all originate in the cerebral cortex.

The cerebral cortex is what we see when we look at the brain. It is the outermost portion that can be divided into the four lobes of the brain. Each bump on the surface of the brain is known as a **gyrus**, while each groove is known as a **sulcus**.

The Four Lobes (*Source: Kendra Van Wagner*)



The cerebral cortex can be divided into four sections, which are known as lobes (see figure above). The frontal lobe, parietal lobe, occipital lobe and temporal lobe. These lobes have been associated with different functions ranging from reasoning to auditory perception.

The frontal lobe is located at the front of the cerebrum. This section reaches maturity when a person is about 25 years old. It handles the functions of planning, emotions, and parts of speech. It is associated with reasoning, motor skills, higher lever cognition, and expressive language. It is also where most of the personality is based. This means that it controls a lot of a person's behaviour and expressions. Because this lobe is so large and located in the front of the skull, the majority of injuries to the brain occur to this lobe. At the back of the frontal lobe, near the central sulcus, lies the motor cortex. This area of the brain receives information from various lobes of the brain and utilises this information to carry out body movements.

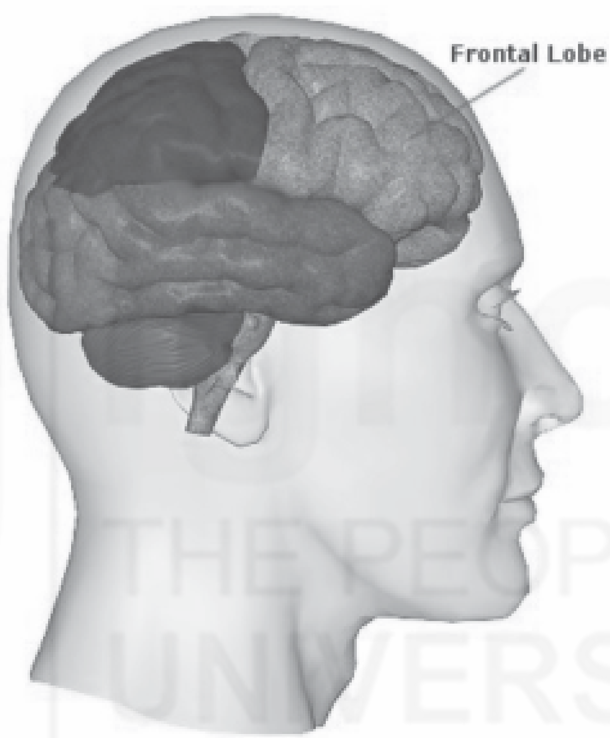
The parietal lobe above the occipital lobe and behind the frontal lobe. It is located in the middle section of the brain and is associated with processing tactile sensory information This part of the cerebellum handles information related to touch, temperature, pain and pressure. This lobe coordinates sensory information and enables the person to correctly perceive their environment as one complete whole. If this area is damaged, a person may have difficulty with coordination, movement or recognition that his or her body is in pain. A portion of the brain known as the somatosensory cortex is located in this lobe and is essential to the processing of the body's senses.

The temporal lobe is located on the side of the cerebrum and at the bottom section of the brain. This lobe is also the location of the primary auditory cortex, which is important for interpreting sounds and the language we hear. The hippocampus is also located in the temporal lobe, which is why this portion of the brain is also heavily associated with the formation of memories. The main purpose of this lobe is to interpret auditory data. This means that it processes information that a person receives through their sense of hearing. This lobe also plays a role in both speech and memory. It is believed that the temporal lobe helps when the brain is transferring memories from short term to long term.

The occipital lobe is the part of the brain that manages data received through the sense of vision. This lobe is located behind and below the parietal and temporal lobes. It is located at the back portion of the brain and is associated with interpreting visual stimuli and information. This part of the brain allows us to distinguish shapes and colours and to process what our eyes see. The primary visual cortex, which receives and interprets information from the retinas of the eyes, is located in the occipital lobe.

Let us now take each of the lobes and discuss them in detail. Let us start with frontal lobe.

4.3 THE FRONTAL LOBE (FIGURE BELOW)



The frontal lobes are considered our emotional control center and home to our personality. There is no other part of the brain where lesions can cause such a wide variety of symptoms (Kolb & Wishaw, 1990). The frontal lobes are involved in motor function, problem solving, spontaneity, memory, language, initiation, judgement, impulse control, and social and sexual behaviour. The frontal lobes are extremely vulnerable to injury due to their location at the front of the cranium, proximity to the sphenoid wing and their large size. MRI studies have shown that the frontal area is the most common region of injury following mild to moderate traumatic brain injury.

There are important asymmetrical differences in the frontal lobes. The left frontal lobe is involved in controlling language related movement, whereas the right frontal lobe plays a role in non verbal abilities. Some researchers emphasise that this rule is not absolute and that with many people, both lobes are involved in nearly all behaviour.

Disturbance of motor function is typically characterised by loss of fine movements and strength of the arms, hands and fingers. Complex chains of motor movement also seem to be controlled by the frontal lobes.

Patients with frontal lobe damage exhibit little spontaneous facial expression, which points to the role of the frontal lobes in facial expression. Broca's Aphasia, or difficulty in speaking, has been associated with frontal lobe damage.

An interesting phenomenon of frontal lobe damage is the insignificant effect it can have on traditional IQ testing. Researchers believe that this may have to do with IQ tests typically assessing *convergent* rather than *divergent* thinking. Frontal lobe damage seems to have an impact on divergent thinking, or flexibility and problem solving ability. There is also evidence showing lingering interference with attention and memory even after good recovery from a TBI(Traumatic Brain Injury).

Another area often associated with frontal damage is that of "behavioural sponteneity." It has been noted that individual with frontal lobe damage displayed fewer spontaneous facial movements, spoke fewer words (left frontal lesions) or excessively (right frontal lesions).

One of the most common characteristics of frontal lobe damage is difficulty in interpreting feedback from the environment. Perseverating on a response, risk taking, and non compliance with rules, and impaired associated learning using external cues to help guide behaviour are a few examples of this type of deficit.

The frontal lobes are also thought to play a part in our spatial orientation, including our body's orientation in space.

One of the most common effects of frontal lobe damage can be a dramatic change in social behaviour. A person's personality can undergo significant changes after an injury to the frontal lobes, especially when both lobes are involved. There are some differences in the left versus right frontal lobes in this area. Left frontal damage usually manifests as pseudodepression and right frontal damage as pseudopsychopathic.

Sexual behaviour can also be effected by frontal lesions. Orbital frontal damage can introduce abnormal sexual behaviour, while dorolateral lesions may reduce sexual interest (Walker and Blummer, 1975).

Some common tests for frontal lobe function are: Wisconsin Card Sorting (response inhibition); Finger Tapping (motor skills); Token Test (language skills).

4.3.1 The Location of the Frontal Lobe

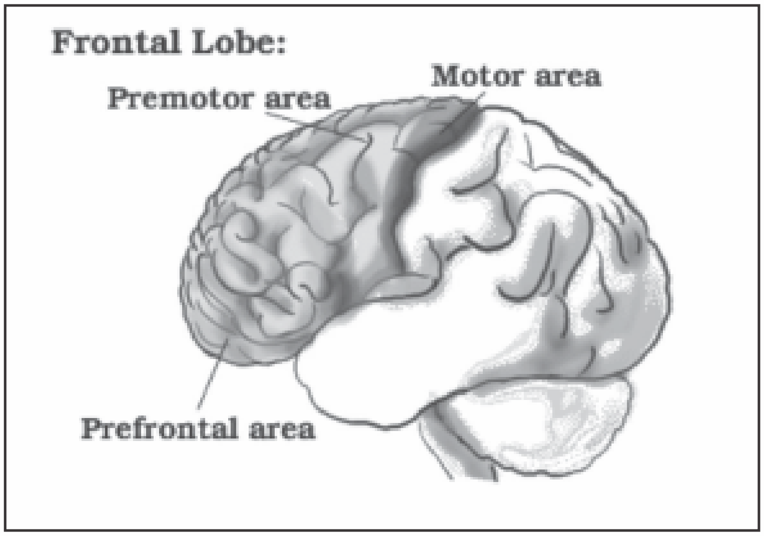
The *frontal lobe* is an area in the brain of humans and other mammals, located at the front of each cerebral hemisphere and positioned anterior to (in front of) the parietal lobes and above and anterior to the temporal lobes (i.e. directly behind the forehead or "temple").

It is separated from the parietal lobe by the post-central gyrus primary motor cortex, which controls voluntary movements of specific body parts associated with the precentral gyrus posteriorly.

It is associated inferiorly by lateral sulcus which separates it from the temporal lobe.

It is associated superiorly by the superior margin of the hemisphere and anteriorly by the frontal pole.

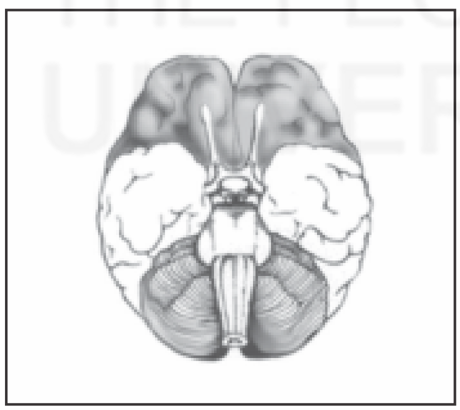
4.3.2 Anatomy of Frontal Lobe



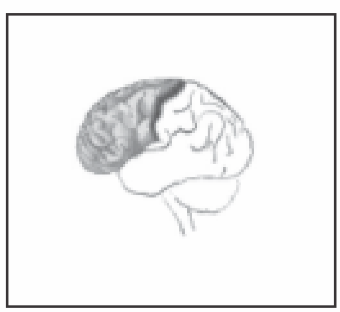
Frontal Lobe: Front part of the brain; involved in planning, organising, problem solving, selective attention, personality and a variety of "higher cognitive functions" including behaviour and emotions.

The anterior (front) portion of the frontal lobe is called the prefrontal cortex. It is very important for the "higher cognitive functions" and the determination of the personality.

The posterior (back) of the frontal lobe consists of the premotor and motor areas. Nerve cells that produce movement are located in the motor areas. The premotor areas serve to modify movements.



Ventral View (From Bottom)



Side View (Cognition and memory)

On the lateral surface of the human brain, the central sulcus separates the frontal lobe from the parietal lobe.

The lateral sulcus separates the frontal lobe from the temporal lobe.

The frontal lobe can be divided into the following:

- a lateral part
- a polar (front almost) part
- an orbital (also called basal or ventra) part
- a medial part.

Each of these parts consists of particular gyri:

i) **Lateral part:** Precentralgyrus, lateral part of the superior frontal gyrus, middle frontal gyrus, inferior frontal gyrus.

ii) **Polar part:** Transverse frontopolar gyri, frontomarginal gyrus.

iii) **Orbital part:** Lateral orbital gyrus, anterior orbital gyrus, posterior orbital gyrus, medial orbital gyrus, gyrus rectus.

iv) **Medial part:** Medial part of the superior frontal gyrus, cingulate gyrus.

The gyri are separated by sulci. E.g., the precentral gyrus is in front of the central sulcus, and behind the precentral sulcus.

The superior and middle frontal gyri are divided by the superior frontal sulcus.

The middle and inferior frontal gyri are divided by the inferior frontal sulcus.

In humans, the frontal lobe reaches full maturity around only after the 20s marking the cognitive maturity associated with adulthood.

4.3.3 Different Functions of Frontal Lobes

The frontal lobes are considered our emotional control center and home to our personality. There is no other part of the brain where lesions can cause such a wide variety of symptoms.

Prefrontal area is involved in the following:

- The ability to concentrate and attend, elaboration of thought.
- The “Gatekeeper”; (judgment, inhibition).
- Personality and emotional traits.
- Deals with Movement.
- Motor Cortex (Brodman’s): voluntary motor activity.
- *Premotor Cortex:* storage of motor patterns and voluntary activities.

Language problems and motor speech problems include the following:

- Impairment of recent memory, inattentiveness, inability to concentrate, behaviour disorders, difficulty in learning new information. Lack of inhibition (inappropriate social and/or sexual behaviour). Emotional lability. “Flat” affect.

- Contralateral plegia, paresis.
- Expressive/motor aphasia.

The frontal lobes are involved in motor function, problem solving, spontaneity, memory, language, initiation, judgment, impulse control, and social and sexual behaviour.

There are important asymmetrical differences in the frontal lobes. The left frontal lobe is involved in controlling language related movement, whereas the right frontal lobe plays a role in non verbal abilities. Some researchers emphasise that this rule is not absolute and that with many people, both lobes are involved in nearly all behaviour.

The executive functions of the frontal lobes involve the ability to recognise future consequences resulting from current actions, to choose between good and bad actions, override and suppress unacceptable social responses, and determine similarities and differences between things or events. Therefore, it is involved in higher mental functions.

The frontal lobes also play an important part in retaining longer term memories which are not task-based. These are often memories associated with emotions derived from input from the brain's limbic system.

The frontal lobe modifies those emotions to generally fit socially acceptable norms.

Psychological tests that measure frontal lobe function include finger tapping, Wisconsin Card Sorting Task, and measures of verbal and figural fluency.

4.3.4 Frontal Lobe Damage

The frontal lobes are extremely vulnerable to injury due to their location at the front of the cranium, proximity to the sphenoid wing and their large size. MRI studies have shown that the frontal area is the most common region of injury following mild to moderate traumatic brain injury (Levin et al., 1987).

The frontal lobe contains most of the dopamine-sensitive neurons in the cerebral cortex. The dopamine system is associated with reward, attention, long-term memory, planning, and drive. Dopamine tends to limit and select sensory information arriving from the thalamus to the fore-brain. A report from the National Institute of Mental Health says a gene variant that reduces dopamine activity in the prefrontal cortex is related to poorer performance and inefficient functioning of that brain region during working memory tasks, and to slightly increased risk for schizophrenia.

A new study has found the strongest evidence regarding what sets humans apart from other primates. This is found in the brain's frontal lobes, particularly in an area the size of a "billiard ball" called the right prefrontal cortex.

Understanding the mental processes of others, that is mentalising is the basis of our socialisation and what makes us human. It gives rise to our capacity to feel empathy, sympathy, understand humor and when others are being ironic, sarcastic or even deceptive. It's a "theory of mind" that has been associated with the frontal lobes, but until now scientists have had difficulty demonstrating this ability to specific regions of the brain.

What is exciting about this study, according to Dr. Timothy Shallice of the Institute of Cognitive Neuroscience at University College London, is that the Rotman study came at this challenge with two different testing methods and both generated similar compelling evidence to show that these higher cognitive functions in humans are "localisable" to a specific region within the frontal lobes. Dr. Shallice wrote the lead editorial in BRAIN.

Dr. Stuss and his research colleagues tested patients who had damage to various parts of the frontal lobes, and other areas of the brain as well. The selective impairment in only some patients provided the ability to precisely localise those regions that are necessary when specific mentalising tasks are performed. Dr Strauss and his colleagues reported that in their study, the frontal lobes were the most critical region for visual perspective taking, and the inferior medial prefrontal region, particularly for the right, for detecting deception. Visual perspective taking is the ability to empathise or identify with the experience of another person.

It has long been known that some patients with frontal lobe damage have significantly changed personalities. What is important about the study is that it helps families, friends and caregivers of the patient to appreciate and understand a very important reason why this occurs. This deficit in mentalising can affect social cognition which is important in everyday human interactions. For example, patients with damage in the specific frontal area are often less empathetic and sympathetic, and they miss social cues which lead to inappropriate judgements.

In a study conducted by Strauss, 32 adults with lesions in frontal and non-frontal brain regions, most commonly as a result of stroke, and a control group of 14 healthy adults, underwent two seemingly very simple tests. Both tasks required participants to guess in which coffee cup a ball was hidden under. Participants sat across a table from the experimenter and a table curtain was used on some occasions to conceal which cup the experimenter hid the ball under. The participant was asked to point to the correct cup.

The first test was on visual perspective taking. In this the participants had to reflect on their own experience to understand and interpret the experience of others. For example, the participants either saw the ball being hidden under a particular cup with the curtain open, or were told that the ball was being hidden when the curtain was closed and they could not see anything.

Then two assistants joined the task. One sat beside the experimenter, and one beside the participant. The table curtain was drawn this time, concealing which cup the ball was placed under. When the participant had to guess where the ball was hidden, the assistants 'helped' by moving beside the examiner and each pointed to a different cup.

Participants needed to realise that one of the assistants had not been in a position to see where the ball was hidden (because they were sitting beside the participant who themselves could not see where the ball was hidden).

The results of this experiment showed that the Frontal lesion subjects had a much higher error rate on the task and it appeared that the 'right' frontal lobe was most critical. While the small number of right frontal subjects (4) makes this only a suggestion, it is still a striking finding, says Dr. Strauss.

In the second test on deception, an assistant sat at the table beside the experimenter and always pointed to a cup where the ball was NOT hidden. Participants had to infer that the assistant was trying to deceive them. Those with right inferior medial prefrontal damage had difficulty catching on to the ruse and were the most frequently deceived.

A team of brain scientists at Carnegie Mellon University and the University of Pittsburgh has found spontaneous reorganisation of cognitive function immediately following brain damage caused by stroke.

The findings are based on functional magnetic resonance imaging (FMRI) scans showing that brain function associated with language shifted away from the stroke-damaged area of the adult brain to the corresponding area on the undamaged side of the brain. The findings show the "healing" that happens after a stroke occurs at a high level of organisation, demonstrating the plasticity of the human brain long into adulthood. Such plasticity was routinely credited to the brain in the first few years of life.

The results also indicate the organisational flexibility of the cortical systems that underlie higher level thinking processes. The researchers say this knowledge may be useful in designing future rehabilitation strategies that can exploit the flexibility.

Using non-invasive FMRI, the team looked at the brains of two stroke patients, 34 and 45 years old, as they read and indicated their comprehension of normal English sentences. Very soon after stroke, the cortical areas on the right sides of their brains, the right-hand homologues of Broca's area or of Wernick's area, showed increasing activation during the sentence comprehension, at about the same time as the patients' ability to process language was coming back to them.

In healthy brains, language functions are carried out by a network of mirror image brain areas in the left and right side of the brain, with one side, usually the left, being dominant. The subordinate side, usually the right, may spend most of its lifetime playing an understudy role, as well as developing its own specialisations.

But if a stroke or some other neurological damage disables one of the network components on the dominant side, the corresponding left side component rapidly and spontaneously emerges from its understudy role, and starts to activate to a normally high level during language processing.

The rapid recovery of the ability to use language after stroke damage to the language network was previously attributed to tissue healing functions, like reduction of swelling in the brain.

Researchers say the new results show that part of the recovery is due to the brain function reorganisation, a re-balancing of the network, like the cast of a play adjusting to the loss of a key actor. The adjustment can begin within a day or two after the stroke, and can continue for many months.

Damage to the frontal lobes can lead to a variety of results:

- Mental flexibility and spontaneity will be impaired, but IQ is not reduced.

- Talking may increase or decrease dramatically.
- Perceptions regarding risk-taking and rule abiding are impaired.
- Socialisation can diminish or increase.
- Orbital frontal lobe damage can result in peculiar sexual habits.
- Dorsolateral frontal lobe damage reduces sexual interest.
- Creativity is diminished or increased as well as problem solving skills.
- Distraction occurs more frequently.
- Loss of smell and/or taste.
- One of the most common characteristics of frontal lobe damage is difficulty in interpreting feedback from the environment.
- Perseverating on a response, risk taking, and non compliance with rules
- Impaired associated learning
- The effects of frontal damage can lead to a dramatic change in social behaviour.
- A person's personality can undergo significant changes after an injury to the frontal lobes, especially when both lobes are involved.
- There are some differences in the left versus right frontal lobes in this area.

Left frontal damage usually manifests as pseudo depression and right frontal damage as pseudo psychopathic.

- An interesting phenomenon of frontal lobe damage is the insignificant effect it can have on traditional IQ testing. Researchers believe that this may have to do with IQ tests typically assessing *convergent* rather than *divergent* thinking.
- Frontal lobe damage seems to have an impact on divergent thinking, or flexibility and problem solving ability.
- There is also evidence showing lingering interference with attention and memory even after good recovery from a Traumatic Brain Injury (TBI).
- Disturbance of motor function is typically characterised by loss of fine movements and strength of the arms, hands and fingers.
- Complex chains of motor movement also seem to be controlled by the frontal lobes.
- Patients with frontal lobe damage exhibit little spontaneous facial expression, which points to the role of the frontal lobes in facial expression.
- Broca's Aphasia, or difficulty in speaking, has been associated with frontal damage by Brown.
- Another area often associated with frontal damage is that of "behavioural spontaneity."

Kolb & Milner (1981) found that individual with frontal damage displayed fewer spontaneous facial movements, spoke fewer words (left frontal lesions) or excessively (right frontal lesions).

- The frontal lobes are also thought to play a part in our spatial orientation, including our body's orientation in space.
- One of the most common Sexual behaviours can also be affected by frontal lesions. Orbital frontal damage can introduce abnormal sexual behaviour, while dorolateral lesions may reduce sexual interest.

Self Assessment Questions

1) Discuss with a diagram the lobes of the brain.

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2) Describe the frontal lobe, its location and anatomy.

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3) What are the functions of the different frontal lobes?

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4) What all would happen if the frontal lobe is damaged?

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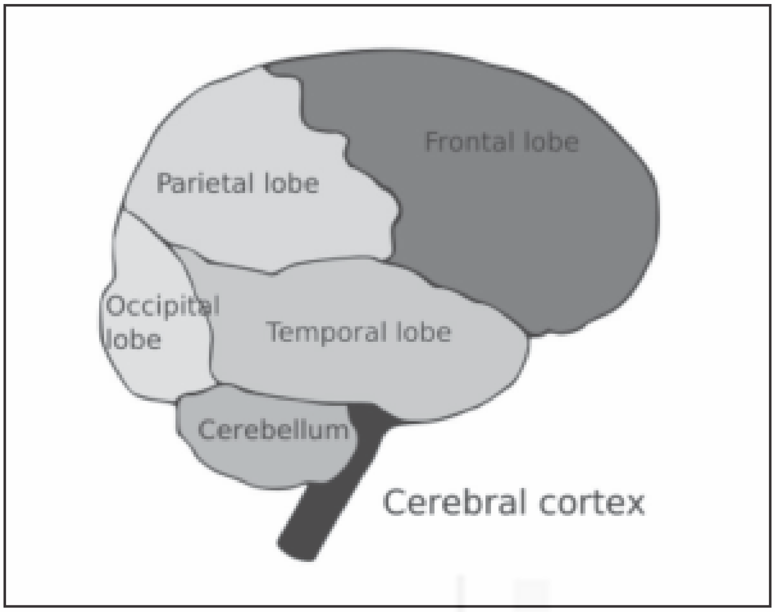
4.4 THE OCCIPITAL LOBES

The occipital lobes are the center of our visual perception system.



The Per striate region of the occipital lobe is involved in visuospatial processing, discrimination of movement and color discrimination.

The primary visual cortex is called the Brodmann area 17, commonly called V1 (visual one). Human V1 is located on the medial side of the occipital lobe within the calcarine sulcus.

The full extent of V1 often continues onto the posterior pole of the occipital lobe.

V1 that is Visual one is often also called striate cortex because it can be identified by a large stripe of myelin, the Stria of Gennari.

Visually driven regions outside V1 are called extrastriate cortex.

There are many extrastriate regions, and these are specialised for different visual tasks, such as visuospatial processing, color discrimination and motion perception.

4.4.1 Occipital Lobe Anatomy

The occipital lobes are one of the four main lobes or regions of the cerebral cortex. They are positioned at the back region of the cerebral cortex and are the main centers for visual processing. In addition to the occipital lobes, posterior portions of the parietal lobes and temporal lobes are also involved in visual perception. Located within the occipital lobes is the primary visual cortex. This region of the brain receives visual input from the retina. These visual signals are interpreted in the occipital lobes.

4.4.2 Location of the Occipital Lobe

The occipital lobes are the smallest of four lobes in the human cerebral cortex. Located in the rearmost portion of the skull, the occipital lobes are part of the forebrain. It should be noted that the cortical lobes are not defined by any internal structural features, but rather by the bones of the skull that overlie them. Thus, the occipital lobe is defined as the part of the cerebral cortex that lies underneath the occipital bone.

The lobes rest on the tentorium cerebelli, a process of dura mater that separates the cerebrum from the cerebellum. They are structurally isolated in their respective cerebral hemispheres by the separation of the cerebral fissure.

At the front edge of the occipital are several lateral occipital gyri, which are separated by lateral occipital sulcus.

The occipital aspects along the inside face of each hemisphere are divided by the calcarine sulcus.

Above the medial, Y-shaped sulcus lies the cuneus, This cuneus is also called the Brodman's area 17 and the area below the sulcus is the lingual gyrus.

4.4.3 Functions of the Occipital Lobe

The most important functional aspect of the occipital lobe is that it contains the primary visual cortex.

Retinal sensors convey stimuli through the optic tracts to the lateral geniculate bodies, where optic radiations continue to the visual cortex.

Each visual cortex receives raw sensory information from the outside half of the retina on the same side of the head and from the inside half of the retina on the other side of the head.

The cuneus (Brodman's area 17) receives visual information from the contralateral superior retina representing the inferior visual field.

The lingula receives information from the contralateral inferior retina representing the superior visual field.

The retinal inputs pass through a "way station" in the lateral geniculate nucleus of the thalamus before projecting to the cortex.

Cells on the posterior aspect of the occipital lobes' gray matter are arranged as a spatial map of the retinal field. Functional neuroimaging reveals similar patterns of response in cortical tissue of the lobes when the retinal fields are exposed to a strong pattern.

If one occipital lobe is damaged, the result can be homonomous vision loss from similarly positioned "field cuts" in each eye.

4.4.4 Occipital Lobe Damage and Its Effects

They are not particularly vulnerable to injury because of their location at the back of the brain, although any significant trauma to the brain could produce subtle changes to our visual perceptual system, such as visual field defects and *scotomas*.

Damage to one side of the occipital lobe causes *homonomous* loss of vision with exactly the same "field cut" in both eyes.

Disorders of the occipital lobe can cause visual hallucinations and illusions.

Lesions in the parietal temporal occipital association area are associated with color agnosia, movement agnosia, and agraphia.

Visual hallucinations (visual images with no external stimuli) can be caused by lesions to the occipital region or temporal lobe seizures.

Visual illusions (distorted perceptions) can take the form of objects appearing larger or smaller than they actually are, objects lacking color or objects having abnormal coloring.

Lesions in the parietal temporal occipital association area can cause word blindness with writing impairments (alexia and agraphia).

Self Assessment Questions

1) Describe the occipital lobe and its importance.

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2) Where is occipital lobe located?

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3) Describe the anatomy of the occipital lobe and its functions.

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4) If there is damage to the occipital lobe what functions are affected?

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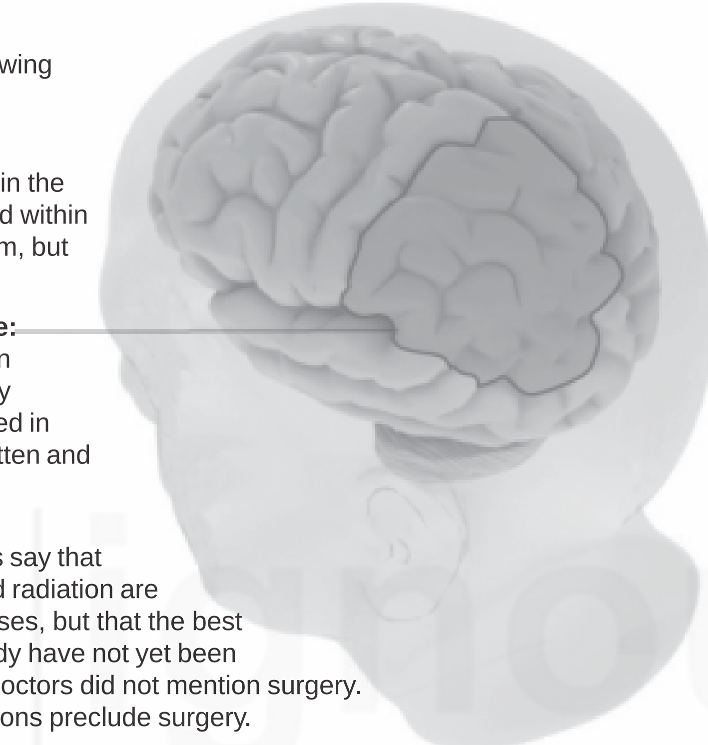
4.5 THE PARIETAL LOBE

THE MEDICAL DETAILS
Senator Edward M. kennedy has been diagnosed with a malignant glioma in his left parietal lobe.

Malignant:
Relatively fast-growing tumor.

Glioma:
Tumor originating in the brain. It can spread within the nervous system, but not outside.

Left Parietal Lobe:
Region of the brain registering sensory perception; involved in understanding written and spoken words.



Treatment:
Kennedy's doctors say that chemotherapy and radiation are usual in similar cases, but that the best options for Kennedy have not yet been determined. The doctors did not mention surgery. Some tumor locations preclude surgery.

SOURCES: Mayo Clinic; neurskills.com: Massachusetts General Hospital

DAVID BUTLER/GLORE STAFF

4.5.1 Location of Parietal Lobe

The parietal lobes are positioned above (superior to) the occipital lobe and behind (posterior to) the frontal lobe.

This lobe is divided into two hemispheres left and right.

The left hemisphere plays a more prominent role for right handers and is involved in symbolic functions in language and maths.

The right hemisphere plays a more prominent role for left handers and is specialised to carry out images and understanding of maps i.e. spatial relationships.

4.5.2 Anatomy of Parietal Lobe

The parietal lobe is defined by four anatomical boundaries: the central sulcus separates the parietal lobe from the frontal lobe.

The parieto occipital sulcus separates the parietal and occipital lobes.

The lateral sulcus is the most lateral boundary separating it from the temporal lobe.

The medial longitudinal fissure divides the two hemispheres.

Immediately posterior to the central sulcus, and the most anterior part of the parietal lobe, is the postcentral gyrus the primary somatosensory cortical area. Dividing this and the posterior parietal cortex is the postcentral sulcus.

The posterior parietal cortex can be subdivided into the superior parietal lobule and the inferior parietal lobule separated by the intraparietal sulcus (IP).

The intraparietal sulcus (IP) and adjacent gyri are essential in guidance of limb and eye movement, and based on cytoarchitectural and functional differences is further divided into medial (MIP), lateral (LIP), ventral (VIP), and anterior (AIP) areas.

4.5.3 Functions of Parietal Lobe

The parietal lobe can be divided into two functional regions.

- One involves sensation and perception and the other is concerned with integrating sensory input, primarily with the visual system.
- The first function integrates sensory information to form a single perception (cognition).
- The parietal lobe plays important roles in integrating sensory information from various parts of the body, knowledge of numbers and their relations (Blakemore & Frith (2005) and in the manipulation of objects.
- The second function constructs a spatial coordinate system to represent the world around us.
- Individuals with damage to the parietal lobes often show striking deficits, such as abnormalities in body image and spatial relations (Kandel, Schwartz & Jessel, 1991).
- Portions of the parietal lobe are involved with visuospatial processing.
- Although multisensory in nature, the posterior parietal cortex is often referred to by vision scientists as the dorsal stream of vision (as opposed to the ventral stream in the temporal lobe).
- Various studies in the 1990s found that different regions of the posterior parietal cortex in Macaques represent different parts of space.
- The lateral intraparietal (LIP) contains a map of neurons (retinotopically-coded when the eyes are fixed representing the saliency of spatial locations, and attention to these spatial locations.
- It can be used by the oculomotor system for targeting eye movements, when appropriate.
- The ventral intraparietal (VIP) area receives input from a number of senses (visual, somatosensory, auditory, and vestibular).
- Neurons with tactile receptive fields represented space in a head-centered reference frame. The cells with visual receptive fields also fire with head-centered reference frame but possibly also with eye-centered coordinate.
- The medial intraparietal (MIP) area neurons encode the location of a reach target in eye-centered coordinates.
- The anterior intraparietal (AIP) area contains neurons responsive to shape, size, and orientation of objects to be grasped as well as for manipulation of hands themselves, both to viewed and remembered stimuli.

4.5.4 Damage to Parietal Lobe and Its Effects

Damage to the left parietal lobe can result in what is called "Gerstmann's Syndrome."

It includes right-left confusion,

difficulty with writing (agraphia) and

difficulty with mathematics (acalculia).

It can also produce disorders of language (aphasia) and the inability to perceive objects normally (agnosia).

Damage to the right parietal lobe can result in neglecting part of the body or space (contralateral neglect), which can impair many self-care skills such as dressing and washing.

Right side damage can also cause difficulty in making things (constructional apraxia), denial of deficits (anosagnosia) and drawing ability.

Bi lateral damage (large lesions to both sides) can cause "Balint's Syndrome," a visual attention and motor syndrome.

This is characterised by the inability to voluntarily control the gaze (ocular apraxia), inability to integrate components of a visual scene (simultanagnosia), and the inability to accurately reach for an object with visual guidance (optic ataxia) (Westmoreland et al., 1994).

Special deficits (primarily to memory and personality) can occur if there is damage to the area between the parietal and temporal lobes.

Left parietal temporal lesions can effect verbal memory and the ability to recall strings of digits (Warrington & Weiskrantz, 1977).

The right parietal-temporal lobe is concerned with non-verbal memory. Right parietal-temporal lesions can produce significant changes in personality.

Self Assessment Questions

1) Discuss the importance of the parietal lobe.

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2) Where is parietal lobe located?

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3) Describe the anatomy of the parietal lobe.

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4) What are the functions of parietal lobe?

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5) If damage occurs to parietal lobe which behaviours are affected?

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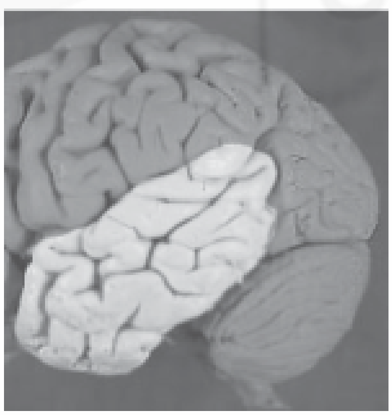
4.6 THE TEMPORAL LOBES



Temporal lobe (pink portion)

4.6.1 Location of Temporal Lobe

The temporal lobes are anterior to the occipital lobes and lateral to the Fissure of Sylvius.

The *temporal lobe* is a region of the cerebral cortex that is located beneath the Sylvian fissure on both cerebral hemispheres of the mammalian brain.

There are two temporal lobes, one on each side of the brain located at about the level of the ears. These lobes allow a person to tell one smell from another and one sound from another. They also help in sorting new information and are believed to be responsible for short-term memory.

Right Lobe - Mainly involved in visual memory (i.e., memory for pictures and faces).

Left Lobe - Mainly involved in verbal memory (i.e., memory for words and names).

4.6.2 Anatomy of Temporal Lobe

The superior temporal gyrus includes an area (within the Sylvian fissure) where auditory signals from the cochlea (relayed via several subcortical nuclei) first reach the cerebral cortex.

This part of the cortex (primary auditory cortex) is involved in hearing.

Adjacent areas in the superior, posterior and lateral parts of the temporal lobes are involved in high level auditory processing.

In humans this includes speech, for which the left temporal lobe in particular seems to be specialised.

Wernicke's area, which spans the region between temporal and parietal lobes, plays a key role (in tandem with Broca's area, which is in the frontal lobe).

The temporal lobe is involved in auditory perception and is home to the primary auditory cortex.

It is also important for the processing of semantics in both speech and vision.

The temporal lobe contains the hippocampus and plays a key role in the formation of long-term memory.

4.6.3 The Functions of Temporal Lobe

The left temporal lobe is not limited to low level perception but extend to comprehension, naming, verbal memory and other language functions.

Blunt trauma to the temporal lobe can result in hair-trigger violent reactions and increased aggressive responses.

The underside (ventral) part of the temporal cortices appear to be involved in high-level visual processing of complex stimuli such as faces (fusiform gyrus) and scenes (parahippocampal gyrus).

Anterior parts of this ventral stream for visual processing are involved in object perception and recognition.

The medial temporal lobes (near the Sagittal plane that divides left and right cerebral hemispheres) are thought to be involved in episodic/declarative memory.

Deep inside the medial temporal lobes lie the hippocampi, which are essential for memory function that is particularly the transference from short to long term memory and control of spatial memory and behaviour.

4.6.4 Temporal Lobe Damage and Its Effects

Damage to this area typically results in anterograde amnesia.

Kolb & Wishaw (1990) have identified eight main symptoms of temporal lobe damage:

1) Disturbance of auditory sensation and perception,
2) Disturbance of selective attention of auditory and visual input,
3) Disorders of visual perception,
4) Impaired organisation and categorisation of verbal material,
5) Disturbance of language comprehension,
6) Impaired long-term memory,
7) Altered personality and affective behaviour,
8) Altered sexual behaviour.

Selective attention to visual or auditory input is common with damage to the temporal lobes.

Left side lesions result in decreased recall of verbal and visual content, including speech perception.

Right side lesions result in decreased recognition of tonal sequences and many musical abilities.

Right side lesions can also effect recognition of visual content (e.g. recall of faces).

The temporal lobes are involved in the primary organisation of sensory input.

Individuals with temporal lobes lesions have difficulty placing words or pictures into categories.

Language can be affected by temporal lobe damage. Left temporal lesions disturb recognition of words.

Right temporal damage can cause a loss of inhibition of talking.

The temporal lobes are highly associated with memory skills.

Left temporal lesions result in impaired memory for verbal material.

Right side lesions result in recall of non-verbal material, such as music and drawings.

Seizures of the temporal lobe can have dramatic effects on an individual’s personality.

Temporal lobe epilepsy can cause perseverative speech, paranoia and aggressive rages (Blumer and Benson, 1975).

Severe damage to the temporal lobes can also alter sexual behaviour (e.g. increase in activity) (Blumer and Walker, 1975).

Self Assessment Questions

1) Discuss the importance of temporal lobe.

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2) Where is temporal lobe located?

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3) Describe the anatomy of temporal lobe.

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4) What are the functions of temporal lobe?

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5) If damage occurs to the temporal lobe what are the consequences?

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4.7 THE LIMBIC SYSTEM

The limbic system, essentially alike in all mammals, lies above the brain stem and under the cortex and consists of a number of interconnected structures. The limbic system, often referred to as the "emotional brain", is found buried within the cerebrum. Like the cerebellum, evolutionarily the structure is rather old. This system contains the thalamus, hypothalamus, amygdala, and hippocampus.

1) **The Thalamus**

A large mass of gray matter deeply situated in the forebrain at the topmost portion of the diencephalon. The structure has sensory and motor functions. Almost all sensory information enters this structure where neurons send that information to the overlying cortex. Axons from every sensory system (except olfaction) synapse here as the last relay site before the information reaches the cerebral cortex. The thalamus carries messages from the sensory organs like the eyes, ears, nose, and fingers to the cortex.

2) **Hypothalamus**

It is a part of the diencephalon, ventral to the thalamus. The structure is involved in functions including homeostasis, emotion, thirst, hunger, circadian rhythms, and control of the autonomic nervous system. The hypothalamus controls the pulse, thirst, appetite, sleep patterns, and other processes in our bodies that happen automatically. It also controls the pituitary gland, which makes the hormones that control our growth, metabolism, digestion, sexual maturity, and response to stress.

3) **Hippocampus**

It is the portion of the cerebral hemispheres in basal medial part of the temporal lobe. This part of the brain is important for learning and memory, for converting short term memory to more permanent memory, and for recalling spatial relationships in the world about us.

4.8 THE AMYGDALA

Amygdala is located in the temporal lobe is involved in memory, emotion, and fear. The amygdala is just beneath the surface of the front, medial part of the temporal lobe where it causes the bulge on the surface called the uncus.

Researchers have linked these structures to hormones, drives, temperature control, emotion, and one part, the hippocampus to memory formation.

Neurons affecting heart rate and respiration appear concentrated in the hypothalamus and direct most of the physiological changes that accompany strong emotion.

Aggressive behaviour is linked to the action of the amygdala, which lies next to the hippocampus.

The latter plays a crucial role in processing various forms of information as part of our long term memory.

Damage to the hippocampus will produce global retrograde amnesia, or the inability to lay down new stores of information.

4.9 LET US SUM UP

The occipital lobe is the visual processing center of the mammalian brain containing most of the anatomical region of the visual cortex. The parietal lobe is a lobe in the brain. It is positioned above (superior to) the occipital lobe and behind (posterior to) the frontal lobe. The parietal lobe integrates sensory information from different modalities. The temporal lobe is a region of the cerebral cortex that is located beneath the Sylvian fissure on both cerebral hemispheres of the mammalian brain. The temporal lobe is involved in auditory perception and is home to the primary auditory cortex. The limbic system structures control behaviour-related signals as well, such as satiety and tranquility (ventromedial nucleus), fear, punishment (thin zone of the periventricular nuclei and central gray area of the mesencephalon), and sexual drive (hypothalamus). Some other limbic areas also control reward and punishment sensations.

4.10 UNIT END QUESTIONS

1) Discuss briefly the structure and anatomy of frontal lobe.
2) Describe the anatomy and functions of occipital lobe.
3) Explain the effects of parietal lobe damage.
4) What is limbic system?
5) Differentiate between thalamus and hypothalamus.
6) Discuss the role of amygdala and hippocampus in human behaviour.

4.11 SUGGESTED READINGS

Mark E. Bear, Barry W. Connors & Michael A.Paradiso (2001) (2nd edition). *Neuroscience. Exploring the Brain*. Lippincott Williams & Wilkins, New York.

Restack, Richard (19096). Brainscapes: *An Introduction to what Neuroscience has Learned about the Structure, Function and Abilities of the Brain*. Discover books, NY.

UNIT 1 BRAIN BEHAVIOUR RELATIONSHIP, CONSCIOUSNESS AND MIND BRAIN RELATIONSHIP

Structure

1.0 Introduction

1.1 Objectives

1.2 Brain-Behaviour Relationship

- 1.2.1 The Brain, Master Organ of the Body
- 1.2.2 Divisions of the Brain
- 1.2.3 Brain Structure

1.3 Mind-Brain Relationship

- 1.3.1 The Relationship between Mind and Brain: The Main Positions
- 1.3.2 Behaviourism
- 1.3.3 Identity Theory
- 1.3.4 Functionalism
- 1.3.5 Eliminative Instrumentalism
- 1.3.6 Consciousness and the Brain Process
- 1.3.7 Selection of Behaviours

1.4 Consciousness

- 1.4.1 The Neural Basis of Consciousness

1.5 Let Us Sum Up

1.6 Unit End Questions

1.7 Suggested Readings

1.8 Answers to Self Assessment Questions

"From the brain and the brain alone arise our pleasures, joys, laughter and jests, as well as our sorrows, pains and grief's" -Hippocrates

1.0 INTRODUCTION

In this unit we will be dealing with the brain behaviour relationship, the consciousness and the mind brain relationship. Then we present brain behaviour relationship in which we describe the brain as the master organ of the body. Provide the divisions of the brain and present the brain structure. Then we discuss the mind and brain relationship within which we deal with the relationship between mind and body, behaviourism, identity theory, functionalism and eliminative instrumentalism. We then deal with consciousness and the brain processes. The next section deals with consciousness as such and presents the neural basis of consciousness.

1.1 OBJECTIVES

After completing this unit, you will be able to:

- Explain the relationship between brain and behaviour;

- Describe the different parts of the brain and the divisions of the brain;
- Explain the relationship between brain and behaviour;
- Elucidate the mind brain relationship;
- Analyse the relationship between mind and body;
- Explain how behaviourism is able to deal with mind brain relationship;
- Elucidate the identity theory and functionalism from the mind brain relationship point of view;
- Describe eliminative instrumentalism; and
- Define consciousness and explain the neural basis of consciousness.

1.2 BRAIN-BEHAVIOUR RELATIONSHIP

Brain is a thinking organ that learns and grows by interacting with the world through perception and action. Mental stimulation improves brain function and actually protects against cognitive decline.

Step back a half-billion years ago, to when the first nerve cells developed. The original need for a nervous system was to coordinate movement, so an organism could go find food, instead of waiting for the food to come to it. Jellyfish and sea anemone, the first animals to create nerve cells, had a tremendous advantage over the sponges that waited brainlessly for dinner to arrive.

After millions of generations of experimentation, nervous systems evolved some amazing ways of going out to eat. But behind all the myriad forms of life today, the primary directive remains. In fact, a diminished ability to move is a good measure of aging. Inflexibility heralds death, while a flexible body and fluid mind are the hallmarks of youth.

Elastic comes from the Greek word for "drive" or "propulsion." It is the tendency of a material to return to its original shape after being stretched. Elasticity is the basic animal drive that powers your muscles, giving you strength and balance – flexibility, mobility, and grace.

Plastic derives from the Greek word meaning "molded" or "formed." It is the tendency of the brain to shape itself according to experience. Plasticity is the basic mental drive that networks your brain, giving you cognition and memory, fluidity, versatility, and adaptability.

Before birth you created neurons, the brain cells that communicate with each other, at the rate of 15 million per hour! When you emerged into the world, your 100 billion neurons were primed to organise themselves in response to your new environment, no matter what your culture, climate, language, or lifestyle was.

During infancy, billions of these extraordinary cells intertwined into the vast networks that integrated your nervous system. By the time you were four or five years old, your fundamental cerebral architecture was complete.

Until your early teens, various windows of opportunity opened when you could most easily learn language and writing, math and music, as well as the coordinated movements used in sports and dance. But, at any age you can and should continue to build your brain and expand your mind.

Throughout life, your neural networks reorganise and reinforce themselves in response to new stimuli and learning experiences. This body mind interaction is what stimulates brain cells to grow and connect with each other in complex ways. They do so by extending branches of intricate nerve fibers called dendrites (from the Latin word for "tree"). These are the antennas through which neurons receive communication from each other.

A healthy, well-functioning neuron can be directly linked to tens of thousands of other neurons, creating a totality of more than a hundred trillion connections, each capable of performing 200 calculations per second! This is the structural basis of your brain's memory capacity and thinking ability.

As a product of its environment, your "three pound universe" is essentially an internal map that reflects your external world. The human brain is able to continually adapt and rewire itself and is responsible for all our behaviours, from breathing to eating to being conscious to being alive. If it ceases to exist we will cease to exist.

1.2.1 The Brain, Master Organ of the Body

The brain is the master organ of the body. From our eyes, ears, nose, and skin, the brain receives messages that tell us what is going on in the world about us. The brain also receives a steady stream of signals from other body organs that enables it to control the life processes.

The brain stores information from past experiences. This is why we can learn, remember, and think. The brain selects and combines messages from the senses with memories and emotions to form various thoughts and reactions.

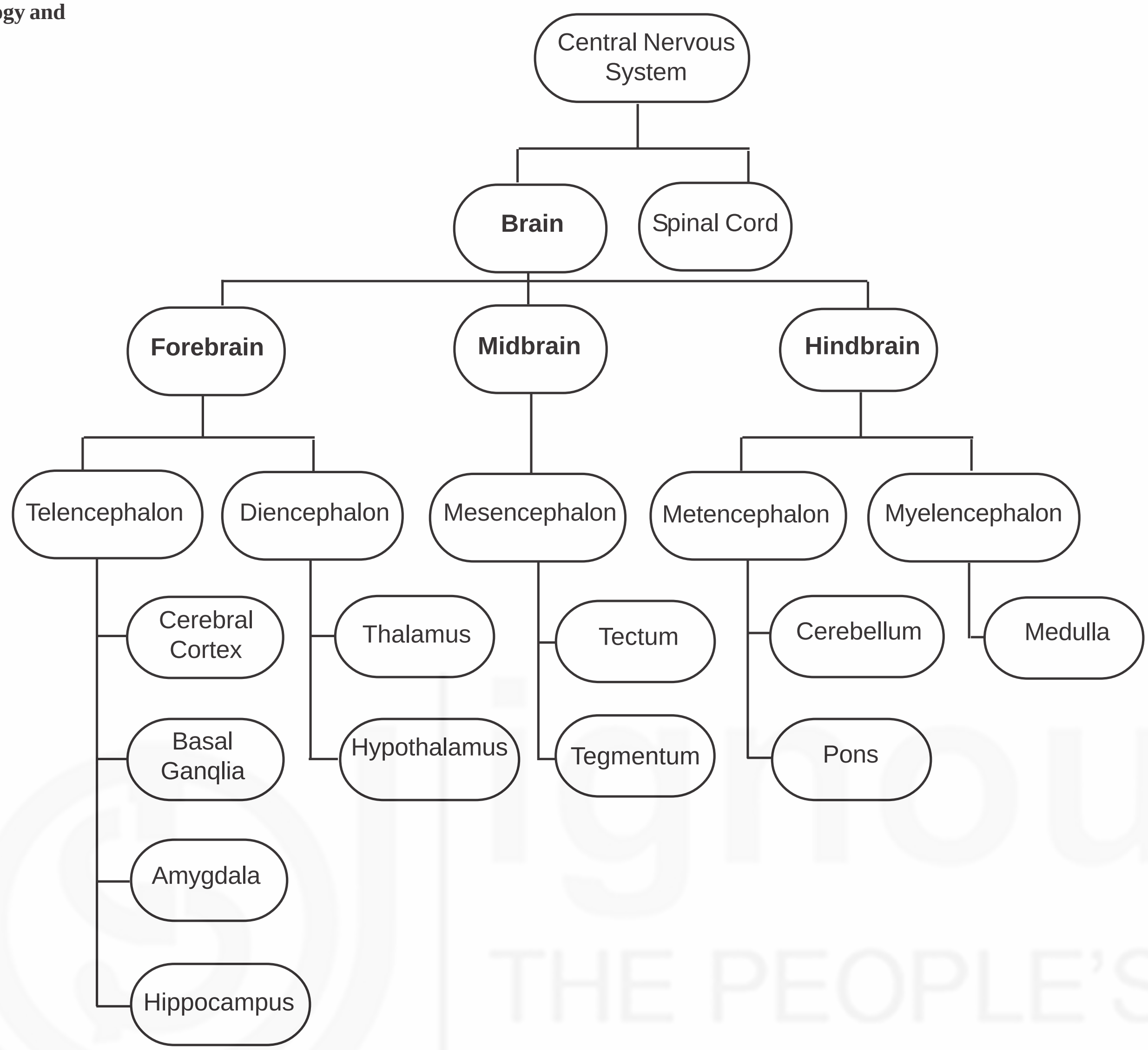
The brain is a greatly expanded bulb at the upper end of the spinal cord. It consists mainly of neurons, or nerve cells; supporting cells, and blood vessels. The nerve cells carry out the brain's functions. Each of the billions of tiny neurons consists of a cell body and a number of fibers. These fibers connect the cell body with other cell bodies. The brain is not a single organ; it has many parts with special functions, though they are all connected.

Messages to the brain all pass through the brain stem. From the brain stem, they go to different parts of the brain for 'processing.' Messages go out through the grain stem to control the muscles and glands of the body.

The brain is vital to our existence. It controls our voluntary movements, and it regulates involuntary activities such as breathing and heartbeat. The brain serves as the seat of human consciousness: it stores our memories, enables us to feel emotions, and gives us our personalities. In short, the brain dictates the behaviours that allow us to survive and makes us who we are. Scientists have worked for many years to unravel the complex workings of the brain. Their research efforts have greatly improved our understanding of brain function.

1.2.2 Divisions of the Brain

The brain has three main divisions: (1) the forebrain, (2) the midbrain, and (3) the hindbrain. Each division has many parts with special functions.



1.2.3 Brain Structure

The human brain consists of three major divisions; hindbrain, midbrain, and forebrain

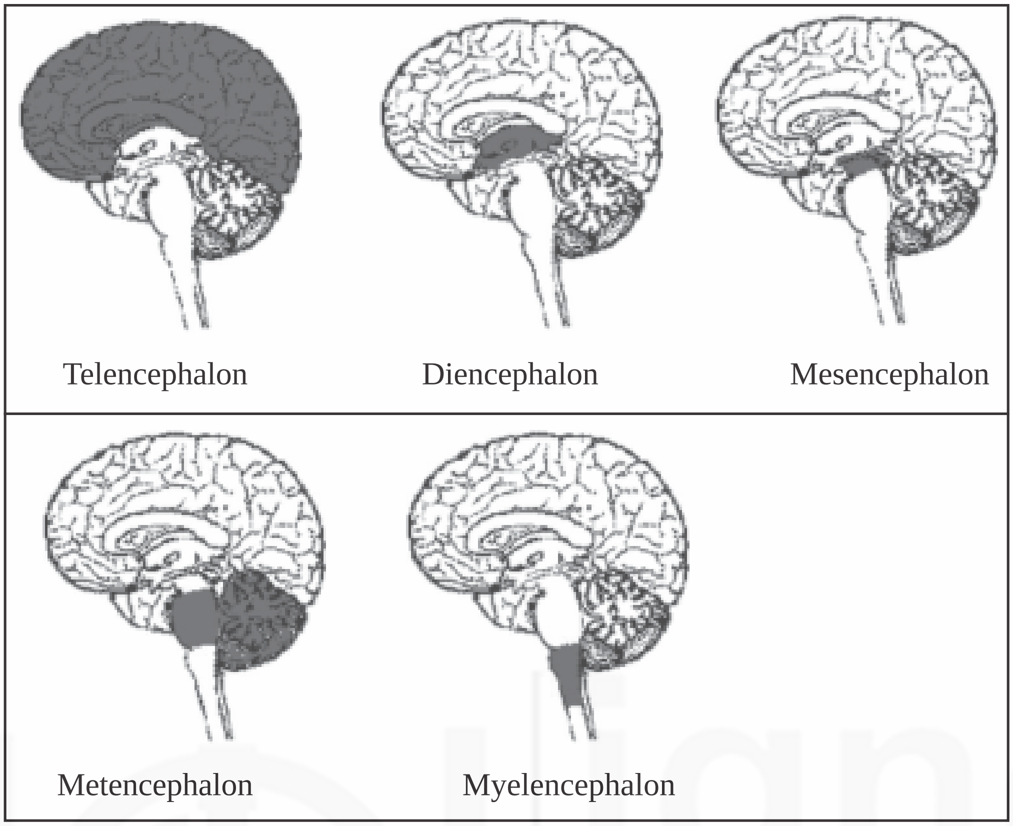
Hindbrain – structures in the top part of the spinal cord, controls basic biological functions that keep us alive.

Midbrain – between the hind and forebrain, coordinates simple movements with sensory information.

Forebrain – controls what we think of as thought and reason.

Major Division	Subdivision	Structures
Prosencephalon (Forebrain)	Telencephalon	Neocortex; Basal Ganglia; Amygdala; Hippocampus; Lateral Ventricles
	Diencephalon	Thalamus; Hypothalamus; Epithalamus; Third Ventricle
Mesencephalon (Midbrain)	Mesencephalon	Tectum; Tegmentum; Cerebral Aqueduct
Rhombencephalon (Hindbrain)	Metencephalon	Cerebellum; Pons; Fourth Ventricle
	Myelencephalon	Medulla Oblongata; Fourth Ventricle

Diagram showing major divisions of the Brain



Forebrain: Found in the area of the forehead, this part of the brain is concerned with all the emotions, planning, organising, reasoning, memory, movement, speech, recognition of auditory stimuli, visual processing, etc. It also deals with our imaginative abilities, creativity, judgments, opinions, etc. The forebrain can be again divided into three parts called the cerebrum, thalamus, and hypothalamus (part of the limbic system).

Cerebral Cortex/Cerebrum: The cerebrum or the cortex is the large part of the brain and is associated with the cognitive functions of the brain, such as thinking and action. So next time you find people moving into doldrums, ask them to get their cerebrum moving. This cerebrum can again be divided into four sections or lobes called:

Lobes of the cortex

The frontal lobe is located at the front of the brain and is associated with reasoning, motor skills, higher level cognition, and expressive language. At the back of the frontal lobe, near the central sulcus, lies the motor cortex. This area of the brain receives information from various lobes of the brain and utilises this information to carry out body movements.

The parietal lobe is located in the middle section of the brain and is associated with processing tactile sensory information such as pressure, touch, and pain. A portion of the brain known as the somatosensory cortex is located in this lobe and is essential to the processing of the body's senses.

The temporal lobe is located on the bottom section of the brain. This lobe is also the location of the primary auditory cortex, which is important for interpreting sounds and the language we hear. The hippocampus is also located in the temporal lobe, which is why this portion of the brain is also heavily associated with the formation of memories.

The occipital lobe is located at the back portion of the brain and is associated with interpreting visual stimuli and information. The primary visual cortex, which receives and interprets information from the retinas of the eyes, is located in the occipital lobe.

These four units together form the cerebrum. Now, a deep furrow is present which divides the brain into two symmetrical halves, called the left and right hemispheres or brain. These two hemispheres are connected and their functions differ slightly. The right hemisphere is seen to be associated with creativity, while the left brain is seen to deal with logical thinking. We often end up using our logical thinking side of the brain, however, fail to use the creative part of the brain as we grow into adults.

Thalamus and Hypothalamus: The thalamus is situated in the forebrain at the uppermost part of the diencephalon (posterior part of the forebrain). It's an important part of the brain as all the sensory information we gather enters into this part, which is then sent via neurons into the cortex. All sensory inputs to the brain, except that of the sense of smell, are through the **thalamus**. The hypothalamus lies ventral to the thalamus and is a part of the diencephalon. It deals with the function of homeostasis (metabolic equilibrium), thirst, hunger, emotions, control of autonomic nervous system and the pituitary gland. The **hypothalamus** is involved with the body's vital drives and activities, such as eating, drinking, temperature regulation, sleep, emotional behaviour, and sexual activity. It controls the functions of many internal body organs and helps coordinate activities of the brain stem.

Midbrain*:* Also known as the mesencephalon, this part is located behind the frontal lobes and in the center of the entire brain. It deals with functions such as hearing, vision, body and eye movements. The midbrain can be divided into three parts called the tectum, tegmentum and cerebral peduncles. The midbrain is the smallest region of the brain that acts as a sort of relay station for auditory and visual information. The midbrain controls many important functions such as the visual and auditory systems as well as eye movement. Portions of the midbrain called the **red nucleus** and the **substantia nigra** are involved in the control of body movement. The darkly pigmented substantia nigra contains a large number of dopamine-producing neurons. The degeneration of neurons in the substantia nigra is associated with Parkinson's disease.

Hindbrain: This is the posterior part of the brain, and is composed of cerebellum, pons and medulla. Often the midbrain, pons and medullas are together referred to as brain stem. The hindbrain is located toward the rear and lower portion of a person's brain. It is responsible for controlling a number of important body functions and process, including respiration and heart rate. The brain stem is an important part of the hindbrain, controlling functions that are critical to life, such as breathing and swallowing. The cerebellum is also part of the hindbrain, playing a role in physical ability.

Cerebellum: The cerebellum forms the posterior part of the brain, just below the cerebrum. However, as compared to the cerebrum, its far smaller; 1/8 the size of the cerebellum. Small as it may seem, it performs crucial functions like balance, movement, co-ordinating muscle movements, etc. It's the cerebellum that helps us maintain our balance, move around. The very fact that we can enjoy all kinds of sport like surfing, skiing, etc. we realise how important this part is. Without the cerebellum, we can say goodbye to even walking.

Pons and Medulla: Pons and medulla along with the midbrain form the brain stem. This partnering act takes control of involuntary muscle movements in the body. For example, muscles of the heart and stomach work irrespective of our desire for them to function. Their movement is not in our control, but is controlled by the brain stem. While running or performing vigorous exercises, it's the brain stem that directs the heart to pump more blood. After a meal, it's the brain stem that directs the stomach to digest the food. The pons and medulla also perform the crucial role of connecting the brain to the spinal cord, thus transform thoughts into actions.

Self Assessment Questions

1) Fill in the blanks:

   Mental stimulation .... brain function and actually .... against cognitive decline.

   The brain cells that communicate with each other, at the rate of .... per hour.

   Brain is also known as .... Pound Universe.

   The brain is .... to our existence.

   The brain has three main divisions: (1) ...., (2) ...., and (3) ....

   The cerebellum forms the .... part of the brain, just below the cerebrum.

   Cerebral Cortex is divided into ...., ..., ... and ....

   Midbrain is also known as ....

   Hindbrain is composed of ...., ..., and ....

   Brain stem is responsible for ....

2) "The brain is the master organ of the body" Justify this statement

3) Match the following

i)	Frontal lobe	a)	Pons and cerebellum
ii)	Cerebellum	b)	Connects both hemisphere
iii)	Thalamus	c)	Balance and body control
iv)	Hypothalamus	d)	Reasoning and judgement
v)	Temporal lobe	e)	Controls basic biological functions
vi)	Corpus callosum	f)	Gathers sensory information
vii)	Hind brain	g)	Maintains Homeostasis
viii)	Occipital lobe	h)	Creativity
ix)	Metecephalon	i)	Visual processing
x)	Right Brain	j)	Memory

1.3 MIND-BRAIN RELATIONSHIP

1.3.1 The Relationship between Mind and Brain: The Main Positions

In modern times, before the 20th century, the most popular interpretation of the mind-brain relationship was some version of dualism. It claims that mind is essentially non-physical. The brain is the place where this nonphysical reality interacts with physical reality. The reason why you cannot "see" the mind when you inspect the brain is that the methods of inspection are adapted to the observation of material phenomena, and not to the observation of immaterial phenomena like e.g. thoughts. So what you can inspect using the methods of the natural sciences, is at most the correlates of consciousness, not the conscious itself.

In the 20th century, a series of materialist, or physicalist, alternatives to dualism have been developed. The main positions are (philosophical) behaviourism, the identity theory, functionalism and eliminativism.

1.3.2 Behaviourism

According to (philosophical) behaviourism the mind is simply the behaviour, or dispositions for behaviour, that an organism exhibits. The brain is not the mind, but the mechanism that enables mind – i.e. the underlying mechanism that enables the complex behaviour which is the mind. And the reason why you cannot observe mind by simply observing the brain is not that mind is something immaterial. The reason is that you are so to speak looking in the wrong place – at the mechanism that makes mind possible, not at mind (the behaviour) itself.

1.3.3 Identity Theory

A frequent objection to behaviourism is that we think of mind not as the behaviour itself but as what causes and regulates behaviour. And what causes and regulates behaviour are brain states; so mental states are brain states according to the (neural) identity theory. This mind-brain identity must be accepted as a kind of scientific truth, comparable to e.g. the identity of light and electromagnetic waves. So the states that you inspect when you inspect the brain are (some of them) mental states – it is only that you will not recognise them as mental states until you have developed the right 'theoretical spectacles'.

1.3.4 Functionalism

An objection to the identity theory is that mental phenomena, e.g. pain, can be realised in the brain in many different ways, depending on what kind of organism we are talking bout. According to functionalism, mind is not brain states, but something more abstract – namely the functional states the brain can be in. Anything (e.g. a complex robot, or an extraterrestrial being) with inner states that performed the right functions would have a mind, even if it did not have a biological brain. In functionalism the relationship between brain and mind is often compared to the relationship between hardware and software. And the reasons why you cannot observe mind by just observing brain processes, is that you are not focusing on a sufficiently abstract level – you are like an engineer who does not understand a computer because he only sees the electronic hardware and not the software (i.e. the set of programmed functions) that runs on this hardware.

1.3.5 Eliminative Instrumentalism

What is common to behaviourism, identity-theory and functionalism is a belief that mental phenomena are real phenomena that can, in the end, be described in terms taken from the natural sciences (including biology) – either as behaviour, or neural states, or functional states. Eliminativism maintains that this is not the case – our common sense conception of mind is a theory of mind ("folk psychology") that is basically wrong, so that nothing corresponds to mental phenomena "in the real world". A correct theory will only refer to brain states and behaviour, not mind. Mind is at most a useful fiction (instrumentalism); and the reasons why you cannot observe the mind by observing the brain, are simply that the mind does not exist – there is no mind to observe.

None of the theories mentioned above have been generally accepted among philosophers working on the mind-brain relationship. Many look on themselves as some kind of materialists (or "physicalists"). Few are fully-fledged dualists, but elements of such a position can also be found in contemporary philosophy – notably the following two points:

1.3.6 Consciousness and the Brain Process

Consciousness cannot be completely reduced to brain processes, and the study of it requires (in addition to methods found in the natural sciences) some special methods – a special kind of self-observation (introspection, or "phenomenological descriptions") and perhaps some kind of interpretation of behaviour (similar to the interpretation of texts).

The answer may also depend on how we conceive the relationship between mind and brain.

Traditionally philosophers have thought of the relationship between mind and matter either in terms of identity ('the mind is nothing but brain states and/or behaviour') or in terms of causality ('mind is different from brain states, but somehow caused by brain states'). Lately it has been proposed that it would be better to think of the relationship as a kind of supervenience-relationship. Mental states supervene on brain states if it is impossible to have a change of mental states without some change in brain states. Or conversely: Complete similarity in brain states entails complete similarity in mental states. Such a relationship implies that the mental is a kind of function of the brain even if it should prove impossible to formulate exact causal laws for how mind depends on the brain.

It has also been pointed out that individual mental events (e.g. the pain that I feel just now) can be identical with individual brain events (e.g. the firing in C-fibres going on just now) without the properties of mental events necessarily being identical with neurological properties. The first type of identity is called "token identity" while the latter is called "type identity". If this view is accepted one can for example say that the pain I feel is in fact token-identical with some brain event, while it has properties (e.g. 'being a throbbing pain') which cannot be identified with neurological properties (though they probably supervene on such properties). Such a view often called non-reductive physicalism, and may be considered a kind of compromise between a physicalist and a dualist position.

Donald Hebb and others have argued that the central question in neuropsychology is the relation between the mind and the brain. The question is easy to ask, yet it is not so easy to grasp what it is that we need to explain. One needed explanation is how we select information on which to act.

1.3.7 Selection of Behaviours

Animals such as simple worms have a limited sensory capacity and an equally limited repertoire of behaviours. Animals such as dogs have a much more sophisticated sensory capacity and a corresponding increase in behavioural options. Primates, including humans, have even further developed sensory capacity and behavioural complexity.

Thus, as sensory and motor capacities increase, so does the problem of selection both of information and of behaviour. Furthermore, as the brain expands, memory increases, providing an internal variable in both stimulus interpretation and response selection. Finally, as the number of sensory channels increases, the need to correlate the different inputs to produce a single "reality" arises.

One way to consider these evolutionary changes is to posit that, as the brain expands to increase sensorimotor capacity, so does some other process (or processes) having a role in sensory and motor selection. One proposed process for selective awareness and response to stimuli is attention.

The concept of attention implies that somehow we focus a "mental spotlight" on certain sensory inputs, motor programs, memories, or internal representations. This spotlight might be unconscious, in that we are not aware of the process, or it might be conscious, such as when we scan our memories for someone's name. The development of language should increase the likelihood of conscious attention, but it is unlikely that all conscious processing is verbal. One can speculate, for example, that the "Eureka" insight of Archimedes entailed conscious processing that was more than just verbal.

The point is that, as sensorimotor capacities expand, so do the processes of attention and consciousness. In broad terms, consciousness is, at a primary level, synonymous with awareness and, at a secondary level, with awareness of awareness. The clear implication is that consciousness is not a dichotomous phenomenon; rather, a gradual evolutionary increase in consciousness is correlated with the ability to organise sensory and motor capacities. The most evolved organiser is language, which implies an increased capacity for the processes of attention.

1.4 CONSCIOUSNESS

Conscious experience is probably the most familiar mental process that we know, yet its workings remain mysterious. Everyone has a vague idea of what is meant by being conscious, but consciousness is easier to identify than to define.

Definitions of consciousness range from the view that it merely refers to complex thought processes to the more slippery implication that it is the subjective experience of awareness or of "inner self." Nonetheless, there is general agreement that whatever conscious experience is, it is a process.

One of the first modern theories of consciousness was proposed by Descartes. He proposed that being able to remember past events and being able to speak were the primary abilities that enabled consciousness. But think if we encounter people who have lost the ability to remember and have lost the ability to speak. We may not describe them as no longer being conscious. In fact, consciousness is probably not a single process but a collection of many processes, such as those associated with seeing, talking, thinking, emotion, and so on.

Consciousness is also not always the same. A person at different ages of life is not thought to be equally conscious at each age; young children and demented adults are usually not considered to experience the same type of consciousness as healthy adults do. Indeed, part of the process of maturation is becoming fully conscious. And consciousness varies across the span of a day as we pass through various states of sleep and waking.

Most definitions of consciousness exclude the conditions of simply being responsive to sensory stimulation or simply being able to produce movement.

Thus, animals whose behaviour is simply reflexive are not conscious. Similarly, the isolated spinal cord, although a repository for many reflexes, is not conscious.

Machines that are responsive to sensory events and are capable of complex movements are not conscious. Many of the functions of normal humans, such as the beating of the heart, are not conscious processes. Similarly, many processes of the nervous system, including simple sensory processes and motor actions, are not conscious. Consciousness requires processes that differ from all of the aforementioned.

Some people have argued that certain processes are much more important for consciousness than others. Language is often argued to be essential to consciousness because language makes a fundamental change in the nature of human consciousness. Gazzaniga (2004) suggest that language acts as an interpreter, which he felt led to an important difference between the functions of the hemispheres. People who are aphasic are not considered to have lost conscious awareness, however; nor are people who have their right hemispheres removed. Famous patient H. M., has a dense amnesia, yet he is quite conscious and can engage in intelligent conversations. In sum, although language may alter the nature of our conscious experience, it seems unlikely that any one brain structure can be equated with consciousness. Rather, it makes more sense to view consciousness as a product of all cortical areas, their connections, and their cognitive operations.

1.4.1 The Neural Basis of Consciousness

As stated earlier, consciousness must be a function of numerous interacting systems, presumably including sensory areas, memory structures, and perhaps structures underlying other processes such as emotion and executive functions. The problem for a theory of the neural basis of consciousness is to explain how all these systems can be integrated.

Most investigators agree that at least four processes must take part:

1) Arousal, the waking up of the brain by nonspecific modulatory systems

2) Perception, the detection and binding of sensory features

3) Attention, the selection of a restricted sample of all available information

4) Working memory, the short-term storage of ongoing events

Engel and Singer (2001) propose that all these processes either require or modify the operation of an overall binding process and that binding is implemented by the transient and precise synchronisation of neural discharges in diffuse neural networks. The general idea is that neurons that represent the same object or event fire their action potentials in a temporal synchrony with a precision of milliseconds. No such synchronisation should take place between cells that are part of different cellular networks. Recall that the idea of synchrony was proposed earlier as a mechanism of attention. Taken further, it is proposed that without attention to an input there is no awareness of it.

Consciousness, a property of complex brains, binds diverse aspects of sensory information into a single event that we experience as reality.

Self Assessment Questions

1) Fill in the blanks:

   i) According to .... the mind is simply the behaviour, or dispositions for behaviour, that an organism exhibits.

   ii) Mental states are brain states according to the .... theory.

   iii) According to ...., mind is not brain states, but something more abstract – namely the functional states the brain can be in.

   iv) .... says that the mind does not exist – there is no mind to observe.

2) Give details of the four processes must take part in consciousness process:

   i) *Arousal*, ...

   ii) *Perception*, ...

   iii) *Attention*, ...

   iv) *Working memory*, ...

3) Explain how would you conceptualise mind brain relationship?

   ....

   ....

   ....

   ....

   ....

1.5 LET US SUM UP

Brain, Mind and Consciousness, the connection between these three still eludes most researchers. The researches are contributing heavily to make some more sense out of these connections. Though, these researches are at its infancy stage. There is still requirement of more information in these areas to come to a concrete conclusion as to how these connections can be best explained. But that certainty is possible only in future with wider information bank.

1.6 UNIT END QUESTIONS

1) Why is our brain also known as “three pound universe”?
2) Give major subdivision of brain with the help of a diagram?
3) “Brain is vital to our existence” justify this statement.
4) Cerebral Cortex is divided into 4 lobes, name these lobes and give their functions?
5) How and why hypothalamus is responsible for our functioning?
6) What is forebrain and what are its functions?
7) What are the sub parts of brain stem and what is the function of brain stem?
8) Explain all the four main positions of mind-brain relationship?
9) Explain the processes that contribute to consciousness.
10) Explain briefly the neural connection of consciousness.

1.7 SUGGESTED READINGS

Block, N. 2002. *Concepts of Consciousness.* In Chalmers 2002

Carlson, N.R. 6th ed., 2005. *Foundations of Physiological Psychology,* Pearson Education Inc: India

Gazzaniga, M.S. ed. 2004. *The Cognitive Neurosciences III.* Cambridge, Mass.: MIT Press.

References

Chalmers, D.J. (ed.) 2002. *Philosophy of Mind*. Oxford: Oxford University Press

Chalmers, D. J. 1996. *The Conscious Mind.* Oxford: Oxford University Press.

Descartes, R. 1641/1996. *Meditations on First Philosophy*. J. Cottingham, trans.-ed. Cambridge, England: Cambridge University Press.

Engel, A., and Singer, W. 2001. *Temporal binding and the neural correlates of sensory awareness.* Trends Cogn. Sci. 5, 16–25.

Gazaaniga, M. S. 1984. *Handbook of Cognitive Neuroscience*, Plenum Press: NY

1.8 ANSWERS TO SELF ASSESSMENT QUESTIONS

1) Fill in the blanks

   Improves, protect against

   15 millions

Three

Vital

The forebrain, the midbrain, the hindbrain

Posterior

Frontal lobe, Parietal lobe, Occipital lobe, and Temporal lobe

Mesencephalon

Cerebellum, pons and medulla

Control of involuntary muscle movements in the body

2) Match the Following

1) d, 2) C, 3) f, 4) g, 5) j, 6) b, 7) e, 8) i, 9) a, 10) h.

3) Fill in the blanks

i) (philosophical) behaviourism

ii) (neural) identity

iii) functionalism

iv) Eliminativism

4) Give details of the four processes must take part in consciousness process:

i) Arousal, the waking up of the brain by nonspecific modulatory systems

ii) Perception, the detection and binding of sensory features

iii) Attention, the selection of a restricted sample of all available information

iv) Working memory, the short-term storage of ongoing events

UNIT 2 CONSCIOUSNESS AND NEURO CHEMICAL PROCESS AND HIGHER CEREBRAL FUNCTIONS

Structure

2.0 Introduction

2.1 Objectives

2.2 Consciousness

2.2.1 Definition of Consciousness

2.2.2 Types of Consciousness

2.2.3 Functions of Consciousness

2.2.4 Neurochemistry of Consciousness

2.2.5 Sleep

2.3 Neurochemical Process

2.3.1 Acetylcholine

2.3.2 Noradrenaline

2.3.3 Serotonin

2.3.4 Dopamine

2.3.5 Histamine

2.3.6 Adenosine

2.3.7 Neurotensin

2.4 Neurons

2.4.1 Neurotransmission

2.4.2 Neurotransmitters

2.4.3 Biogenic Amines

2.4.4 Amino Acids

2.4.5 Peptide

2.5 Neurochemical Process and Higher Cerebral Functions

2.5.1 Attention

2.5.2 Neurochemistry of Attention

2.5.3 Memory

2.5.4 Long term Potentiation (LTP)

2.6 Let Us Sum Up

2.7 Unit End Questions

2.8 Suggested Readings

2.9 Answers to Self Assessment Questions

2.0 INTRODUCTION

This unit deals with consciousness, neurochemical process and higher mental functions. We start with Consciousness, define consciousness, types of consciousness and functions of consciousness. Then we take up the neurochemistry of consciousness, followed by sleep and its effect on the consciousness. Then we deal with the neurochemical processes in which we consider acetylcholine, noradrenalin, serotonin etc. This is followed by a discussion on neurons and how these connect to each other through synapse. We then present the neurotransmitters, biogenic amines, amino acides and peptides. Then we discuss the neurochemical process and higher cerebral functions which takes into account attention, neurochemistry of attention, memory and long term potentiation.

2.1 OBJECTIVES

After completing this unit, you will be able to:

- Define Consciousness;
- Elucidate the types of consciousness;
- Explain the functions of consciousness;
- Analyse the Neurochemical processes;
- Explain the structure and functions of neurons;
- Describe the role of neurotransmitters, biogenic amines and peptides;
- Relate neurochemical process with higher cerebral functions; and
- Neurochemical process and higher cerebral functions such as attention, memory etc.

2.2 CONSCIOUSNESS

The importance of the brain in our everyday lives can never be underestimated. The brain has physical properties that are in a constant state of flux. The brain never rests totally but is always teeming with electrochemical activity. All cognitive functions such as consciousness, attention, memory, thinking, the use of language and many more are reflection of the modulated pattern of chemical activity among specialised cells i.e. neuron , that are mostly concentrated in the brain's cerebral cortex. We owe our entire cognitive universe to the functioning of these neurons which transmits information in the form of electrical waves.

2.2.1 Definition of Consciousness

Consciousness is a phenomenon that is shared by nearly all people. It cannot be directly seen or touched. Yet it is real enough to most people. It is the fundamental state that denotes the being as alive and gives the body the necessary information about the world outside it and about the body itself. It covers cognitive functions such as attention, sensory experiences, memory and states such as being awake or dreaming.

Several definitions of Consciousness have been proposed by different authors:

Consciousness consists of all the sensations, perceptions, memories and feelings you are aware of at any instance (Farthing, 1992).

Consciousness is the awareness of environmental and cognitive events such as sights and sounds of the world as well as of one's memories, thoughts, feelings and bodily sensations. By this definition consciousness has two sides:

Consciousness includes a realisation of environmental stimuli. For example one might become mindful of an old tune, a headache, or visual recognition of an old friend.

Consciousness also includes once cognisance of mental events – thoughts that results from memories

Consciousness is a psychological construct – a concept i.e. devised to help us understand our observations or behaviours. The construct of consciousness has several meanings.

Consciousness as sensory awareness: our sense organs (Eyes, ears, nose etc.) enable us become aware of the environment.

Consciousness as inner state: We are conscious of thoughts, images, emotions and memories within ourselves though they may not have physical occurrence of these aspects.

Consciousness as the waking state: consciousness is also referred to as the waking state as opposed for example to sleep.

All the above definitions highlight that Consciousness overall constitutes subjective experience i.e. awareness, the ability to experience feelings and wakefulness means having a sense of selfhood.

Consciousness can be defined as the immediate knowledge or perception of the presence of any object, state, or sensation. It is the feeling, persuasion, or expectation, especially inward sense of guilt or innocence. It actually refers to the state of being conscious. It is the knowledge of one's own existence, condition, sensations, mental operations, acts, etc.

2.2.2 Types of Consciousness

There are two types of consciousness, (i) Individual consciousness (ii) Collective or Universal consciousness. Let us take up the individual consciousness. Every individual human being needs consciousness for a happy life. Clear consciousness forms as a power of consciousness and it can do everything.

The physical brain is not a source of experience as some current neuroscientists now mistakenly believe. While areas of the brain are associated with different consciousness functions, many neuroscientists do admit that they cannot locate emotions, mind, and soul in the brain. They cannot also fully explain the human psyche with neuroanatomy. The physical brain is a relay station, translating emotional, mental, and spiritual events and information into neuro electrochemical events and information.

Neurochemicals and associated brain processes are simply channel selectors for various states of consciousness. All states of consciousness exist independent of the physical body. This relay station works in both directions, that is spiritual, mental, or emotional states trigger neuro electrochemical events in the brain (physical consciousness) and neurochemical stimulation, for example through drugs etc., open access to specific states of emotion, thought, or spiritual awareness. Contemporary physics has proven very clearly that solid physical matter is an illusion and that all is energy only. Therefore, to say that the solid physical brain is the mind, is a mistake. While the brain appears to be solid, it is not. Actually it is the energy appearing solid, but is not solid. It is energy, only. The mind is also energy, an energy that interacts with the energy that creates the appearance of a brain.

The physical body is composed of the energy states of solids, liquids, and gases and is dependent upon the etheric body for its vitality, life, organisation, and many processes that result in health.

2.2.3 Functions of Consciousness

Consciousness allows individuals to be aware of his/her surrounding, thereby defining the context and removing ambiguities. There are quite a few functions of consciousness and these are given below:

1) **Simplification and Selection of information:** There is much "editing" that goes on in the mind—from the first cuts as the senses to those of perception, memory, and thinking—but still there is far too much information available at once, so there needs to be a choice in what the organism does at any moment. It is in consciousness that the choice is made.

2) **Guiding and overseeing actions**: Consciousness connects brain and body states with external occurrences. In order to function in a complex environment, actions must be planned, guided and organised: We must know when and where to walk; when to speak and what to say; when to eat, drink, eliminate, and sleep. These actions must be coordinated with events in the outside world. At any moment the content of consciousness is what we are prepared to act on next.

3) **Setting priorities for action:** It is not enough for our actions to be coordinated with events in the outside world; they must reflect our internal needs. Pain can flood consciousness in the same way that an emergency fills the front page of a newspaper. The priority system gives certain events, those affecting survival, fast access or a controlling influence on consciousness. Survival and safety come first; while hunger will not intrude as dramatically as does pain, the need will be felt if left unattended.

4) **Detecting and resolving discrepancies:** Since the information selected to enter consciousness is usually about changes in the external and internal worlds, when there is a discrepancy between our stored knowledge about the world and an event, it is more likely to come to consciousness. For instance, a woman in a bikini would probably not attract too much attention on the beach, but if she wore the same outfit to a formal dinner it would certainly be noticed. Discrepancies may arise internally as well. For instance, you are usually not conscious of your breathing. However, when you have a cold your breathing may enter your consciousness, and this may tell you to slow down or to see a doctor. Consciousness involves actions to reduce the discrepancy, as when you straighten out a crooked painting on the wall because it does not fit with the other paintings.

   Other functions include the following:

5) **Adaptation and learning function:** Adaptation to novel experiences requires more conscious involvement, for successful learning and problem solving.

6) **Reflective and Self Monitoring Function:** Through conscious inner speech and imagery one can reflect upon and to some extent control one self's conscious and unconscious functioning.

7) **Error Detection and Editing Function:** Consciousness helps us avoid acting solely through habit. It allows us to make novel responses to familiar situations and to use prior knowledge to respond appropriately to novel situations.

8) **Decision-making:** Consciousness helps us to make rational decisions instead of relying on emotional responses.

2.2.4 Neurochemistry of Consciousness

Conscious experience is probably the most familiar mental process that we know, yet its workings remain mysterious. Consciousness is not directly accessible for study. Hence the neurochemistry of consciousness is studied by examining the neurochemical correlates of well recognised natural states and alterations of consciousness. These include natural functions such as sleep and dreaming, attention, memory, etc. Altered states constitutes changes induced by drugs and by pathological states such as dementia, psychotic states etc.

In the present context neuro chemical process of consciousness will be explained by examining the neurotransmitters involved in waking state through various stages of sleep.

2.2.5 Sleep

Sleep involves a global alteration of brain functioning, and occupies one third of our lives, The transition from waking to sleep is one of the most dramatic natural alterations in consciousness. Sleep is differentiated from waking state by reduction in neuronal responsiveness, inattention to sensory stimuli, and loss of consciousness. These two states differ fundamentally in most physiological parameters including the activity of a variety of key neurotransmitter systems.

Sleep Structure: Electroencephalogram (EEG) recordings reveal the two most basic states of sleep - REM (Rapid Eye Movement) sleep and NREM sleep. NREM comprises of four stages (Stages1 to 4). EEG pattern of wakeful state and different stages of sleep is explained further.

Active wakefulness: It is accompanied by low amplitude, high frequency beta waves. In relaxed wakefulness with eyes closed, the brain emits alpha waves. Alpha waves are low amplitude brain waves of about 8 to 13 cycles per second.

NREM (non-rapid-eye-movement) SLEEP

Stage 1 sleep: As an individual becomes drowsy, and enters stage 1, alpha wave decreases and theta waves appear. Theta waves with a frequency of about 6 to 8 cycles per second are accompanied by slow rolling eye movements. Stage 1 is the lightest stage of sleep. After 30 to 40 minutes of stage 1 sleep one undergoes a rather steep descent into stages 2, 3 and 4.

Stage 2 sleep: In stage 2 sleep is composed of largely theta background, and is characterised by:

Sleep spindles: regular spindle shaped waves of 13-15 cycles/sec with waxing and waning amplitude

K-complexes- high voltage spikes present intermittently. Stage 2 occupies about 50% of sleep.

Stages 3 and 4, Slow wave sleep (SWS): During deep sleep stages 3 and 4, brain produces slow delta waves. In stage 3 delta waves have a frequency of 1 to 3 cycles per second.

Stage 4 sleep: The deepest stage of sleep, shows predominant delta activity with frequency of 0.5 to 2 cycles per second and highest amplitude. Slow wave sleep usually lasts for 70–90 minutes and takes place during the first hours of sleep.

REM (rapid-eye-movement) SLEEP

After deep stage 4 sleep, comes REM sleep. It derives its name from the rapid eye movements; observable beneath the closed eyelids.REM sleep is characterised by rapid, low amplitude brain waves similar to that of light stage 1 sleep. REM sleep is associated with dream.

2.3 NEUROCHEMICAL PROCESS

Alertness and sleep are dependent on the activity of the brain as a whole, although different levels of consciousness are determined primarily by areas of the brain stem. A key anatomical structure in the regulation of waking and sleeping, (and thus consciousness), is the reticular formation, located in the brain stem. It is a highly complex interlacing network of fiber bundles.

Neuro chemically, there is a great diversity of neurotransmitters present: serotonin, mainly from the mid-line raphe nuclei; noradrenaline from the locus coeruleus; acetylcholine from pedunculopontine nuclei with also peptidergic and dopaminergic components.

The alterations in the activity of these neurotransmitters either triggers or accompany the onset of natural sleep and distinguish slow wave or non-REM from REM sleep thus providing one of the most compelling arguments in favour of chemical neurotransmission being specifically involved in mechanisms of conscious awareness.

Pharmacological manipulations of these neurotransmitters provide evidence for the role of neuro chemical processes in consciousness. In this context it is important to understand that there are two categories of drugs used to vary the level of neurotransmitters.

Antagonist (drugs that decreases the level of neurotransmitters)

Agonist (drugs that increases the level of neurotransmitters)

2.3.1 Acetylcholine (Ach)

Cholinergic mechanisms are important in wakefulness and cortical activation. In general, increased acetylcholine is associated with wakefulness and REM sleep and decreased level of acetylcholine promotes sleep and non-REM sleep phenomena.

2.3.2 Noradrenaline

Increased level of noradrenalin is implicated in wakefulness. Locus coeruleus noradrenergic neurons decrease their rate of firing at sleep onset. Drugs that diminish noradrenergic neurotransmission tend to cause sedation, while the reverse is the case for drugs that potentiate noradrenergic function.

2.3.3 Serotonin

Serotonin complements the action of noradrenalin and acetylcholine in promoting wakefulness and cortical responsiveness. Experiments provide evidence that the level of serotonin during waking is higher in most cortical and subcortical areas than during sleep.

The seretonergic neurons in the raphe nuclei show the highest firing rate during waking decrease their firing rate during slow wave sleep.

2.3.4 Dopamine

An increase in dopamine activity produces an increase in wakefulness. Dopaminergic neurons in the ventral tegmental areas are constantly active throughout the various stages of sleep, including SWS or non-REM. D-amphetamine, methylphenidate, high doses of L-dopa and cocaine, which predominantly enhance dopamine activity, induce arousal and decrease REM sleep.

2.3.5 Histamine

Histamine is involved in controlling the level of consciousness during waking. The level of histamine diminishes during sleep and its antagonists induce sleep and impair daytime vigilance

2.3.6 Adenosine

The adenosine plays a major role in inducing sleep. Injections of adenosine promote sleep and decrease wakefulness. Conversely, adenosine receptor antagonists' caffeine and theophylline are widely used as stimulants to induce vigilance and promote wakefulness.

During wakefulness adenosine accumulates in the extracellular space of the basal forebrain. The increase in extracellular adenosine concentration decreases the activity of the wakefulness-promoting cholinergic neurons in the basal forebrain. When the activity of the wakefulness-active cells decreases sufficiently sleep is initiated. During sleep the extracellular adenosine concentrations decrease, and thus the inhibition of the wakefulness-active cells also decreases allowing the initiation of a new wakefulness period.

2.3.7 Neurotensin

Although little is known about the role of this peptide during the sleep-wake cycle, it has recently been shown that neurotensin injections in the basal forebrain decreases slow wave sleep and increases REM sleep.

Therefore it can be concluded that several neurotransmitters are involved in the modulation of the sleep-wake cycle. In particular the elevation in adenosine levels and concomitant reduction in cholinergic, serotonergic, noradrenergic and histaminergic neurotransmission appear to be specifically related to the sudden loss or major reduction in conscious awareness that occurs at the onset of sleep.

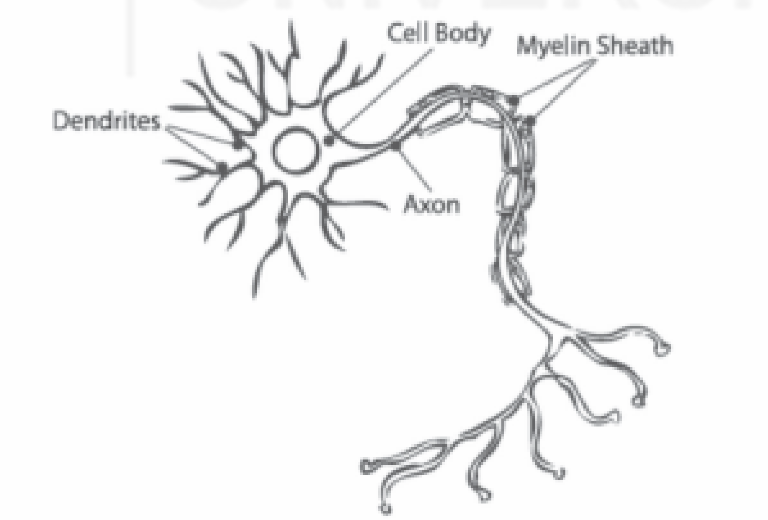
Self Assessment Questions

Match the Following:

1) Neurotensin	a) Beta waves
2) Stage 1sleep	b) Promotes wakefulness
3) Altered states of consciousness	c) Sensations, perceptions, memories and feelings you are aware of at any instance
4) Increased level of acetylcholine	d) Theta waves
5) Awake	e) Dreaming
6) Consciousness	f) Increases REM sleep
7) Decreased Histamine	g) Pathological states such as dementia, psychotic states
8) REM sleep	h) Induces sleep

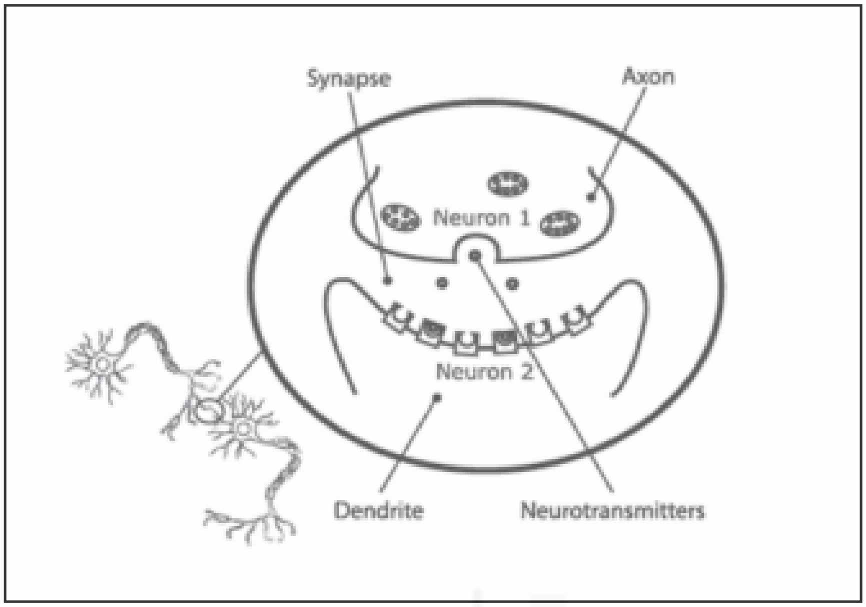
2.4 NEURONS

Information is constantly exchanged between the brain and other parts of the body through both electrical and chemical impulses. Cells called neurons are responsible for carrying these impulses. A neuron has three main parts. The *cell body* directs all the neuron's activities. *Dendrites*, short branches that extend out from the cell body, receive messages from other neurons and pass them on to the cell body. An *axon* is a long fibre that transmits messages from the cell body to the dendrites of other neurons or to other tissues in the body, such as muscles. A protective covering, called the *myelin sheath*, covers the axons of many neurons. Myelin insulates the axons and helps messages from nerve signals travel faster, farther, and more efficiently.



2.4.1 Neurotransmission

The exchange of information between the axon of one neuron and the dendrites of another neuron is called neurotransmission. Neurotransmission takes place through the release of chemicals into the space between the axon of the first neuron and the dendrites of the second neuron. These chemicals are called neurotransmitters. The space between the axon and the dendrite is called a *synapse.*



When neurons communicate, an electrical impulse travels down the axon and causes neurotransmitters to be released from the end of the axon into the synapse. The neurotransmitters cross the synapse and bind to special molecules, called receptors, on the dendrite of the second neuron. Receptors are found on the dendrites and cell bodies of all neurons. The neurotransmitters bind to receptors in the same way as a key fits into a lock i.e. a specific neurotransmitter binds only to its corresponding receptor. The receptors convert the information into chemical or electrical signals which are then transmitted to the cell body and eventually to the axon. The axon then carries the signal to another neuron or to body tissues such as muscles.

Once a neurotransmitter binds to a receptor, a series of events follow. First, the message carried by the neurotransmitter is passed on to the receiving neuron. Second, the neurotransmitter is inactivated. It is either broken down by an enzyme or reabsorbed by the axon from which it was released. Other molecules, called transporter molecules, complete this reabsorption process. These molecules are located in the cell membranes of the axon that releases the neurotransmitters. They pick up specific neurotransmitters from the synapse and carry them back across the cell membrane and into the axon, where they are recycled for use at a later time.

2.4.2 Neurotransmitters

There are different types of neurotransmitters found in brain. Each neurotransmitter has a specific role to play in the functioning of the brain. Cognitive functions rely on neurotransmitter processes to coordinate what signals are sent between the different areas of the brain. As already discussed above neurotransmitters are chemicals manufactured by nerve cells and are released whenever a nerve cell is stimulated. Neurotransmitter messages can be generalised as either excitatory or inhibitory messages. An excitatory neurotransmitter is one that increases the activity of neurons, and an inhibitory neurotransmitter decreases the activity of neurons.

The three principal neurotransmitters systems found in the brain are:

Biogenic amines

The biogenic amines are the best understood neurotransmitters because they were the first to be discovered and constitute the neurotransmitter substance in only a small percentage of neurons. Biogenic amines include dopamine, epinephrine, norepinephrine, serotonin, acetylcholine, and Histamine

Amino acids

Amino acids were discovered later and are present in 70% of neurons. Gamaaminobutyric acid (GABA) and Glutamate are examples of aminoacids.

Peptides

The peptide neurotransmitters are intermediate in terms of the percentage of neurons that contain such neurotransmitter.

Brief description of each neurotransmitter is given below:

2.4.3 Biogenic Amines

Acetylcholine

Acetylcholine is found in many parts of the brain having particularly high concentrations in the cerebral cortex, limbic system, basal, forebrain, hypothalamus and thalamus.

Receptors

The two major types of cholinergic receptors are muscarinic and nicotinic.

Dopamine

Dopaminergic neurons occur in two closely connected groups: Ventral tegmental area (VTA) of the midbrain and Substantia nigra,(in medial region of the midbrain). While substantia nigra neurons project to the striatum, VTA neurons serves to most areas of cerebral cortex and limbic system.

Receptors

At least five types of Dopamine receptors, D1 to D5 are known to exist. D1 and D2 are evenly distributed in the straitum. D2 receptors also occur throughout the cerebral cortex particularly temporal lobe. D3 receptors are concentrated in the limbic portion, and in hippocampus.

Norepinephrine and Epinephrine

The major concentration of noradrenergic (and adrenergic) cell bodies is found in locus ceruleus a nucleus in the reticular formation. The axons of these neurons project through the medial forebrain to the cerebral cortex, the limbic system the thalamus and the hypothalamus.

Receptors

The two broad groups of adrenergic and noradrenergic receptors are á-adrenergic receptors and â-adrenergic receptors. The á-adrenergic receptors are further subdivided into two types á1, á 2 and â-adrenergic receptors are subdivided into â1 â2 and â3 . The â1 subtype predominates in the cerebral cortex and â2 in the cerebellum.

Serotonin

The major site of serotonergic cell bodies is in upper pons and the midbrain, specifically the median and dorsal raphe nuclei and to a lesser extent in caudal locus ceruleus . These neurons serve to the basal ganglia, limbic system and cerebral cortex.

Receptors

Seven types of serotonin receptors have been recognised: 5-HT1 through 5-HT7 receptors with numerous subtypes, totaling 14 distinct receptors. 5HT1A receptors are widely distributed, concentrated in limbic areas (e.g., hippocampus and amygdala), in the cerebral cortex and also in raphé nuclei. Basal ganglia and hippocampus have 5HT1B receptors, and the 5HT1D receptor subtype is also evident in basal ganglia. 5HT2 or 5HT2A receptors are concentrated in cerebral cortex. 5HT3 receptors are present at low densities in cortex with highest densities in medulla and spinal cord.

Histamine

A fifth member of the monoamine transmitter group is histamine. That release histamine as their neurotransmitter is located in the hypothalamus and project to cerebral cortex, limbic system and thalamus.

Receptors

There are three types of histamine receptors. H1 receptors occur throughout the CNS with particularly high densities in the thalamus and hippocampus H2 receptors are concentrated in the striatum, hippocampus and thalamus and H3 receptors in cortex, hippocampus and amygdala.

2.4.4 Amino Acids

GABA (Gamaaminobutyric acid)

GABA is the principal inhibitory transmitter in the brain. The concentration of GABA is up to 1000 times greater than that of other transmitters like acetylcholine or dopamine. Neurons containing GABA are relatively small, and widely distributed, especially in regions—cerebral cortex, striatum, hypothalamus, septum and thalamus.

Receptors

There are two types of GABA receptors: GABAA and GABAB.

Glutamate

It is the principal excitatory transmitter in the brain and is found throughout the central nervous system.

Receptors

Glutamate receptors include NMDA (N-methyl-D-aspartate) and AMPA (amino3hydroxy-5-methyl-4-isoxazole proprionic acid) subtypes which are concentrated in cortex and striatum, and the kainate subtype.

2.4.5 Peptide

There are as many as 300 peptide neurotransmitters found in the brain. Peptide is a short protein consisting of fewer than 100 amino acids. Examples of peptides are somatostatin, neuropeptide Y, galanin, substance P, neurotensin, vasopressin adenosine etc. Peptide implicated in consciousness is discussed below.

Adenosine

Adenosine has four different receptor subtypes (A1, A2A, A2B and A3). Adenosine A2A receptors are concentrated in striatum. Adenosine receptor modulation is one of the most important modulatory mechanisms of altering the level of consciousness.

Neurotensin

Neurons containing neurotensin (NT) are concentrated in the hypothalamus, striatum, amygdala. Receptors are localised in basal forebrain cholinergic neurons, dopaminergic nuclei and hypothalamus.

Self Assessment Questions

1) An excitatory neurotransmitter .... the activity of neurons.
2) The space between the axon and the dendrites is called ....
3) .... is the principal inhibitory transmitter in the brain.
4) The three parts of a neuron are ...., ..., and ....
5) The two receptors of Acetylcholine neurotransmitter is ...., ...
6) The axon of a neuron is covered by ....
7) The two amino acids are ....and,..................................

2.5 NEUROCHEMICAL PROCESS AND HIGHER CEREBRAL FUNCTIONS

As discussed above consciousness is a combination of multiple higher cerebral functions. The knowledge of the neuro chemical processes involved in these functions also contributes to the understanding of consciousness. Two of the most important higher cerebral activities i.e. attention and memory is discussed below.

2.5.1 Attention

Attention can be defined as "the concentration of mental effort on sensory or mental events.

There are three types of attention *selective attention, sustained attention* and *divided attention*.

Selective or Focused attention refers to the capacity to perform a task in the presence of distracting stimuli. The capacity to listen to conversation at a railway station, identify a friend in crowd.

Sustained attention requires 'holding' attention over relatively long periods of time. The capacity to study or the capacity to listen to a lecture for an extended length of time is an example of sustained attention.

Divided attention refers to the ability to perform or attend to two or more tasks simultaneously. The concept of divided attention explains dual tasking, wherein two tasks require effort and attention. For example a subject may be presented with stimuli which vary with respect to color and motion and monitor changes in both the dimensions.

2.5.2 Neurochemistry of Attention

Different neurotransmitters systems are implicated in attention. Cholinergic, dopaminergic and serotonergic systems play major roles in neurochemical machinery of attention.

Acetylcholine: More than any other neurotransmitter, acetylcholine has been implicated in attentional processes. Blockage of Muscarinic receptors by a drug scopolamine (antagonist) results in impaired performance on a number of task measuring sustained attention. On the other hand Nicotine (agonist) administration improves task performance on the measures of sustained attention. Lesions of the basal forebrain cholinergic system result in impaired attentional function in rats and monkeys. Therefore it seems that increased level of acetylcholine is important for sustained attention.

Dopamine: Dopamine plays a pivotal role in aspects of shifting attention. Administration of D1/D2 receptor antagonist haloperidol impairs the ability to shift attention from one aspect to another aspect of a task. Thus increased level of dopamine is required to enhance the ability of shifting attention.

Seretonin: Low level of serotonin is implicated in the improved performance on tasks assessing focussed attention.

2.5.3 Memory

Memory is the retention of information over time**.**

Stages or Process of Memory: There are three stages of memory

Encoding process: It is the process of receiving sensory input and transforming it into a form or code, which can be stored.

Storage: It is the process of actually putting coded information into memory. There are three systems of memory storage

Sensory memory: It holds information from the external world in its original sensory form for fraction of a second to few seconds. Information is quickly lost if not transferred into short term or long term memory.

Short-term memory: It is a limited capacity memory system in which information is retained for only as long as 30 seconds unless strategies are used to retain it longer.

Long-term memory: It is a relatively permanent type of memory that stores huge amount of information for a long time. Long-term memory is further divided into explicit and implicit memory.

Explicit memory: This is the conscious recollection of information such as specific facts or events and at least in humans that can be verbally communicated. There are two subtypes of explicit memory.

Episodic memory: It is the retention of information about the where and when of life's happening.

Semantic Memory: Semantic means meanings. It is a person's knowledge about the world. It includes general knowledge, knowledge about meanings of words famous individuals, important places etc.

Implicit memory: It is related to unconsciously remembering skills and perceptions rather than consciously remembering facts. Examples include skills of driving a car or typing. Once learnt the individuals do not have to remember consciously how to drive a car or type. The subsystems of implicit memory are:

Procedural memory involves memory for skills.

Classical conditioning: It implies automatic learning of associations between stimuli. A small child may develop fear of dogs if the dog approaches the child and barks on him repeatedly.

Working Memory: It has often been suggested that memory does not always work in three stage sequence and the model of memory system comprising of sensory, short-term and long-term memory is too simplistic.

Therefore another concept has been introduced by Alan Baddeley i.e. Working Memory.

It is a system that temporarily holds information as people perform cognitive tasks. It is a kind of mental workbench on which information in manipulated and assembled to help us comprehend language, make decisions and solve problems. It is an active memory system.

Retrieval: This is the process of gaining access to stored, coded information when it is needed.

Neurochemistry of Memory: Memory is the result of certain neural mechanism and biochemical responses in the brain following sensory input. First the neural mechanism will be discussed followed with the role of various neurotransmitters.

2.5.4 Long Term Potentiation (LTP)

It is a neural mechanism that plays a role in encoding of new information. Encoding takes place as a result of changes in the strength of synapses among neurons in neuronal networks that process and store information. This change occurs when one or more axons connected to some dendrite bombard it with a brief but rapid series of stimuli-such as 100 synaptic excitations per second for 1to 4 seconds. The burst of intense stimulation leaves the synapses potentiated (more responsive to new input of the same type) for minutes, days or weeks. This phenomenon is termed as long term potentiation. It occurs in many brain areas and is particularly prominent in hippocampus.

The chemicals involved in LTP are glutamate and its receptors – NMDA and AMPA. A wide variety of drugs that interfere with LTP also blocks encoding process whereas drugs that facilitate LTP enhance the process.

Acetylcholine

Acetylcholine, a well known neurotransmitter, plays a critical synaptic role in the initial formation of memory. Chemical blockage of the acetylcholine receptors makes it harder to learn and remember even in healthy young people. Evidence for it comes from pharmacological studies conducted on human subjects wherein blockage of muscarinic cholinergic receptors by drugs such as scopolamine impaired the encoding of new memories. Conversely, drugs which activated nicotinic receptors enhanced the encoding of new information.

Similarly administration of scopolamine into the hippocampus impaired encoding of spatial memory. It has also been found that administration of drug that increases the level of acetylcholine in Alzheimer's disease (characterised of memory problems) improves memory by inhibiting the action of acetyl cholinesterase, an enzyme that breaks down acetylcholine and reduces its amount.

Overall it can be said that decreased acetylcholine in the brain cause problems with memory function.

Serotonin

Increased level of serotonin is implicated in the enhancement of memory. It plays a significant role in classical conditioning wherein stimuli are paired repeatedly, by increasing the efficiency of neural transmission at certain synapses. It has been also found that a chemical lesion in the raphe nuclei containing large concentration of serotonin leads to memory problem.

Adrenaline and Noradrenaline

Both these neurotransmitter strengthen memory when they are released into the blood stream following learning. Stressful events stimulate release of stress hormones from the adrenal glands-adrenaline and steroids-which in turn stimulate amygdala (a structure in limbic system) to release noradrenaline. These hormones and neurotransmitters acting together heighten memory for stressful events.

Dopamine

Dopamine is important for working memory and drug that increases the level of dopamine in the brain or facilities the action of dopamine, enhances working memory capabilities.Dopamine helps to maintain the ongoing information in the face of interference by signaling when the information in working memory should be updated. It is suggested that anatomy of the dopamine system is such that dopamine-producing cells have a strong connection to the prefrontal cortex– the brain region that is considered most important for protecting maintained information from distraction.

Self Assessment Questions

Put *True or False* to the following statements:

1) Decreased acetylcholine improves memory functioning. ( )
2) Noradrenalin plays role in emotional memory. ( )
3) Scopolamine is a drug that increases acetylcholine. ( )
4) Increased level of Serotonin enhances focused attention. ( )

5) Nicotinic receptor improves memory. ( )

6) In long-term potentiation axons bombard dendrite with a brief but rapid series of stimuli. ( )

7) Implicit memory involves unconscious processing. ( )

8) Glutamate is involved in Long term potentiation of synapses. ( )

9) Selective attention requires holding of attention over relatively long periods of time. ( )

10) Working memory is a permanent storage of information. ( )

2.6 LET US SUM UP

In this unit you have read all about the Cells called neurons that are responsible for carrying electrochemical impulses. A neuron comprises of a cell body, dendrites, and axon. The exchange of information between the axon of one neuron and the dendrites of another neuronon is called neurotransmission and it takes place through the release of chemicals called neurotransmitters.

Neurotransmitters cross the synapse and bind to special molecules, called receptors and thereafter they are inactivated.

The three principal neurotransmitters systems found in the brain are biogenic amines, amino acids and peptides.

Consciousness overall constitutes subjective experience i.e. awareness, the ability to experience feelings and wakefulness means having a sense of selfhood.

Functions of Consciousness includes defining context, adaptation and learning function, reflective and self monitoring function, error detection and editing function, decision-making.

Since consciousness is not directly accessible for study, the neurochemistry of consciousness is studied by examining the neurochemical correlates of its natural and altered states.

In the present context neurochemical process of consciousness has been explained by examining the neurotransmitters involved in waking state through various stages of sleep.

Neurotransmitters implicated are elevated levels of cholinergic, serotonergic, noradrenergic, dopaminergic and histaminergic neurotransmission contribute to waking state and increased adenosine induces sleep.

Since consciousness covers multiple higher cerebral function. The two most important discussed here are attentional process and memory.

Attention is “the concentration of mental effort on sensory or mental events and its subtypes are selective attention, sustained attention and divided attention.

Increased level of acetylcholine and dopamine is implicated in sustained attention and shifting of attention whereas low level of serotonin is implicated in focused attention.

Memory is the retention of information over time and comprises of three stages encoding process, storage and retrieval. Subtypes of memory include sensory memory, short-term memory and long-term memory.

In biochemical process of memory glutamate is implicated in long term potentiation (LTP), increased levels of acetylcholine and plays a critical synaptic role in the encoding of memory.

Increased level of serotonin is implicated in classical conditioning. Adrenaline and Noradrenaline plays role in memory for stressful events whereas increased level of Dopamine is important for working memory.

2.7 UNIT END QUESTIONS

1) What is a neuron? Explain with the help of a diagram the different parts of a neuron.
2) What are different types of biogenic amines? Briefly describe the areas in the brain where the amino acids are mainly found along with the receptors.
3) Define consciousness and its functions.
4) Briefly describe the biochemical mechanism of consciousness.
5) Define attention and its subtypes. Briefly discuss the neurochemicals implicated in attentional processes.

2.8 SUGGESTED READINGS

Kalat, J.W. (2001). *Biological Psychology.* Thomson Learning. Canada.

Levinthal, C.F. (1990). *Introduction to Physiological Psychology*. Pearson Education. New jersy, U.S.A.

Perry, E., Ashton. H., & Young, A. (2001) *Neurochemistry of Consciousness* John Benjamins Publishing Company, Amsterdam, Philadelphia

Santrock, J.W. (2006). *Psychology Essentials*. Tata McGraw Hill, New Delhi

Solso, R. L. (2001). *Cognitive Psychology.* Dorling Kindersley Pvt. Ltd. India

2.9 ANSWERS TO SELF ASSESSMENT QUESTIONS

Fill in the Blanks

1) Increase, 2) Synapse, 3) GABA, 4) Cell body, axon, and dendrites. 5) Muscarinic and Nicotinic, 6) Myelin seath, 7) GABA andGlutamate.

Match the Following: 1f, 2d, 3g, 4b,5a, 6c, 7h, 8e.

True or False

1) F, 2) T, 3) F, 4) F ,5) T, 6) T , 7) T, 8) T, 9) F, 10) F.

UNIT 3 NEUROBIOLOGICAL AND NEUROPSYCHOLOGICAL ASPECTS IN THE DEVELOPMENT OF MEMORY, EMOTION AND CONSCIOUSNESS

Structure

3.0 Introduction

3.1 Objectives

3.2 Memory

3.3 Neurobiological and Neuropsychological Aspects of Memory

- 3.3.1 Neurobiology of Short Term Memory
- 3.3.2 Neurobiology of Long Term Memory
- 3.3.3 Neural Substrates of Implicit Memory
- 3.3.4 Neural Substrates of Explicit Memory
- 3.3.5 Neural Substrates of Emotional Memory

3.4 Anatomy of the Hippocampus

- 3.4.1 The Perirhinal Cortex
- 3.4.2 The Temporal Cortex
- 3.4.3 Parietal and Occipital Cortex
- 3.4.4 Frontal Cortex

3.5 Emotion

- 3.5.1 Nature of Emotions
- 3.5.2 Anatomy of Emotion
- 3.5.3 Cortical Connections of Emotion
- 3.5.4 Frontal Lesions and Emotion
- 3.5.5 Brain Circuits for Emotion

3.6 Neuropsychological Theories of Emotion

- 3.6.1 Somatic Marker Hypothesis
- 3.6.2 Cognitive Emotion Interaction
- 3.6.3 Cognitive Asymmetry and Emotion
- 3.6.4 Cognitive Control of Emotion

3.7 Consciousness

- 3.7.1 Neurobiology and Neuropsychology of Consciousness
- 3.7.2 Involvement of Cerebral Regions in Consciousness

3.8 Let Us Sum Up

3.9 Unit End Questions

3.10 Suggested Readings

3.0 INTRODUCTION

Memory is generally defined as the processes of encoding, storing and retrieving information. During the 1960's, a number of models that attempted to explain the workings and interactions of memory processes and systems were proposed by experts in the field. One model proposed by Atkinson and Shiffrin (1968) has been nicknamed the "Modal Memory Model" because it was typical of others and was probably one of the most influential (Baddeley, 1998). Memory is thought to begin with the encoding or converting of information into a form that can be stored by the brain. However, the term emotion refers to positive or negative feelings that are produced by particular situations. For example being treated unfairly makes us unhappy, seeing someone suffer makes us sad, and being closed to loved one make us feel happy. This further raise the question that does emotion help us in remembering? How are our emotions connected to our thoughts? How is our brain connected to our mind, our body, and ultimately, our consciousness? These are the some question we will be discussing in this section and will be attempting to explain the neurobiological association of different parts of the brain in over all functioning of memory, emotion and consciousness.

3.1 OBJECTIVES

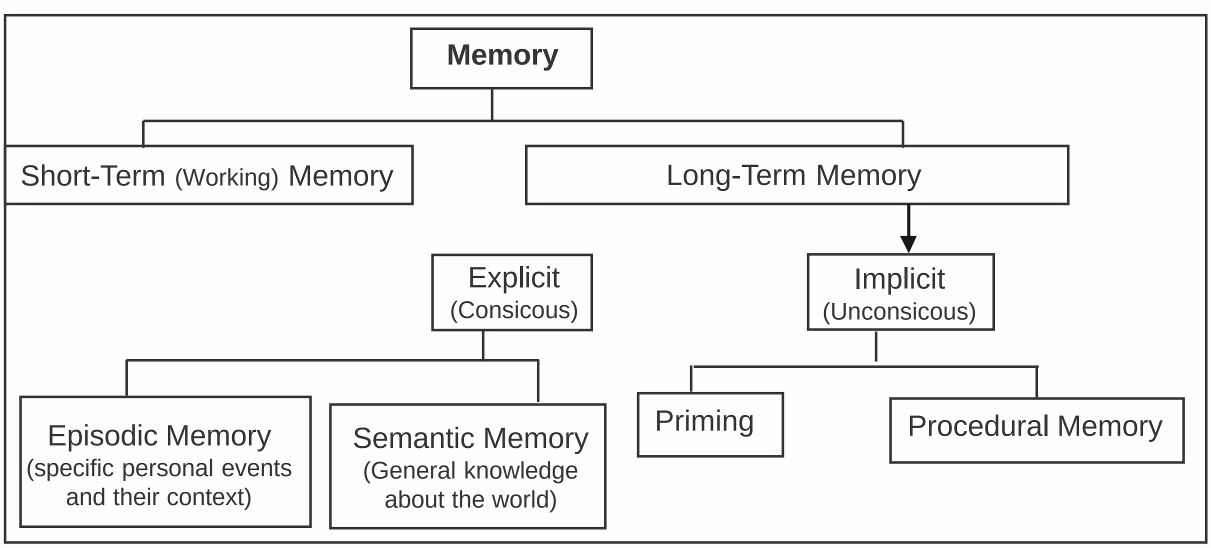
After completing this unit, you will be able to:

- Define the concept and meaning of memory, emotion and consciousness;
- Describe nature and associated features of memory, emotion and consciousness; and
- Differentiate the neurobiological and neuropsychological aspects of memory, emotion and consciousness.

3.2 MEMORY

Memory is the process by which we encode, store and retrieve the information. The information is initially recorded in a form usable to memory is known as *encoding*. The maintenance of material saved in the memory system is *storage*, and the material in memory storage is located, brought in to awareness, and used is known as *retrieval*.

The processes of encoding, storing and retrieving the information are necessary for memory to operate successfully. Many psychologists studying memory suggest that there are different systems or stages through which information must travel if it is to be remembered. According to enduring theories, the two major classification of memory are the short term memory and the long term memory. Refer to the diagram below.



i) **Short-term memory:** Short-term memory is the work bench of our consciousness, and includes our awareness of the sensations, feelings and thoughts that are experienced. Closely related to "working memory", short term memory is like a receptionist for the brain. As one of two main memory types, short-term memory is responsible for storing information temporarily and determining if it will be dismissed or transferred on to long-term memory. Although it sounds complicated, this process takes for short-term memory less than a minute to complete.

ii) **Long -term memory systems:** Long-term memory refers to the continuing storage of information. It may last from a minute or so to weeks or even years. From long term memory you can recall general information about the world that you learned on previous occasions, memory for specific past experiences, specific rules previously learned, and the like. In Freudian psychology, long-term memory would be to recall the preconscious and unconscious material within the mind. This information is largely outside of our awareness, but can be called into working memory to be used when needed. Long term memory has no limit to capacity and can store vast amounts of information.

Long term memories are of three types:

i) implicit memory

ii) explicit memory and

iii) emotional memory

These are supported by three pathways in the brain. We recall implicit memories of skills, conditioned reactions and events unconsciously or on prompting. However, we can spontaneously and consciously recall explicit memories for events and facts. Emotional memory refers to the affective properties of stimuli or events and is generally vivid. It has aspects of both conscious and unconscious long term memory. All these three memories are distinguished by differences in the way in which the information is processed.

Implicit memory is unconscious, non intentional memory. Your abilities to use language and to perform motor skills such as riding a bicycle or playing a sport are implicit memories. It depends simply on receiving the sensory information and does not require any manipulation by higher level.

Explicit memory is the conscious intentional remembering of fact based on semantic memories (2+2 = 4) and personal experiences, or episodic memories (What you did last night).

Explicit memory depends on conceptually driven, or top down, processing, in which a subject reorganises the data to store it.

Emotional Memory is arousing, vivid, and available on prompting. Thus, like implicit memory, it relies on bottom up processing.

Emotional memory likewise has the intentional, top down element of explicit memory in that the internal cues that we use in processing emotional events and it can also be used to initiate their spontaneous recall.

Self Assessment Questions

1) Discuss the neurobiological and neuropsychological aspects of memory.

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2) What are the neurobiological aspects of short term memory?

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3) Elucidate the neurobiology of long term memory.

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4) What are the three types of long term memory? Discuss the three pathways.

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5) Discuss the neural Substrates of Implicit Memory. Explicit memory and emotional memory.

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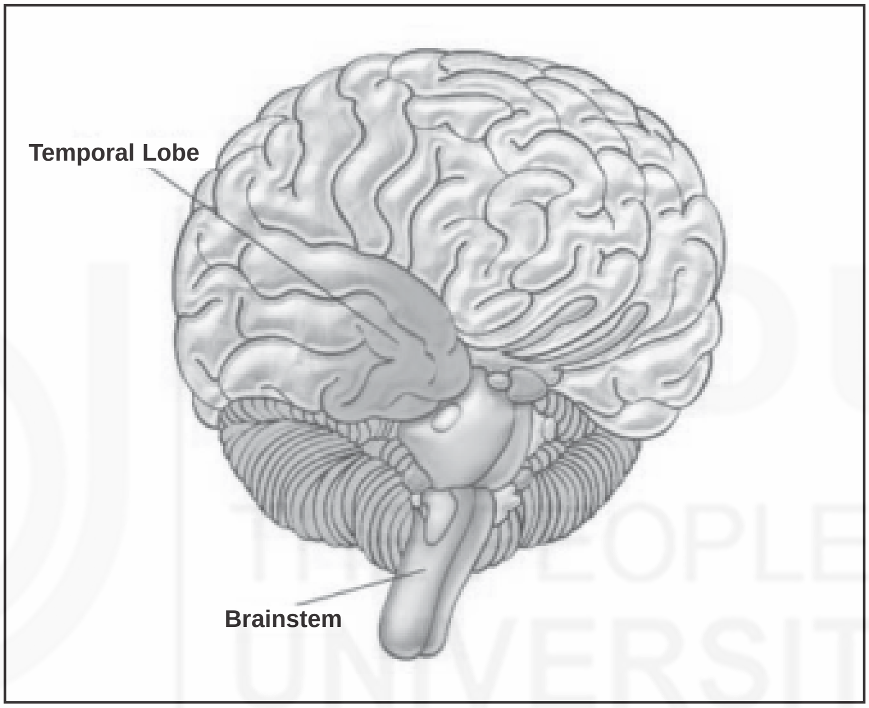
3.3 NEUROBIOLOGICAL AND NEUROPSYCHOLOGICAL ASPECTS OF MEMORY

The first evidence that the temporal lobe might play a role in human memory came to light by the case of H. M. in 1900, when Vladimir Bekhterev autopsied the brain of a patient who had shown severe memory impairment. He discovered the impact of bilateral softening in the region of the medial temporal cortex on human behaviours. Brenda Milner and her coworkers in the 1950s not only confirmed the role of the temporal lobe in memory but also indicated the special contribution of different structures within the temporal lobes to different kinds of memory.



3.3.1 Neurobiology of Short Term Memory

In 1890, William James drew a distinction between memories that endure for a very brief time and for longer term. Not until 1958, however, there was any separate short term and long term memories. In 1958, this was specifically postulated by Donald Broadbent. According to Broadbent, Short term memory, sometimes also called the *working memory* or *temporal memory* refers to a neural record for recent events and their order. It is the system that we use for holding sensory events, movements, and cognitive information such as digits, words, names or other items for a brief period. Short term memory is mediated by different regions in the cerebral cortex such as temporal lobe, some specific areas of frontal lobe, and motor cortex. The detail discussions of these are given below.

i) **Short Term Memory and Temporal Lobe:** Warrington and her colleagues describe a patient, who received a left posterior temporal lesion. The lesion resulted in an almost total inability to repeat verbal stimuli such as digits, letters, words and sentences. In contrast, his long term recall of paired associates words or short stories was nearly normal. Warrington and her colleagues also found that some patients apparently have defects in short term recall of the same stimuli presented auditorily. Short term memory deficits can also result from damage to the polymodal sensory areas of the posterior parietal cortex and the posterior temporal cortex.

ii) **Short Term Memory and Frontal Lobe:** Damage to the frontal cortex is the recognised cause of many impairments of short term memory for tasks in which subjects must remember the temporary location of stimuli. The tasks themselves may be rather simple given this cue, make that response after a delay. But as one trial follows another, both animals and people with frontal lobe lesions start to mix up the previously presented stimuli.

L. Prisko devised a “compound stimulus” task in which two stimuli in the same sensory modality are presented in succession, separated by a short interval. A subjects’ task is to report whether the second stimulus of the pair is identical with the first. In half the trials, the stimuli were the same in the other trials, they were different. Thus, the task required the subject to remember the first stimulus of a pair in order to compare it with the second while suppressing the stimuli that had been presented in previous trials.

3.3.2 Neurobiology of Long Term Memory

There is no single entity in the mind called memory and no single brain structure or process which can be labeled the seat of memory (Squire & Kandel, 1998). Instead, research posits several memory systems with discrete interacting anatomical substrates sub served by long evolved molecular components. Long term memory is subdivided into explicit (declarative) and implicit (procedural) memory.

Explicit memory provides factual knowledge of the world (semantic) and personal past (episodic).

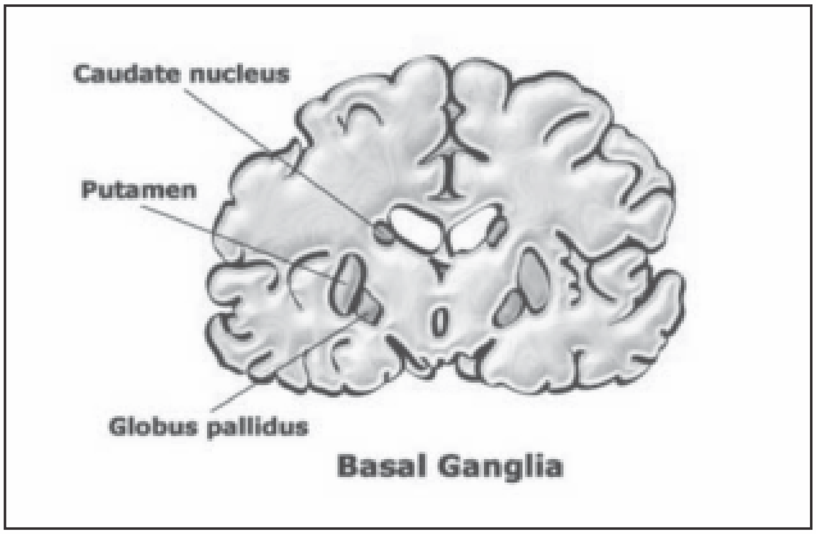
Explicit memories are recollected in consciousness, with long-term encoding dependent on the hippocampus (Squire & Kandel, 1998).

Implicit memory stores our skills, tasks, habits and emotional reflexes; however, their expression does not necessitate immediate transfer into the consciousness or require the hippocampus for long-term encoding, but is likely to be mediated through the cerebellum, basal ganglia and amygdala (Squire & Kandel, 1998).

The different parts of cerebral cortex involved in Implicit and explicit memory have been discussed in detail as below.

3.3.3 Neural Substrates of Implicit Memory

Petri and Mishkin suggest a brain circuit for implicit memory. The key structures in this proposed circuit are the neocortex and basal ganglia (the caudate nucleus and putamen) The basal ganglia receives projections from all regions of the neocortex and send projections through the globus pallidus and ventral thalamus to the premotor cortex. The basal ganglia also receives projection from cells in the substantia nigra. The motor cortex shares connections with the cerebellum, and it in turn also contributes to implicit memory.



i) **The Basal Ganglia:** Evidence from other clinical and experimental studies supports a formative role for the basal ganglia circuitry in implicit memory. In a study of patients with Huntington's chorea, a disorder characterised by the degeneration of cells in the basal ganglia, were impaired in the mirror drawing task, on which patients with temporal lobe lesions are unimpaired (Martone et al., 1984). Conversely, the patients with Huntington's chorea were unimpaired on a verbal recognition task.

ii) **The Motor Cortex:** Positron emission tomography was used to record regional cerebral blood flow as normal subjects learned to perform a motor task (Grafton et al., 1992). In this Pursuit Rotor Task, a subject attempts to keep a stylus in particular location on a rotating turntable that is about the size of a vinyl record album. The task draws on skills that are very much like the skills needed in mirror drawing. The researchers found that performance of this motor task is associated with increases in regional cerebral blood flow in the motor cortex, basal ganglia and cerebellum. Acquisition of the skill was associated with a subset of these structures, including the primary motor cortex, the supplementary motor cortex, and the pulvinar nucleus of the thalamus.

A more dramatic demonstration of the role of the motor cortex in implicit learning comes from a study by Alvaro Pascual Leone and his colleagues. In this study, subjects were required to press one of the four numbered buttons by using a correspondingly numbered finger in response to numbered cues provided on a television monitor.

For example, when number 1 appears on the screen, push button 1 with finger 1 . The measure of learning was the decrease in reaction time between the appearance of the cue and the pushing of the button on successive trials.

iii) **The Cerebellum:** The motor regions of the cortex also receive projections through the thalamus from the cerebellum. Kyu Lee and Richard Thompson presented evidence that the cerebellum occupies an important position in the brain circuits taking part in motor learning. They suggested that the cerebellum plays an important role in a form of learning called classical conditioning.

In their model, a puff of air is administered to the eyelid of a rabbit, paired with a stimulus such as a tone. Eventually, the rabbit becomes “conditioned” to blink in expectation of the air puff whenever the tone is sounded. Lesions to pathways from the cerebellum abolish this conditioned response but do stop the rabbit from blinking in response to an actual air puff, the unconditioned response.

3.3.4 Neural Substrates of Explicit Memory

Evidence is growing that neural system, each consisting of a number of structures, support different kinds of memory. On the basis of animal and human studies, Herbert Petri and Mortimer Mishkin propose a largely temporal frontal lobe neural basis for explicit memory. Most are in the temporal lobe or closely related to it, such as the hippocampus, the rhinal cortices in the temporal lobe, and the prefrontal cortex.

Nuclei in the thalamus also are included, in as much as many connections between the prefrontal cortex and the temporal cortex are made through the thalamus. The regions that make up the explicit memory circuit receive input from the neocortex and from the ascending systems in the brainstem, including the acetylcholine, serotonin, and noradrenalin systems. Explicit memory function and contribution of different brain regions are described in the following section:

3.3.5 Neural Substrates of Emotional Memory

In fear conditioning, a noxious stimulus is used to elicit fear, an emotional response. A rat or other animal is placed in a box that has a grid floor through which a mild but noxious electrical current can be passed (This shock is roughly equivalent to the static electrical shock that we get when we rub our feet on a carpet and then touch a metal object or another person).

When the tone is later presented without the sock, the animal will act afraid. It may become motionless and may urinate in expectation of the shock. The presentation of a novel stimulus, such as a light in the same environment has little effect on the animal. Thus, the animal tells us that it has learned the association between the tone and the shock.

Because the conditioned response is emotional, circuits of the amygdala, rather than the cerebellum, mediate fear conditioning. Although both eye blink and fear conditioning are pavlovian and different parts of the brain mediate the learning. Whether emotional memories are implicit or explicit is not altogether clear; in fact, they could be both.

Self Assessment Questions

1) Discuss the neurobiology of Short term memory.

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2) Elucidate the relationship between short term memory, temporal and frontal lobes.

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3) Describe the neurobiology of long term memory.

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4) What are the neural substrates of implicit memory.

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5) Discuss the neural substrates of explicit memory.

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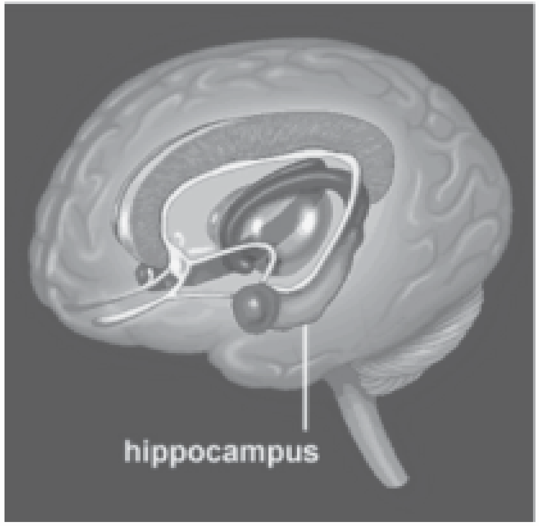
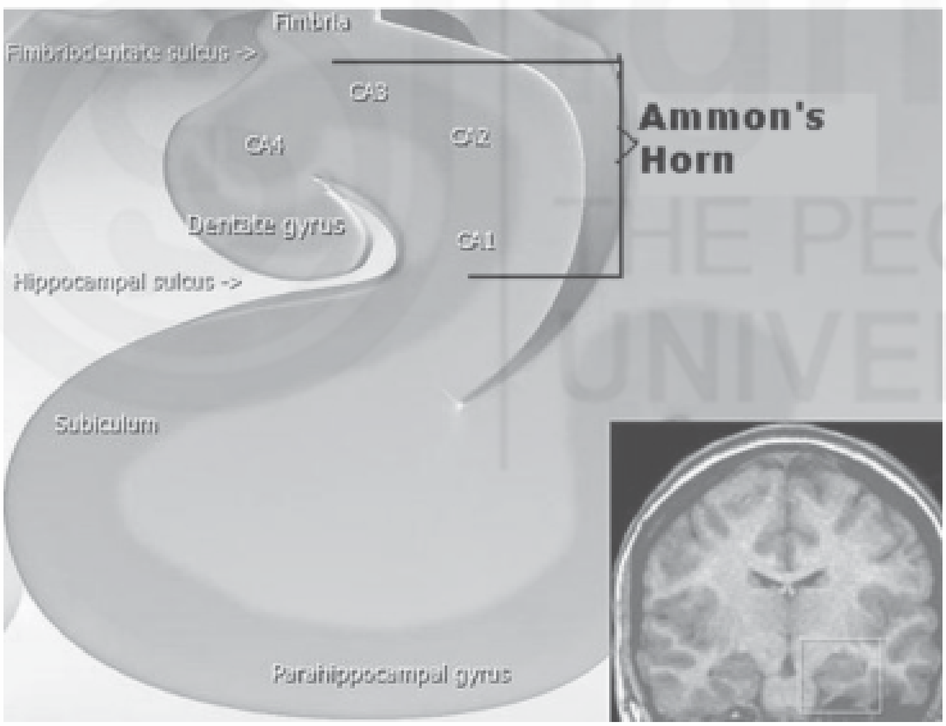
3.4 ANATOMY OF THE HIPPOCAMPUS

Because the hippocampus figures prominently in discussions of memory, we describe its anatomy in some detail, both in reference to its position as a way station between the posterior sensory cortex and the frontal cortex and in reference to its intrinsic complexity. In the 1960s, anatomist H. Chandler Elliott described the hippocampus as "quite archaic and vestigial, possibly concerned with primitive feeding reflexes no longer emergent in man." This structure, small in comparison with the rest of the human forebrain, plays a dominant role in the discussion of memory.



The hippocampus extends in a curve from the lateral neocortex of the medial temporal lobe toward the midline of the brain and has a tube like appearance. It consists of two gyri, *Ammon's horn* and the *Dentate gyrus*. If you imagine cutting a tube length wise and placing one half on top of the other so that their edges overlapped, the upper half would represent Ammon's horn and the lower one the Dentate gyrus. (See the picture below)



The hippocampus is reciprocally concerned with the rest of the brain through two major pathways.

i) The perforant pathway (because it perforates the hippocampus) consents the hippocampus to the posterior neocortex and

ii) The fimbria-fornix (arch-fringe, because it arches along the edge of the hippocampus),

These connect the hippocampus to the thalamus and frontal cortex, the basal ganglia, and the hypothalamus.

Through its connection to these two pathways, the hippocampus can be envisioned as a way station between the posterior neocortex on one end of the journey and the frontal cortex, basal ganglia, and brainstem on the other.

Within the hippocampus, input from the neocortex goes to the dentate gyrus, and the dentate gyrus projects to Ammon's horn. (as is seen in the above picture).

Thus, the granule cells are the "sensory" cells of the hippocampus, and the pyramidal cells are its motor" cells that facilitate this processing and memory function.

3.4.1 The Perirhinal Cortex

When Corkin and her colleagues used MRI to reexamine the temporal lobe removal, they found that the resection removed most of the entorhinal cortex. The rhinal cortex that is the cortex surrounding the rhinal fissure, including the entorhinal cortex and the perirhinal cortex, is often damaged in patients with medial temporal lobe lesions.

These lesions and the damage are relevant for amnesia.

Elisabeth Murray and her colleague have used neurotoxic lesion techniques to selectively damage the cells of either the hippocampus or the rhinal cortex in monkeys and then examined the specific contributions of each structure to amnesia. In Murray's studies, monkeys reach through the bars of their cage to displace objects under which a reward may be located. To find the reward, the animals must make use of their abilities to (1) recognise objects or (2) recognise a given object in a given context.

In these studies of memory for objects and contexts, animals with selective hippocampal removal displayed no impairments on the object recognition test but were impaired when the test included context. In contrast, animals with rhinal cortex lesions displayed severe anterograde and retrograde impairments on the object recognition tests. Thus the conclusion from the results of these studies is that objects recognition (factual, or semantic, knowledge) depends on the rhinal cortex, whereas contextual knowledge (autobiographic, or episodic, knowledge) depends on the hippocampus.

3.4.2 The Temporal Cortex

Because one treatment for epilepsy is the removal of the affected temporal lobe, including both neocortical and limbic systems a large number of patients have undergone such surgery and have subsequently undergone neuropsychological study. The results of these studies suggest significant differences in the memory impairments stemming from damage to the left and right hemispheres.

They also show that the temporal neocortex makes a significant contribution to these functional impairments. After right temporal lobe removal, patients are impaired on face recognition spatial position and maze learning tests. Left temporal lobe lesions are followed by functional impairments in the recall of word lists, the recall of consonant trigrams, and non-spatial associations.

Milner and her colleagues concluded that the lesions of the right temporal lobe result in impaired memory of nonverbal material. Lesions of the left temporal lobe, on the other hand, have little effect on the nonverbal tests but produce deficits on verbal tests such as the recall of previously presented stories and word pairs, as well as the recognition of words or numbers and recurring nonsense syllables.

3.4.3 Parietal and Occipital Cortex

Cortical injuries in the parietal, posterior temporal and possibly, occipital cortices sometimes produces specific long term memory difficulties. Examples include color amnesia, prosopagnosia, object anomia (Inability to recall the names of objects), and topographic amnesia (inability to recall the location of an object in the environment). Many of these deficits appear to develop in the presence of bilateral lesions only.

3.4.4 Frontal Cortex (Hemispheric Encoding and Retrieval Asymmetry)

The frontal cortex also participates in memory. An interesting pattern of hemispheric asymmetry is seen in comparisons between the encoding of memory and its retrieval. The pattern is usually referred to as HERA, for hemispheric encoding and retrieval asymmetry. HERA makes three predictions:

1) The left prefrontal cortex is differentially more engaged in encoding semantic information than in retrieving it.
2) The left prefrontal cortex is differentially more engaged in encoding episodic information than in retrieving it.
3) The right prefrontal cortex is differentially more engaged in episodic memory retrieval than is the left prefrontal cortex.

Self Assessment Questions

1) With the help of a diagram describe the anatomy of the hippocampus.

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2) Describe the perihinal cortex and indicate its functions.

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3) How does memory retrival etc. take place in the temporal cortex?

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4) Discuss the role of parietal and occipital lobes in memory retrieval etc.

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5) How does frontal cortex participate in memory.

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3.5 EMOTION

Emotion, like memory, entails cognitive processes that may either be conscious or lie outside our awareness. We begin this topic by exploring the nature of emotion and how neuroscientists have studied emotion and developed theories over the past century.

3.5.1 Nature of Emotions

To neurophysiologists, impairments of movement, perception, language, or memory affect not only how a person expresses and reacts to emotion but also how others perceive that person's emotions. Indeed, some view emotion as an inconvenient remnant of our evolutionary past, a nonconscious time when humans literally were driven by "instincts" such as emotion.

An emotional experience may include all sorts of thoughts or plans about who said or did what or what will be done in the future. Your heart may pound, your throat tighten; you may sweat, tremble, or flush. Strong emotional feelings (rage or elation) are not always verbalised. Marked changes in facial expression, tone of voice or vole posture-even tears of sadness or joy-are sufficient to convey emotion to others.

Neurophysiologists view emotion not as a thing but rather as an inferred behavioural state called affect, a conscious, subjective feeling about a stimulus independent of where or what it is. Affective behaviour is internal and subjective.

As observers, we can infer emotion in others only from their behaviour (what they say and do) and by measuring physiological changes associated with emotional processes. Emotion includes at least four principal behavioural components:

Physiological Behaviour: Physiological components include central and autonomic nervous system activity and the resulting changes in neuro hormonal and visceral activity. Emotion produces changes in heart rate, blood pressure, the distribution of blood flow, perspiration, and the digestive system, among others, as well as the release of hormones that may affect the brain or the ANS.

Distinctive motor behaviour: Facial expression, tone of voice, and posture express emotional states. These motor behaviours are especially important to observing emotions because they convey overt action that can differ from observed verbal behaviour.

Self-reported cognition: Cognitive processes are inferred from self reported rankings. Cognition operates in the ream of subjective emotional feelings (feeling love or hate, feeling loved or hated) and other cognitive processes (plans, memories, or ideas).

Unconscious behaviour: This component incorporates unconscious inference-cognitive processes that influence behaviour of which we are not aware. We may make decisions on the basis of “intuition” or a hunch or on other apparently unfounded bases.

3.5.2 Anatomy of Emotion

Psychologists began to speculate about emotions at the turn of the twentieth century, but they had little knowledge about the neural; basis of emotional behaviour. By the late 1920s, physiologists began to examine the relation between autonomic, endocrine and neuro-hormonal factors and inferred emotional states, with particular emphasis on measuring indices such as heart rate, blood pressure, and skin temperature.

Philip Bard made one of the first major anatomical discoveries about emotion while working in Walter Cannon’s laboratory in the late 1920s. Working with cats, Bard showed that emotional response depends on the diencephalon, which includes the thalamus and hypothalamus.

He found that, if the diencephalon was intact, animals showed strong “emotional” responses, but if the animals were decerebrate, leaving the diencephalon disconnected from the midbrain, they were unemotional.

The lesion and stimulation studies on the diencephalon were important, because they led to the idea that the thalamus and hypothalamus contain the neural circuits for the overt expression of emotion and for autonomic responses such as changes in blood pressure heart rate, and respiration.

3.5.3 Cortical Connections of Emotion

Two contributions in the 1930s shed light on the nature of the cortical structures and connections implicated in emotion. In both cases, investigators were studying something other than emotion and made serendipitous findings that fundamentally changed our thinking about the emotional brain.

i) **Kluver-Bucy Syndrome:** A major finding came in 1939, when Heinrich Kluver and Paul Bucy announced the rediscovery of an extraordinary behavioural syndrome that had first been noted by Sanger Brown and Edward Schaefer in1888. An obvious aspect of this extraordinary set of behaviours is lack of affect. For example, animals displaying Kluver-Bucy syndrome show no fear whatsoever to threatening stimuli such as snakes or to “threat” signals from humans or other animals, situations in which normal animals show strong aversion.

Wendy Marlowe and colleagues reported on a patient with Kluver-Bucy symptoms that resulted from meningoencephalitis (inflammation of the brain and the meninges).

Behavioural patterns were distinctly abnormal. He exhibited a flat affect, and, although originally restless, ultimately became remarkably placid. He appeared indifferent to people or situations.

He spent much time gazing at the television but never learned to turn it on; when the set was off, he tended to watch reflections of others in the room on the glass screen. On occasion became facetious, smiling inappropriately and mimicking the gestures and actions of others. Once initiating an imitative series, he would perseverate copying all movements made by another for extended period of time.

In addition, he commonly generated a series of idiosyncratic, stereotyped gestures employing primarily his two little fingers which he would raise and tough end- to–end in repetitive fashion. The patient’s sexual behaviour was a particular source of concern while in hospital. Although vigorously heterosexual prior to his illness, he was observed in hospital to make advances toward other male patients by stroking their legs and inviting fellatio by gesture; at times he attempted to kiss them. Although on a sexually mixed floor during a portion of his recovery, he never made advances towards women, and, in fact, his apparent reversal of sexual polarity prompted his fiancée to sever their relationship. (Marlowe et. al., 1975, pp.55-56)

ii) **Psychsurgery:** At about the time of kluver and Bucy’s discovery, a less dramatic, but in many ways more important discovery was made. Carlyle Jacobsen studied the behaviour of chimpanzee in a variety of learning tasks subsequent to frontal lobe removals. In 1935, he reported his findings on the effects of the lesions at the Second International Neurology Congress in London. He casually noted that after the surgery similar lesions in people might relieve various behavioural problems.

Thus was born psychosurgery and the frontal lobotomy. Unbelievably, fontal lobotomies were performed on humans without an empirical basis. Not until the late 1960s was any systematic research done on the effects of frontal lobe lesions on the affective behaviour of nonhuman animals. Experimental findings by several laboratories clearly confirm the results of frontal lobotomies on humans. Frontal lobe lesion in rats, cats and monkeys have severe effects on social and affective behaviour across the board.

3.5.4 Frontal Lesions and Emotion

Spouses or relatives often complain of personality changes in brain damaged patients, but the parameters of these changes have been poorly specified in human subjects. The results of research on animals, particularly nonhuman primates, make possible the identification of six behavioural changes associated with emotional process after frontal lesions.

Reduced social interaction: This was noted especially after orbito-frontal and anterior cingulate lesions, monkeys become socially withdrawn and even fail to re establish close preoperative relations with family members. The animals sit alone; seldom if ever engage in social grooming or contact with other monkeys and in a free ranging natural environment, become solitary leaving the troop together.

Loss of Social dominance: This happened after orbito-frontal lesions, monkeys that were formerly dominant in a group do not maintain their dominance, although the fall from power may take week to complete, depending on the aggressiveness of other monkeys in the group.

Inappropriate social interaction: Monkeys with orbito-frontal lesions fail to exhibit the appropriate gestures of submission to dominant animals and may approach any other animal without hesitation, irrespective of that animals social dominance. This behaviour often results in retaliatory aggression from the dominant, intact animals.

Altered social preference: Although normal animals prefer to sit beside intact monkeys of the opposite sex, monkeys with large frontal lesions prefer to sit with other frontal lesion monkeys of the same sex, presumably because they are less threatening.

Reduced affect: Monkeys with frontal lesions largely abandon facial expressions, posturing, and gesturing in social situations. Thus, monkeys with frontal lesions show a drastic drop in the frequency and variability of facial expression and are described as poker faced.

Reduced Vocalisation: Lesions of the frontal cortex reduce spontaneous social vocalisation. Indeed, after anterior cingulate lesions, rhesus monkeys effectively make no normal vocalisations at all.

In general then, lesions of the monkey orbito-frontal cortex produce marked changes in social behaviour. In particular lesion monkeys become less socially responsive and fail to produce or respond to species typical stimuli.

3.5.5 Brain Circuits for Emotion

In the early 1930s, the limbic lobe including the amygdala and prefrontal cortex were identified as brain regions implicated in emotion. Although the original limbic structures identified by Papez in the late 1930s focused on the hippocampus and its connections with the hypothalamus, modern views of the limbic system include the amygdala and prefrontal cortex. The hippocampus, amygdala, and prefrontal cortex all connect with the hypothalamus. The mammillary nucleus of the hypothalamus connects to the anterior thalamus, with in turn connects to the cingulate cortex. Connections from the cingulate cortex complete the circuit by connecting to the hippocampus, amygdala, and prefrontal cortex. Although the entire circuit is important for emotional behaviour, the amygdala and prefrontal cortex hold the key to understanding the nature of emotional experience.

Like the prefrontal cortex, the amygdala receives inputs from all sensory systems to be excited; the cells of the amygdala, like those of the prefrontal cortex require complex stimuli. Many cells in the amygdala are multimodal, in fact some respond to visual, auditory, somatic, gustatory and olfactory stimuli just as prefrontal cells do.

3.6 NEUROPSYCHOLOGICAL THEORIES OF EMOTION

One theme runs through all modern theories of emotion: emotion and cognition are intimately related and likely entail overlapping neural system. It therefore follows that changes in cognitive abilities will be related to changes in emotion and vice versa. Here, we outline three current theories that represent the major lines of thinking in cognitive neuroscience regarding emotion:

3.6.1 Somatic Marker Hypothesis

The core of Damasio's somatic marker hypothesis which states that when a person is confronted with a stimulus of biological importance, the brain and the body change as a result. This has its origin in William James ideas. In the late nineteenth century James began to argue that an emotion consists of a change in body and brain states in response to the evaluation of a particular event. For example, if you encounter a poisonous snake as you walk along a path your somatic markers including heart rate, respiration and sweating, increase. You interpret these physiological changes as fear.

Whereas James was really talking about intense emotions such as fear or anger. Damasio's theory encompasses a much broader range of bodily changes. For example, there may be a change in motor behaviour, facial expression, autonomic arousal, or endocrine changes as well as neuromodulatory changes in the brain. Hence, for Damasio, emotions engage those neural structures that represent body states and those structures that somehow link the perception of external stimuli to body states. The somatic markers are thus linked to external events and influence cognitive processing.

3.6.2 Cognitive Emotional Interaction

Ledoux's Theory is evolutionary in nature. The general idea is that emotions evolved to enhance the survival of animals and, as the brain evolved, cognitive and emotional processes grew more and more interrelated. In contrast with Damasio, LeDoux has not tried to account for all emotions rather has chosen one emotion namely; fear-as an exemplar of how to study brain behaviour relations in emotion.

In LeDoux's view, all animals inherently detect and respond to danger, and the related neural activities eventually *evolve* to produce a feeling. In this case, it produced fear. When a mouse detects a cat, fear is obviously related to predation, and, in most situations, animals such as mice have fear related either to predation or to danger from other mice who may take exception to their presence in a particular place. For humans, however, fear is a much broader emotion that today is only rarely of predation but routinely includes stress-situations in which we must "defend" ourselves on short notice.

The key brain structure in the development of conditioned fear is the amygdala, which sends outputs to stimulate hormone release and activate the ANS and thus generates emotion, which we interpret in this case as fear. Physiological measures of fear conditioning can rank autonomic functioning (for example, heart rate or respiration), and quantitative measures can rank behaviour (for example, standing motionless) after the tone is heard.

Damage to the amygdala interferes with fear conditioning, regardless of how it is measured. People with damage to the temporal lobe that includes the amygdala are impaired at fear conditioning, yet imaging studies show activation of the amygdala during fear conditioning (LaBar et al., 1998). How does the amygdala "know" that a stimulus is dangerous? LeDoux proposes two possibilities. Both implicate neural networks, one genetically evolved and one shaped by learning.

3.6.3 Cognitive Asymmetry and Emotion

We have seen in both Damasio's and LeDoux's theories that emotion entails cognitive appraisals. Because significant asymmetries exist in a variety of cognitive functions, it follows that related emotional systems also must be lateralised. This idea is not new and can be traced to at least the 1930s, when clinicians reported detailed observations of patients with large unilateral lesions, noting an apparent asymmetry in the effects of left- and right-hemisphere lesions on emotional behaviour.

Kurt Goldstein suggested that left-hemisphere lesions produce "catastrophic" reactions characterised by fearfulness and depression. However, right hemisphere lesions produce "indifference." The results of the first systematic study of these contrasting behavioural effects, by Gainotti in 1969, showed that catastrophic reactions were found in 62% of his left hemisphere sample compared with only 10% of his right hemisphere cases. In contrast, indifference was common in the right hemisphere patients, found in 38% compared with only 11 % of the left hemisphere cases. A key point to remember in regard to Goldstein's and Gainotti's observations is that, if the left hemisphere is damaged extensively, then the behaviour that we observe is in large part a function of what the right hemisphere can do. Thus, if we observe a catastrophic reaction after a left hemisphere injury, one conclusion is that this behaviour is coming from the right hemisphere. This conclusion leads directly to the idea that the right hemisphere normally plays a major role in the production of strong emotions, especially in emotions regarded as negative, such as fear and anger.

3.6.4 Cognitive Control of Emotion

Humans produce an amazing range of emotions, but we also have the cognitive capacity to control them. For example, we may have expectations about how a stimulus might feel (e.g., a syringe injection of penicillin) and our expectations can alter the actual feeling when we experience the event. Nobukatsu Sawamoto and colleagues found that non painful stimuli are perceived as painful when participants expect pain, and this is correlated with activation of the cingulate cortex, a region associated with pain perception.

The use of cognitive processes to change an existing emotional response has also recently been studied using noninvasive imaging. Kevin Ochsner and James Gross reviewed such studies and conclude that when subjects reappraise self-emotions there is concurrent activation of the prefrontal and cingulate cortex.

Self Assessment Questions

1) Define emotion and describe the nature of emotion.

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2) Delineate the anatomy of emotions.

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3) What are the cortical connections of emotions?

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4) Discuss Kluver Bucy syndrome.

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5) What do you understand by psychosurgery? When is it needed?

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6) What happens to emotions when there is frontal lesions?

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7) Describe the brain circuits of emotions.

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8) Elucidate the neuropsychologial theories of emotions.

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9) Discuss the Somatic Parker hypothesis and congnitive emotional interaction.

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10) Describe cognitive control of emotions.

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3.7 CONSCIOUSNESS

Conscious experience is probably the most familiar mental process that we know, yet its workings remain mysterious. Everyone has a vague idea of what is meant by being conscious, but consciousness is easier to identify than to define.

Definitions of consciousness, which we define as the level of responsiveness of the mind to impressions made by the senses, range from the view that it merely refers to complex thought processes to the more slippery implication that it is the subjective experience of awareness or of "inner self." Nonetheless, there is general agreement that, whatever conscious experience is, it is a process. Descartes proposed one of the first modern theories of consciousness. He proposed that being able to remember past events and being able to speak were the primary abilities that enable consciousness.

In fact, consciousness is probably not a single process but a collection of many processes, such as those associated with seeing, talking, thinking, emotion, and so on.

Consciousness is also not always the same. A person at different ages of life is not thought to be equally conscious at each age; young children and demented adults are usually not considered to experience the same type of consciousness as healthy adults do. Indeed, part of the process of maturation is becoming fully conscious and consciousness varies across the span of a day as we pass through various states of sleep and waking.

Most definitions of consciousness exclude the conditions of simply being responsive to sensory stimulation or simply being able to produce movement. Thus, animals whose behaviour is simply reflexive are not conscious. Similarly, the isolated spinal cord, although a repository for many reflexes, is not conscious. Machines that are responsive to sensory events and are capable of complex movements are not conscious. Many of the physiological functions of normal humans, such as the beating of the heart, are not conscious processes. Similarly, many processes of the nervous system, including simple sensory processes and motor actions, are not conscious. Consciousness requires processes that differ from all the aforementioned.

3.7.1 Neurobiology and Neuropsychology of Consciousness

Consciousness allows us to select behaviours that correspond to an understanding of the nuances of sensory inputs. As stated earlier, consciousness must be a function of numerous interacting systems, presumably including sensory areas, memory structures, and perhaps the structures underlying other processes such as emotion and executive functions.

The theory of the neural basis of consciousness explains how all these systems can be integrated. Before examining this idea more closely, we need to examine processes that are believed to be prerequisites of consciousness. Most investigators agree that at least four processes must take part:

- Arousal, the waking up of the brain by nonspecific modulatory systems
- Perception, the detection and binding of sensory features
- Attention, the selection of a restricted sample of all available information
- Working memory, the short-term storage of ongoing events

Andreas Engel and Wolf Singer proposed that all these processes either require or modify the operation of an overall binding process and that binding is implemented by the transient and precise synchronisation of neural discharges in diffuse neural networks. The general idea is that neurons that represent the same object or event fire their action potentials in a temporal synchrony with a precision of milliseconds.

No such synchronisation should take place among cells that are part of different neural networks. Recall that the idea of synchrony was proposed earlier as a mechanism of attention. Taken further, without attention to an input, there is no awareness of it. But what produces the synchrony? Neuronal groups exhibit a wide range of synchronous oscillations (6-80 Hz) and can shift from a desynchronised state to a rhythmic state in milliseconds. Thus, we can predict that, when we become consciously aware of some event, there should be evidence of synchronous activity among widely separated brain regions.

A review of the evidence on synchrony and consciousness concludes that phase synchrony acts not only to bind the sensory attributes but also to bind all dimensions of the cognitive act, including associative memory, emotional tone, and motor planning (Thompson and Varella, 2001). The problem, however, is that all studies to date are correlative. There is no direct evidence that changes in synchrony lead to changes in either behaviour or consciousness. A search for such evidence is the likely direction of studies on consciousness in both laboratory animals and human subjects in the coming decade.

3.7.2 Involvement of Cerebral Regions in Consciousness

Little is known about the essential cerebral regions for consciousness. One way to investigate this matter is to identify which structures in the brain are inactive when we are unconscious and active when we are conscious. Notice that, in all cases, there is inactivation of the dorso-lateral prefrontal cortex, the medial frontal cortex, the posterior parietal cortex and the posterior cingulate cortex. The brain activation in a quiet resting state identifies two distinct neural networks of structures that are either correlated or anti-correlated. Again, there is evidence of a general fronto-parietal network.

A second way to look for cerebral substrates is to look for structures that might synchronise activity. Crick and Koch introduced the novel idea that a little-studied brain region may play central role in the processes that bind diverse sensory attributes. The claustrum, meaning “hidden away,” is a thin sheet of gray matter that, in the human brain, lies below the general region of the insula. Its connectivity is unique in that it receives input from virtually all regions of the cortex and projects back to almost all regions of the cortex.

Virtually nothing is known about the functions of the claustrum in any mammalian species, in large part because it is almost impossible to damage selectively; Crick and Koch proposed that this unique anatomy is compatible with a global role in integrating information to provide the gist of sensory input on a fast time scale. They provocatively state: “This should be further experimentally investigated, in particular if this structure plays a key role in consciousness (Crick and Koch, 2005).

In summary, the emerging field of cognitive social neuroscience is radically changing our understanding of how the brain participates in the complex social behaviour of humans such as different types of memory function, emotional behaviours and consciousness. The literature comprising of lesion studies tended to focus on the perception and production of social behaviour. The new perspective is allowing insights into the very nature of how the brain allows humans to think about themselves and one another.

Self Assessment Questions

1) Define consciousness and delineate the nature of consciousness.

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2) Discuss the neurobiological aspects of consciousness.

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3) Discuss the neuropsychological aspects of Consciousness.

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4) Elucidate the involvement of cerebral regions for consciousness.

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3.8 LET US SUM UP

Memory is generally defined as the processes of encoding, storing and retrieving information. Memory is thought to begin with the encoding or converting of information into a form that can be stored by the brain. However, the term emotion refers to positive or negative feelings that are produced by particular situations. Memory is the process by which we encode, store and retrieve the information. The information is initially recorded in a form usable to memory is known as *encoding*. The maintenance of material saved in the memory system is *storage,* and the material in memory storage is located, brought in to awareness, and used is known as *retrieval*.

The processes of encoding, storing and retrieving the information are necessary for memory to operate successfully. Many psychologists studying memory suggest that there are different systems or stages through which information must travel if it is to be remembered. According to enduring theories, the two major classification of memory are the short term memory and the long term memory.

Long term memories are of three types:

i) implicit memory,

ii) explicit memory and

iii) emotional memory

These are supported by three pathways in the brain.

The first evidence that the temporal lobe might play a role in human memory came to light by the case of H. M. in 1900, when Vladimir Bekhterev autopsied the brain of a patient who had shown severe memory impairment. In 1890, William James drew a distinction between memories that endure for a very brief time and for longer term. Not until 1958, however, there was any separate short term and long term memories. In 1958, this was specifically postulated by Donald Broadbent. According to Broadbent, Short term memory, sometimes also called the *working memory* or *temporal memory* refers to a neural record for recent events and their order. It is the system that we use for holding sensory events, movements, and cognitive information such as digits, words, names or other items for a brief period. Short term memory is mediated by different regions in the cerebral cortex such as temporal lobe, some specific areas of frontal lobe, and motor cortex. Long term memory is subdivided into explicit (declarative) and implicit (procedural) memory.

The different parts of cerebral cortex involved in Implicit and explicit memory include the basal ganglia, the motor cortex and the cerebellum.

Then we discussed the anatomy of the hippocampus. We showed how these are related to memory. Then we showd how the frontal coretex and occipital cortex function in regard to memory and related factors. Then we took up temporal cortex and dealt with it in terms of memory. Then we discussed the neural substrates of emotional memory. The next section was on emotion. We discussed the nature of emotion and anatomy of emotions. Then we pointed out how the frontal lesions affect the emotion. This was followed by brain ciorcuits of emotion. We then discussed the different theories of emotion. We then took up discussion on The consciousness and related the same to the neurobiology and neuropsychology of consciousness. Then we discussed about the involvement of cerebral regions in consciousness.

3.9 UNIT END QUESTIONS

1) Define Memory and discuss the neurobiological and Neuropsychological aspects of Memory.
2) What are the Neurobiology of Short Term and long term Memory?
3) Discuss the neural substrates of Explicit Memory and emotional memory.
4) Define emotion and state its nature.
5) Discuss the anatomy of emotions and present the cortical connections of emotion.
6) Discuss the brain circuits of emotion.
7) Elucidate the Neuropsychological Theories of Emotion and discuss the Neurobiology and Neuropsychology of Consciousness.
8) How are cerebral regions involved in consciousness.

3.10 SUGGESTED READINGS

Levinthal Charles F (2007). *Introduction to Physiological Psychology*. PHI Learning Private Limited, India.

Neil R.Carlson (2007). *Foundation of Physiological Psychology*. Pearson Education, Inc., India.

Robert S. Feldman (2004). *Understanding Psychology*. Tata McGraw Hill Education Private Limited, New Delhi, India-110008.

UNIT 4 NERVOUS SYSTEM DISEASES

Structure

4.0 Introduction
4.1 Objectives
4.2 Nervous System Diseases
4.3 Causal Factors
4.4 Classification
4.5 Vascular Disorders
    4.5.1 Cerebral Ischemia
    4.5.2 Migraine Stroke
    4.5.3 Cerebral Hemorrhage
    4.5.4 Angiomas and Aneurysms
4.6 Traumatic Brain Injuries
    4.6.1 Open-Head Injuries
    4.6.2 Closed-Head Injuries
4.7 Epilepsy
    4.7.1 Focal Seizures
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    4.10.2 Poliomyelitis
    4.10.3 Multiple Sclerosis
    4.10.4 Paraplegia
    4.10.5 Brown-Sequard Syndrome
    4.10.6 Hemiplegia
4.11 Disorders of Sleep
    4.11.1 Narcolepsy
    4.11.2 Insomnia
4.12 Let Us Sum Up
4.13 Unit End Questions
4.14 Suggested Readings

4.0 INTRODUCTION

This unit deals with the various nervous system disorders. We start with defining what is nervous system disorders and then move on to different types of disorders based on certain standard classification. We start with vascular disorders in which we discuss cerebral ischemia, migraine stroke, cerebral hemorrhage, and angiomas and aneurysms. This is followed by another group of nervous system disorders called the Traumatic brain injuries. Then we take up epilepsy and discuss under it the focal seizures, generalised seizures, akinetic and myoclonic seizures and the tumors. In the following section we describe the different types of headaches such as the migraines, and headaches associated with neurological diseases. Then we discuss the diseases caused by infections under which we describe the disorders caused by viral infections, bacterial infections and mycoctic infections. This is followed by a description of the disorders due to motor neurons and the spinal cord. This includes myasthenia gravis, poliomyelitis, paraplegia, hemiplegia and Brown Sequard syndrome. Following this we present sleep disorderssuch as narcolepsy etc.

4.1 OBJECTIVES

After reading this unit, the students will be able to:

- Define the concept and meaning of nervous system diseases;
- Describe nature and associated features of different nervous system diseases;
- Explain the involvement of different parts of nervous system in the manifestation of symptoms; and
- Understand and differentiate the neurobiological and neuropsychological aspects of nervous system diseases.

4.2 NERVOUS SYSTEM DISEASES

The nervous system consists of the brain, the spinal cord, and the network of nerves throughout the rest of the body. It is sometimes called the master system, since it regulates and coordinates every other body system. The nervous system provides a rapid means for the various parts of the body to communicate with each other. It allows us to adjust to the world around us and cope with the challenges of life. It influences how we act or react to specific situation. The nervous system is composed of two major parts; *the central nervous system (CNS)* and *the peripheral nervous system (PNS).* The central nervous system is the brain and spinal cord, where most information is processed. The peripheral system is the network of nerves throughout the rest of the body. The peripheral nervous system allows signals to travel between the central nervous system and the body's sensory receptors and motor effectors. Besides these, a functional division also exists: the *somatic* nervous system and the *autonomic* nervous system where the autonomic nervous system is further divided in *sympathetic* and *parasympathetic* nervous system.

Nervous system diseases are the disorders of the body caused by structuctural, biochemical or electrical abnormalities in the brain or spinal cord, or in the nerves leading to or from them. The symptoms can be manifested in the form of paralysis, muscle weakness, poor coordination, loss of sensation, seizures, confusion, pain and altered levels of consciousness. The identification of symptoms and diagnoses are done on the basis of neurological examination and neuropsychological assessments and studied and treated within the specialties of neurology and clinical neuropsychology. The World Health Organisation estimated that neurological disorders and their sequel affect as many as one billion people worldwide, and identified health inequalities and social stigma/discrimination as major factors contributing to the associated disability and suffering (WHO, 2006).

4.3 CAUSAL FACTORS

Although, the brain and spinal cord are surrounded by tough membranes, enclosed in the bones of the skull and spinal vertebrae, and chemically isolated by the so-called blood-brain barrier, they are very susceptible if compromised. An individual's neurons, the building blocks of the nervous system, and the neural networks into which they form, are susceptible to electrochemical and structural disruption. While neuro-regeneration may occur in the peripheral nervous system, it is thought to be rare in the brain and spinal cord and therefore results in different form of neural diseases. The genetic and congenital abnormalities, infections, malnutrition, brain injury, spinal cord injury and nerve injury are some of the very important contributory factors for the development of nervous system diseases.

4.4 CLASSIFICATION

Neurological disorders can be categorised according to the primary location affected, the primary type of dysfunction involved, or the primary type of cause. The broadest division is between central nervous system (CNS) disorders and peripheral nervous system (PNS) disorders. Here in this section we have discussed various nervous system diseases under the section of Vascular Disorders, Traumatic Brain Injuries, Epilepsy, Tumors, Headaches, Infections, Disorders of Motor Neurons and Disorders of Sleep.

4.5 VASCULAR DISORDERS

Normal central nervous system functioning can be affected by a number of vascular problems, because blood-vessel disease or damage can greatly-even totally-reduce the flow of oxygen and glucose to a brain region. If such interference lasts longer than 10 minutes, all cells in the affected region die. The common term used in the discussion of this cerebral vascular disorder is *stroke,* also known as cerebral vascular accident. Thus, a stroke is the sudden appearance of neurological symptoms as a result of the interruption of blood flow. If the flow through small blood vessels, such as capillaries, is interrupted, the effects are more limited than the often-devastating consequences of damage to large vessels. If a stroke or other cerebral vascular disorder is in one restricted part of a vessel (and other parts of the system are relatively healthy), the prognosis can be rather good, because vessels in the surrounding areas can often supply blood to at least some of the deprived area. On the other hand, if a stroke affects a region supplied largely by weak or diseased vessels, the effects can be much more serious, because there is no possibility of compensation. Of the numerous vascular disorders that affect the central nervous system, the most common are ischemia, migraine stroke, cerebral hemorrhage, angiomas, and arteriovenous aneurysms.

4.5.1 Cerebral Ischemia

Ischemia refers to any of a group of disorders in which the symptoms are caused by vessel blockage preventing a sufficient supply of blood to the brain. In thrombosis, for example, some of the blood in a vessel has coagulated to form a plug or clot that has remained at the place of its formation. This is known as embolism. An embolism can be a blood clot, a bubble of air, a deposit of oil or fat, or a small mass of cells detached from a tumor. Reduction in blood flow can also result from other factors that narrow the vessel. The most common example of such narrowing is a condition marked by thickening and hardening of the arteries, called cerebral arteriosclerosis. When ischemia is temporary, it may be termed cerebral vascular insufficiency or transient ischemia, indicating the variable nature of the disorder with the passage of time. The onset of transient attacks is often abrupt; in many cases, they are experienced as fleeting sensations of giddiness or impaired consciousness.

4.5.2 Migraine Stroke

Since the late 1800s, physicians have recognised that migraine attacks may lead to infarcts and permanent neurological deficits. Such migraine strokes are relatively rare compared with other types, but they are believed to account for a significant proportion of strokes in young people (under 40 years of age), especially women. The immediate cause of these strokes is probably some form of vasospasm-constriction of blood vessels-but the underlying cause of the vasospasm remains a mystery. The classic migraine stroke is experienced with a variety of neurological symptoms, including impaired sensory function (especially vision), numbness of the skin (especially in the arms), difficulties in moving, and aphasia.

4.5.3 Cerebral Hemorrhage

Cerebral hemorrhage is a massive bleeding into the substance of the brain. The most frequent cause is high blood pressure, or *hypertension.* Other causes include congenital defects in cerebral arteries, blood disorders such as leukemia, and toxic chemicals. The onset of cerebral hemorrhage is abrupt, and the bleeding may quickly prove fatal. It usually occurs when a person is awake, presumably because the person is more active and thus has higher blood pressure.

4.5.4 Angiomas and Aneurysms

Angiomas are congenital collections of abnormal vessels that divert the normal flow of blood. These capillaries, venous, or arteriovenous (A-V) malformations are masses of enlarged and tortuous cortical vessels that are supplied by one or more large arteries and are drained by one or more large veins, most often in the field of the middle cerebral artery. However, aneurysms are vascular dilations resulting from localised defects in the elasticity of a vessel. They can be visualised as balloon like expansions of vessels that are usually weak and prone to rupture. Although, aneurysms are usually due to congenital defects, they may also develop from hypertension, arteriosclerosis, embolisms, or infections. A characteristic symptom of an aneurysm is severe headache, which may be present for years, because the aneurysm is exerting pressure on the dura mater, which is richly endowed with pain receptors.

4.6 TRAUMATIC BRAIN INJURIES

Brain injury is a common result of automobile and industrial accidents and of war injuries. Brain injury can affect brain function by causing direct damage to brain by disrupting blood supply; by inducing bleeding, leading to increased intracranial pressures, by causing swelling, by opening the brain to infections and by producing the scarring of brain tissue. There are two main types of brain trauma: open head injury and closed head injury.

4.6.1 Open Head Injuries

Open head injuries are TBIs in which the skull is penetrated, as in gun shot or missile wounds, or in which fragment of bone penetrate the brain substance. Open head injuries tend to produce distinctive symptoms that may undergo rapid and spontaneous recovery. The neurological sign may be highly specific, and many of the effects of the injuries closely resemble those of the surgical excision of small area of cortex.

4.6.2 Close Head Injuries

Closed-head injuries result from a blow to the head, which can subject the brain to a variety of mechanical forces:

- Damage at the site of the blow, a bruise (contusion) called a **coup,** is incurred where the rain has been compacted by the bone's pushing inward, even when the skull is not fractured.

- The pressure that produces the coup may push the brain against the opposite side or end of the skull, producing an additional bruise, known as a **countercoup.**

- The movement of the brain may cause a twisting or shearing of nerve fibers, producing microscopic lesions. In addition, twisting and shearing may damage the major fiber tracts of the brain, especially those crossing the midline, such as the corpus callosum and anterior commissure. As a result, connection between the two sides of the brain may be disrupted, leading to a disconnection syndrome.

- Bruises and strains caused by the impact may produce bleeding (hemorrhage). Because the blood is trapped within the skull, it acts as a growing mass (hematoma), exerting pressure on surrounding structures.

- As with blows to other parts of the body, blows to the brain produce edema, another source of pressure on the brain tissue.

Closed-head injuries are commonly accompanied by coma. According to Muriel Lezak, the duration of unconsciousness can serve as a measure of the severity of damage, because it correlates directly with mortality, intellectual impairment, and deficits in social skills. The longer a coma lasts, the greater the possibility of serious impairment and death.

Often, the chronic effects of closed head injuries are not accompanied by any obvious neurological signs, and the patients may therefore be referred for psychiatric evaluation. Thorough psychological assessments are especially useful in these cases for uncovering seriously handicapping cognitive deficits that have not yet become apparent. Although, the prognosis for significant recovery of cognitive functions is good, there is less optimism about the recovery of social skills or normal personality, areas that often change significantly.

Self Assessment Questions

1) Discuss the Nervous System Diseases and put forward the causative factors.

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2) Classify the nervous system diseases.

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3) Describe cerebral Ischemia.

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4) Give an account of Migraine stroke.

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5) What do you understand by cerebral hemorrhage?

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6) Discuss traumatic brain injuries. What do you understand by open closed head injuries?

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4.7 EPILEPSY

In epilepsy, a person suffers from recurrent seizures of various types that register on an electroencephalogram and are associated with disturbances of consciousness. Epileptic episodes have been called convulsions, seizures, fits, and attacks, but none of these terms on its own is entirely satisfactory, because the character of the episodes can vary greatly.

Epileptic seizures are classified as symptomatic seizures if they can be identified with a specific cause, such as infection, trauma, tumor, vascular malformation, toxic chemicals, very high fever, or other neurological disorders.

They are called idiopathic seizures if they appear to arise spontaneously and in the absence of other diseases of the central nervous system. The most remarkable clinical feature of epileptic disorders is the widely varying length of intervals between attacks , that is from minutes to hours to weeks or even years. In fact, it is almost impossible to describe a basic set of symptoms to be expected in all or even most people with the disorder. At the same time, three particular symptoms are found in many types of epilepsy:

1) **An aura, or warning, of impending seizure:** This aura may take the form of a sensation-an odor or a noise-or it may simply be a “feeling” that the seizure is going to take place.

2) **Loss of consciousness:** Ranging from complete collapse in some people to simply staring off into space in others, loss of consciousness is often accompanied by amnesia in which the victim forgets the seizure itself and the period of lost consciousness.

3) **Movement:** Seizures commonly have a motor component, although the characteristics vary considerably. Some people shake during an attack; others exhibit automatic movements, such as rubbing the hands or chewing.

A diagnosis of epilepsy is usually confirmed by an EEG. In some epileptics, however, seizures are difficult to demonstrate in this way, except under special circumstances (for example, in an EEG recorded during sleep). Several schemes for classifying epilepsy have been published through the years. Four commonly recognised types of seizures are:

i) focal seizures,

ii) generalised seizures, and

iii) akinetic and

iv) myoclonic seizures.

These are being discussed in the following section.

4.7.1 Focal Seizures

A focal seizure begins in one place and then spreads. As for example in a **Jacksonian focal seizure,** the attack begins with jerking movements in one part of the body (for example, a finger, a toe, or the mouth) and then spreads to adjacent parts. John Hughlings-Jackson hypothesized in 1870 that such seizures probably originate from the point (focus) in the neocortex representing the region of the body where the movement is first seen.

However, **Complex partial seizures,** another type of focal seizure, originate most commonly in the temporal lobe. Complex partial seizures are characterised by three common manifestations:

1) subjective experiences that presage the attack such as forced, repetitive thoughts, sudden alterations in mood, feelings of deja vu, or hallucinations;

2) automatisms, which are repetitive stereotyped movements such as lip smacking or chewing or activities such as undoing buttons; and

3) postural changes, such as when the person assumes a catatonic, or frozen, posture.

4.7.2 Generalised Seizures

Generalised seizures are bilaterally symmetrical without focal onset. One subtype, the grand mal attack, is characterised by loss of consciousness and by stereotyped motor activity. This kind of seizure typically comprises three stages:

1) a tonic stage, in which the body stiffens and breathing stops;

2) a clonic stage, in which there is rhythmic shaking; and

3) a postseizure, also called postictal depression, during which the patient is confused. About 50% of these seizures are preceded by an aura.

The other subtype, petit mal attack is a loss of awareness during which there is no motor activity except for blinking, turning the head, or rolling the eyes.

4.7.3 Akinetic and Myoclonic Seizures

Akinetic seizures are ordinarily seen only in children. Usually, an affected child collapses suddenly and without warning. These seizures are often of very short duration, and the child may get up after only a few seconds. The fall can be dangerous, however, and a common recommendation is to have the children wear football helmets until the seizures can be controlled by medication.

Myoclonic seizures are massive seizures that basically consist of a sudden flexion or extension of the body and often begin with a cry.

4.7.4 Tumor

Tumor, or *neoplasm*, is a mass of new tissue that persists and grows independently of its surrounding structures and has no physiological use. Brain tumors grow from glia or other support cells rather than from neurons. Tumors account for a relatively high proportion of neurological disease compared with other causes. After the uterus, the brain is the most common site for them.

Tumors that are not likely to recur after removal are called *benign*, and tumors that are likely to recur after removal, that is often progressing and becoming a threat to life are called *malignant*. The brain is affected by many types of tumors, and no region of the brain is immune to tumor formation.

A tumor may develop as a distinct entity in the brain, a so-called encapsulated tumor, and put pressure on the other parts of the brain. Some encapsulated tumors are also cystic, which means that they produce a fluid filled cavity in the brain, usually lined with the tumor cells.

Because the skull is of fixed size, any increase in its contents compresses the brain, resulting in dysfunctions.

In contrast with encapsulating tumors, so called infiltrating tumors are not clearly marked off from the surrounding tissue. They may either destroy normal cells and occupy their place or surround existing cells (both neurons and glia) and interfere with their normal functioning.

The general symptoms of brain tumors, which result from increased intracranial pressure, include headache, vomiting, swelling of the optic disc (papilledema), slowing of the heart rate (bradycardia), mental dullness, double vision (diplopia), and, finally, convulsions, as well as functional impairments due to damage to the brain where the tumor is located.

4.8 HEADACHES

Headache is so common among the general population that rare indeed is the person who has never suffered one. Headache may constitute a neurological disorder in itself as in migraine; it may be secondary to neurological diseases such as tumor or infection; or it may result from psychological factors, especially stress as in tension headache. There are different kinds of headaches such as migraine and headache associated with neurological disease etc.

4.8.1 Migraine

Perhaps the most common neurological disorder, migraine afflicts some 5% to 20% of the population at some time in their lives. The World Federation of Neurology defines migraine as a "Familial disorder characterised by recurrent attacks of headache widely variable in intensity, frequency and duration. Attacks are commonly unilateral and are usually associated with anorexia, nausea, and vomiting. In some cases they are preceded by or associated with neurological and mood disturbances". There are several types of migraine, including classic migraine, common migraine, cluster headache, and hemiplegic and ophthalmologic migraine.

i) **Classic migraine:** This is probably the most interesting form, occurring in about 12% of migraine sufferers, because it begins with an aura, which usually lasts for 20 to 40 minutes. The aura is thought to occur because constriction of one or more cerebral arteries has produced ischemia of the occipital cortex.

   The results of PET studies have shown that, during the aura, there is a reduction in blood flow in the posterior cortex, and this reduction spreads at the rate of about 2 millimeters per minute, without regard to its location.

The headache is experienced as an intense pain localised in one side of the head, although it often spreads on that side and sometimes extends to the opposite side as well.

A severe headache can be accompanied by nausea and vomiting, and it may last for hours or even days.

ii) **Common migraine:** This is the most frequent type, occurring in more than 80% of migraine sufferers. There is no clear aura as there is in classic migraine, but there may be a gastrointestinal or other "signal" that an attack is pending.

iii) **Cluster headache:** This is a unilateral pain in the head or face that rarely lasts longer than 2 hours but recurs repeatedly for a period of weeks or even months before disappearing. Sometimes long periods pass between one series of cluster headaches and the next.

The remaining two types of migraine,

iv) **Hemiplegic migraine and ophthalmologic migraine:** These are relatively rare and include loss of movement of the limbs and eyes, respectively.

4.8.2 Headache Associated with Neurological Diseases

Headache is a symptom of many nervous system disorders, usually resulting from the distortion of pain sensitive structures. Common disorders producing headache include tumor, head trauma, infection, vascular malformations, and severe hypertension (high blood pressure). The characteristics and locations of these headaches vary according to the underlying cause.

4.8.3 Muscle Contraction Headache

This is one of the most common headaches. It is also known as tension or nervous headaches. They result from sustained contraction of the muscles of the scalp and neck caused by constant stress and tension, especially if poor posture is maintained for any length of time.

Patients describe their pain as steady, nonpulsing, tight, squeezing, or pressing or as the feeling of having the head in a vise.

Some patients complain of a crawling sensation.

The headaches may be accompanied by anxiety, dizziness, and bright spots in front of the eyes.

In some people, caffeine may exacerbate the headaches, presumably because it exacerbates anxiety.

4.8.4 Non Migrainous Vascular Headaches

This headache associated with dilation of the cranial arteries and can be induced by a wide variety of diseases and conditions. The most common causes are fever, anoxia (lack of oxygen), anemia, high altitude, physical effort, hypoglycemia (low blood sugar), foods, and chemical agents.

In addition, this headache may result from congestion and edema of the nasal membranes, often termed vasomotor rhinitis, which is assumed to be a localised vascular reaction to stress.

Self Assessment Questions

1) Discuss the symptoms and nature and course of epilepsy.

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2) What are focl seizures?

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3) Describe generalised seizures.

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4) Differentiate between akinetic and myoclonic seizures.

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5) What are the effects of tumors on the nervous system? Whjat diseases emerge as a result of tumor?

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6) Describe and classify headaches.

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4.9 INFECTIONS

Infection is the invasion of the body by disease-producing (pathogenic) microorganisms and the reaction of the tissues to their presence and to the toxins generated by them. Because the central nervous system can be invaded by a wide variety of infectious agents-including viruses, bacteria, fungi, and metazoan parasites-the diagnosis and treatment of infection are important components of clinical neurology. Infections of the nervous system are particularly serious because the affected neurons and glia usually die, leaving permanent lesions.

4.9.1 Viral Infections

A virus is an encapsulated aggregate of nucleic acid that may be made of either DNA or RNA. Some viruses, such as those causing poliomyelitis and rabies, are called neurotropic viruses, because they have a special affinity for cells of the central nervous system. In contrast, **pantropic** viruses (such as those that cause mumps and herpes simplex) attack other body tissues in addition to the CNS. Most viral infections of the nervous system produce nonspecific lesions affecting widespread regions of the brain, such as lesions due to St. Louis encephalitis, rabies, and poliomyelitis.

4.9.2 Bacterial Infections

Bacterium is a loose generic name for any microorganism (typically one celled) that has no chlorophyll and multiplies by simple division. Bacterial infections of the central nervous system result from an infestation of these organisms, usually through the bloodstream. The most common neurological disorders resulting from bacterial infection are meningitis and brain abscess. In meningitis, the meninges are infected by any of a variety of bacteria. Brain abscesses also are produced by a variety of bacteria, secondary to infection elsewhere in the body.

4.9.3 Mycotic Infections

Invasion of the nervous system by a fungus is known as a mycotic infection. A fungus is any member of a large group of lower plants (in some taxonomic schemes) that lack chlorophyll and subsist on living or dead organic matter; the fungi include yeasts, molds, and mushrooms. Ordinarily, the central nervous system is highly resistant to mycotic infections, but fungi may invade a brain whose resistance has been reduced by diseases such as cancer or tuberculosis.

4.10 DISORDERS OF MOTOR NEURONS AND THE SPINAL CORD

A number of movement disorders are produced by damage either to the spinal cord or to cortical projections to the spinal cord. These disorders include myasthenia gravis, a disorder of the muscle receptors; poliomyelitis, a disorder of the motor-neuron cell bodies; multiple sclerosis, a disorder of myelinated motor fibers; paraplegia and Brown-Sequard syndrome, caused by complete transection or hemitransection of the spinal cord, respectively; and hemiplegia, caused by cortical damage.

4.10.1 Myasthenia Gravis

Myasthenia gravis (severe muscle weakness) is characterised by muscular fatigue in the wake of very little exercise. It may be apparent after a short period of exercise or work, toward the end of a long conversation, or sometimes even after a few repetitions of a movement. Rest brings a feeling of recovery. The rapid onset of weakness after exercise distinguishes myasthenia gravis from other disorders such as depression or general fatigue. There are no visible signs of muscle pathology.

Although myasthenia can affect people of any age, it is most likely to begin in the third decade of life and is more common in women than in men. The muscular weakness is caused by a failure of normal neuromuscular transmission due to a paucity of muscle receptors for acetylcholine. These receptors may have been attacked by antibodies from the patient's own immune system.

4.10.2 Poliomyelitis

Poliomyelitis is an acute infectious disease caused by a virus that has a special affinity for the motor neurons of the spinal cord and sometimes for the motor neurons of the cranial nerves. The loss of these motor neurons causes paralysis and wasting of the muscles. If the motor neurons of the respiratory centers are attacked, death can result from asphyxia. The occurrence of the disease was sporadic and sometimes epidemic until the Salk and Sabin vaccines were developed in the 1950s and 1960s. Since then, poliomyelitis has been well controlled.

4.10.3 Multiple Sclerosis (MS; Sclerosis, from Greek, Meaning "Hardness")

This is a disease characterised by the loss of myelin, largely in motor tracts but also in sensory tracts. The loss of myelin is not uniform, rather, it is lost in patches-small, hard, circumscribed scars, called sclerotic plaques in which the myelin sheath and sometimes the axons are destroyed.

Multiple sclerosis produces strange symptoms that usually appear first in adulthood. The initial symptoms may be loss of sensation in the face, limbs, or body, blurring of vision; or loss of sensation and control in one or more limbs.

Often, these early symptoms go into remission, after which they may not appear again for years. In some forms, however, the disease may progress rapidly in just a few years until an affected person is limited to bed care. The cause of MS is still not known. Proposed causes include bacterial infection, a virus, environmental factors, and an immune response of the central nervous system.

4.10.4 Paraplegia

Paraplegia (from the Greek *para*, "alongside of," and *plegia*, "stroke") is a condition in which both lower limbs are paralyzed (quadriplegia is the paralysis of all four extremities). Paraplegia results when an injury to the spinal cord is below the first thoracic spinal nerve. This results in the loss of feeling and movement, to some degree, of the legs. Paraplegics can experience anything from impairment of leg movement to complete loss of leg movement all the way up to the chest. Paraplegics are able to move their arms and hands. The degree of function that a person with paraplegia will experience depends upon the level of injury, type of injury, and whether the injury was complete or incomplete. The complications of paraplegia include (i) Skin care issues (ii) Loss of bladder control (iii) Loss of bowel control (iv) Loss of sensory function (v) Loss of motor function. Treatment during the acute phase will focus on returning as much function as possible. Long term treatment will focus on learning to compensate with disabilities, and keeping complications at bay.

4.10.5 Brown-Sequard Syndrome

Brown-Sequard syndrome is a rare spinal disorder that results from an injury to one side of the spinal cord in which the spinal cord is damaged but is not severed completely. It is usually caused by an injury to the spine in the region of the neck or back. In many cases, affected individuals have received some type of puncture wound in the neck or in the back that damages the spine and causes symptoms to appear.

Characteristically, the affected person loses the sense of touch, vibrations and/or position in three dimensions below the level of the injury (hemiparalysis or asymmetric paresis). The sensory loss is particularly strong on the same side (ipsilateral) as the injury to the spine. These sensations are accompanied by a loss of the sense of pain and of temperature (hypalgesia) on the side of the body opposite (contralateral) to the side at which the injury was sustained.

Symptoms of Brown-Sequard syndrome usually appear after an affected individual experiences a trauma to the neck or back. First symptoms are usually loss of the sensations of pain and temperature, often below the area of the trauma. There may also be loss of bladder and bowel control. Weakness and degeneration (atrophy) of muscles in the affected area may occur. Paralysis on the same side as that of the wound often occurs. Paralysis may be permanent if diagnosis is delayed.

Individuals with this syndrome have a good chance of recovering a large measure of function. More than 90% of affected individuals recover bladder and bowel control, and the ability to walk. Most affected individuals regain some strength in their legs and most will regain functional walking ability.

This syndrome is often a consequence of a traumatic injury by a knife or gunshot to the spine or neck. In many cases, however, it is caused by, or is the result of, other spinal disorders such as cervical spondylosis, arachnoid cyst or epidural hematomas. BrownSequard syndrome may also accompany bacterial or viral infections. Blunt traumas, such as occur in a fall or automobile accident, on rare occasions may be the cause of the Brown-Sequard syndrome.

There is no specific treatment for individuals with Brown-Sequard syndrome. In most instances, treatment focuses on the underlying cause of the disorder. Treatment may involve drugs that control muscle symptoms, and there is some dispute as to whether high-dose steroid administration is effective.

Devices that help an affected individual continue daily activities such as braces, hand splits, limb supports, or a wheelchair are important. Various other aids may be necessary if the patient has difficulty breathing or swallowing. Other treatment is symptomatic and supportive.

4.10.6 Hemiplegia

The characteristics of hemiplegia (again, *hemi* means "half") are loss of voluntary movements on one side of the body, changes in postural tone, and changes in the status of various reflexes. Hemiplegia results from damage to the neocortex and basal ganglia contralateral to the motor symptoms. In infancy, such damage may result from birth injury, epilepsy, or fever. In young adults, hemiplegia is usually caused by rupture of a congenital aneurysm or by an embolism, a tumor, or a head injury. Most cases of hemiplegia, however, are found in middle-aged to elderly people and are usually due to hemorrhaging as a consequence of high blood pressure and degeneration of the blood vessels.

Self Assessment Questions

1) What are the nervous system diseases caused by infection?

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2) What are the types of infections one comes across?

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3) Discuss mycotic infections.

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4) Discuss the nervous system diseases caused by disorders of motor neurons and the spinal cord.

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5) Give a description of Myasthenia gravis.

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6) What do you understand by Brown sequard syndrome.

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4.11 DISORDERS OF SLEEP

The need for sleep varies considerably from one person to another, as well as in the same person at different stages of life. We have all been told that we need eight hours of sleep each night for good health. In fact, there are both long and short sleepers. Some people can stay healthy on as little as an hour of sleep per day, whereas others may need to sleep as much as 10 to 12 hours. The definition of what constitutes adequate sleep must be decided within the context of a person's sleep history. People who suffer from disorders related to sleep are usually examined in a sleep laboratory for 1 to 2 days. A polygraph (Poly meaning "many") records their brain waves, or EEG; an electromyogram, or EMG, records muscle activity; an electro oculogram, or EOG, records eye movements; and a thermometer measures body temperature during sleep. Together, these recordings provide a comprehensive and reliable description of sleep waking behaviour.

Sleep disorders are generally divided into two major groups:

1) narcolepsy, which is characterised by excessive sleep or brief inappropriate episodes of sleep, often associated with other symptoms; and

2) insomnia, which is characterised by an inadequate amount of sleep, an inability to fall asleep, or frequent inconvenient arousals from sleep. These two are dealt with in detail below.

4.11.1 Narcolepsy

This is an inappropriate attack of sleep, the affected person has an overwhelming impulse to fall asleep or simply collapses into sleep at inconvenient times. Attacks may be infrequent or may occur many times a day. Narcolepsy disorders are surprisingly common. The estimates suggest that as much as 0.02% of the population may suffer from them. Males and females seem equally affected. The narcolepsies include

1) sleep attacks,

2) cataplexy,
3) sleep paralysis, and
4) hypnagogic hallucinations.

Although all these disorders do not generally exist at the same time or in the same person, they are present together often enough to be considered interrelated.

i) **Sleep attacks:** These are brief, often irresistible, episodes of sleep, probably slow wave, NREM, naplike sleep that last about 15 minutes and can occur at any time. Their approach is sometimes recognisable, but they can also occur without warning. Episodes are most apt to occur in times of boredom or after meals, but they can also occur during such activities as sexual intercourse, scuba diving, or baseball games. After a brief sleep attack, the affected person may awaken completely alert and remain attack free for a number of hours.

ii) **Cataplexy:** Catalepsy (Greek, 'cata' meaning "down," and 'plexy' meaning "strike") is a complete loss of muscle tone or a sudden paralysis that results in "buckling" of the knees or complete collapse. The attack may be so sudden that the fall results in injury, particularly because the loss of muscle tone and reflexes prevents an affected person from making any motion that would break the fall. During the attack, the person remains conscious and, if the eyelids stay open or are opened, can recall seeing events that took place during the attack. In contrast with sleep attacks, cataplexic attacks usually occur at times of emotional excitement, such as when a person is laughing or angry.

iii) **Sleep paralysis:** This is an episode of paralysis in the transition between wakefulness and sleep. The period of paralysis is usually brief but can last as long as 20 minutes. Sleep paralysis has been experienced by half of all people, if classroom surveys are a true indication of its frequency. In contrast with cataplexy, the paralysed person can be easily aroused by being touched or called by name and, if experienced with the attacks, can terminate them by grunting or using some other strategy that shakes off the sleep. What appears to happen in sleep paralysis is that the person wakes up but is still in the state of paralysis associated with dream sleep.

iv) **Hypnagogic hallucinations:** Hypnagogic hallucinations (Greek, 'hypnos' meaning "sleep," and 'gogic' meaning "enter into") are episodes of auditory, visual, or tactile hallucination during sleep paralysis as an affected person is falling asleep or waking up. The hallucinations are generally frightening; the person may feel that a monster or something equally terrifying is lurking nearby. A curious feature of the hallucinations is that the person is conscious and often aware of things that are actually happening. These hallucinations may actually be dreams that a person is having while still conscious.

4.11.2 Insomnia

The results from studies of people, who claim that they do not sleep, or wake up frequently from sleep show that their insomnia can have many causes. Nevertheless, systematic recordings of EEGs from poor sleepers before and during sleep show that the sleepers exaggerated the length of time that it took them to get to sleep. But poor sleepers do have decreased dream sleep, move more during sleep, and go through more transitions between sleep stages than normal people do. Moreover, when awakened from slow-wave sleep, they claim that they have not been sleeping. Insomnia may be associated with nightmares and night terrors, sleep apnea (arrested breathing during sleep), restless legs syndrome (RLS, described in the Snapshot below), myoclonus (involuntary muscle contraction), the use of certain kinds of drugs, and certain kinds of brain damage.

i) **Nightmares:** Nightmares are intense, frightening dreams that lead to waking. Less common are *night terrors*, attempts to fight or flee accompanied by panic and screams or similar utterances. Nightmares occur during dream sleep, but night terrors occur during NREM sleep. Night terrors are usually brief (1 or 2 minutes) and are usually forgotten on waking.

ii) **Sleep apnea:** Sleep apnea (from the Greek for "not breathing"), a periodic cessation of respiration in sleep that ranges in length from about 10 seconds to 3 minutes, is of two types.

   i) Obstructive sleep apnea

   ii) Central sleep apnea

The obstructive sleep apnea occurs mainly in the course of dream sleep and seems to be caused by a collapse of the oropharynx during the paralysis of dream sleep. Patients with this problem invariably have a history of loud snoring sounds produced as a consequence of the difficulty of breathing through the constricted air passage. The obstruction can be reduced through surgical intervention.

The Central sleep apnea stems from a central nervous system disorder. It primarily affects males and is characterised by a failure of the diaphragm and accessory muscles to move.

Sleep apnea can be caused or aggravated by obesity, which contributes to narrowing of the air passage. According to Caterina Tonon, oxygen deprivation incurred in sleep apnea can lead to neuronal loss in the brain.

Self Assessment Questions

1) Discuss the various disorders of sleep.

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2) Describe cataplexy.

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3) What is narcolepsy and how does it differ from insomnia.

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4) What are Hypnogogic hallucinations?

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5) What is sleep apnea.

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4.12 LET US SUM UP

The nervous system consists of the brain, the spinal cord, and the network of nerves throughout the rest of the body. The nervous system provides a rapid means for the various parts of the body to communicate with each other. The nervous system is composed of two major parts; *the central nervous system (CNS)* and *the peripheral nervous system (PNS*. Besides these, a functional division also exists: the *somatic* nervous system and the *autonomic* nervous system where the autonomic nervous system is further divided in *sympathetic* and *parasympathetic* nervous system.

Nervous system diseases are the disorders of the body caused by structuctural, biochemical or electrical abnormalities in the brain or spinal cord, or in the nerves leading to or from them. The symptoms can be manifested in the form of paralysis, muscle weakness, poor coordination, loss of sensation, seizures, confusion, pain and altered levels of consciousness. The identification of symptoms and diagnoses are done on the basis of neurological examination and neuropsychological assessments and studied and treated within the specialties of neurology and clinical neuropsychology. An individual's neurons, the building blocks of the nervous system, and the neural networks into which they form, are susceptible to electrochemical and structural disruption. While neuro-regeneration may occur in the peripheral nervous system, it is thought to be rare in the brain and spinal cord and therefore results in different form of neural diseases.

Neurological disorders can be categorised according to the primary location affected, the primary type of dysfunction involved, or the primary type of cause. The broadest division is between central nervous system (CNS) disorders and peripheral nervous system (PNS) disorders. Vascular disorders include Cerebral Ischemia, Migraine stroke, Cerebral Hemorrhage, Angiomas and Aneurysms.

Brain injury is a common result of automobile and industrial accidents and of war injuriesTraumatic Brain Injury include Open head injury, Close head injuries, etc. Then we dealt with epilepsy in which we described the different types of epilepsy and their symptopms. The we took up tumor for discussion followed by headaches. We discussed under headaches migraines, and their types, headaches associated with neurological diseases, Muscle Contraction Headache, Non migrainous vascular headaches. Then we dwealt with infections and the various types of infections that could cause neurological disorders. This was followed by a discussion on disorders of the motor neurons and the spinal cord under which we discussed myasthenia gravis and other related disorders. Then we presented multiple sclerosis, paraplegia, Brown-Sequard syndrome , Hemiplegia, etc. Then we moved on to sleep disorders that included narcolepsy, insomnia, sleep apnea etc.

4.13 UNIT END QUESTIONS

1) Discuss the nervous system diseases and their causes in general.
2) How are the nervous system diseases classified? Give the classification in your own words.
3) What are the vascular disorders under the nervous system diseases? Give a brief description.
4) What are traumatic brain injuries? How are they caused.
5) Describe epilepsy.
6) What are the various types of headaches ounder the nervous system diseases? Give a description of migraine.
7) How do infections cause nervous system diseases?
8) Discuss the disorders of motor neurons and pinal cord.
9) What are the various types of sleep disorders ? Describe.

4.14 SUGGESTED READINGS

WHO (2007). *WHO Neurological Disorders: Public Health Challenges.* WHO Press, 1211 Geneva 27, Switzerland.

Merck Veterinary Manual (2008). *Nervous System*. Merck & Co., Inc. Whitehouse Station, NJ USA.

Jeffrey L. Cummings and Michael S. Mega, (2003). *Neuropsychiatry and Behavioral Neuroscience,* Oxford University Press.

Levinthal Charles F (2007). *Introduction to Physiological Psychology*. PHI Learning Private Limited, India.