
UNIT 4 COGNITIVE FUNCTIONS - NORMAL AND PATHOLOGICAL

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4.0 INTRODUCTION

This is the last unit of the block. Till now you must have understood different facts about abnormality in behaviour. This unit will try to explain you the contribution of cognitive functioning towards human behaviour. Basically, the cognitive function refers to a person's ability to process thoughts like memory, ability to learn new information, comprehension, decision- making, problem-solving, and the ability to read, write and speak. Usually the healthy or normal individuals have a sound brain which is capable enough to acquire new skills in each of these areas, especially in early childhood, and of developing personal and individual thoughts about the world. Factors such as aging and disease may affect cognitive function over time, resulting in issues like memory

loss and trouble thinking of the right words while speaking or writing. Cognitive function is an intellectual process by which one becomes aware of, perceives, or comprehends ideas. It involves all aspects of perception, thinking, reasoning, and remembering.

In order to understand how normal cognitive functions work and how they are restored after damage, neuropsychologists have developed various assessment methods, called methods of neuropsychological assessment. These aim to provide information and understanding about the functioning level of several cognitive areas (e.g. attention, memory, visuo-spatial ability, etc.) and can be interpreted in both quantitative and qualitative terms. In this unit, you will come to know about the various disorders related to improper brain functioning and the different ways of neuropsychological assessment.

4.1 OBJECTIVES

By the end of this unit, you will be able to:

- understand the different processes and functions of cognition;
- understand the process of pathological cognitive functions;
- know the various disorders related to impairment in cognitive functions; and
- understand the importance of neuropsychological assessments.

4.2 GENERAL COGNITIVE FUNCTIONS

Generally the cognitive function is described in terms of the concept of intellectual ability. There are also primary factors at a lower level (e.g. quantitative reasoning, spelling, free recall and simple reaction time) which takes place with the the help of intellectual skills as a function of brain.

Predominantly, there are certain cognitive domains which deals with various functions essential for the normal and healthy well being. Infact these domains are assessed even when neuropsychological tests are administered, because any impairment in brain is related to improper functioning of these cognitive domains. In the following subsections, you will be explained about the various cognitive domains and functions.

4.2.1 Attention

Technically speaking, *attention* is the process of allocating resources to various inputs. For the brain to function effectively there is a need for a selective process that helps the organism to focus on the most important information for further processing. The process of attention involves several processes including sensory selection, response selection, attentional capacity and sustained performance. Attention is often divided into the following components: alertness/arousal, focused attention, selective attention, divided attention and sustained attention (vigilance). The different tests designed to assess impairment in attention (which affects normal functioning of individuals) usually

measures more than one of these processes as motor speed, speed of information processing, verbal ability, etc.

The capacity to sustain attention over a period of time is impaired in patients with brain injury or children with attention-deficit hyperactivity disorder. The impairment affects the performance of the patient on a continuous or repeated activity. Attention deficits may be related to slow processing speed, which can be evaluated by measures of reaction time and information processing speed.

4.2.1.1 Types of Attention

It is important for you to know that attention are of different types as discussed below:

Selective attention

Our environment provides us various information at a single time and our sensory apparatus is constantly exposed to many inputs, yet we seem to automatically focus on one channel of input at the expense of others. This ability to focus on one stimulus in the presence of many stimuli is known as selective attention. For example, if you are hungry you will look for some edible item only from your kitchen irrespective of other items present over there.

Vigilance

This refers to our ability to sustain attention over time on the same stimulus that is, concentration. For example, when we are listening to a lecture, we will try to focus on the talk throughout. Obviously, this is different from selective attention; it requires more conscious effort. Variability in vigilance skill is related to some neurological diseases and psychiatric disorders.

Arousal and alertness

These are terms that have usually been linked to physiological states that may vary in relation to attention. Consider your own circadian pattern of alertness for example. Every 24 hours you experience 6–8 hours of sleep during which time you are relatively unresponsive to external stimuli, although a clap of thunder or a loud firework may nevertheless disturb you. During your waking hours, you are certainly more alert at some times than others. Research has shown that alertness generally improves through the day, reaching a peak in early evening, and then diminishing towards bedtime. Sudden unexpected events can interfere with your level of alertness when you are awake, just as they can when you are asleep.

4.2.2 Executive Functions

These are complex processes which are more related to a kind of supervisory capacity. Executive function is of importance for purposeful, goal-directed behaviour. Studies indicate that, in situations where no previously learned routines are of use, executive functions contribute to the development of new strategies and monitor their effectiveness.

The concept of Executive Function was introduced by Lezak. The concept encompassed components of volition (motivation to act), planning, purposive action, and regulatory execution. Executive function is therefore a complex mental process involving emotional arousal, cognitive processing and planning, and execution dependent on both emotional needs and cognitive processes.

Executive functions are needed for all mental activities requiring control of temporal sequence and multitasking. The sequencing and multitasking nature of executive function involves several areas of brain areas like the different functional circuits of the frontal lobes, each functional system engaging to carry out a specific task demand. The logistic of the executive function could be explained using the model of working memory. Working memory is required to understand or speak a logical sentence and to tackle a complex logical or strategic problem, to do so the brain employs all its different functional capabilities in a complex chain of processing. Frontal cortex plays a vital role because it regulates the processes and interaction of both the emotional function and working memory. This makes it clear that an increase in emotion arousal has an adverse effect on the efficiency of executive function. During overwhelming emotional arousal, processing related to working memory is inhibited, and effectiveness in planning, thinking, and decision making is impeded along with narrowing of ability for attention supervision of information intake and their processing.

For example, “if you are thirsty while working in your room, then you will feel like having water. Your previous experience of drinking water has made it clear to you that water will quench your thirst. Your experience may also reveal that drinking water is available in the adjacent room. The retrieval of the stored information of your earlier experience helps to draw a new action plan, which could ultimately help you to quench your thirst, when executed. The action plan involves strategies to get up from your seat, and walk out of the door and go into the next room. This is possible only if you have the necessary visual information of the location and distance of a door that would let you out of the room and into the next room. Having the related visual information helps you to walk to the door. The movements are regulated by the relevant visual sensory information. The visual information of the location of the door and its distance help to walk in that direction. However, until one has walked through the door, the visual information of the door is only a hypothesis, which has a probability to be wrong. Walking through the door is the reality verification of the sensory information. Once you have a glass of water in front of you on the table, you need to have further visual information of the location of the glass on the table and its distance from you. These pieces of information regulate your extension of the hand towards the glass and its termination before the fingers reach the glass. The next task is to lift the glass from the table. Even before the glass is lifted, you approach it with all the fingers of your right/left hand. How will you do this if you were to lift a piece of paper or a heavy book from the table? In the case of the paper, you will try to lift it with your index finger and the thumb, while you may use both the hands to lift a book or heavier object. Why wouldn't we try to lift the glass with either the hands or only two fingers? It is the anticipation of the weight of the object that helps to assume a motor set even before the actual execution is on its way. Anticipation is based on your experience,

which is readily made available to the frontal cortex so that it could be used to regulate the motor act. The anticipation is verified only when you carry out the act itself. Motor regulation therefore takes place on actual outcome as well as anticipated effects of an intended act.

Dysfunction in executive functions can be manifested as inappropriate social behaviour, difficulties in decision-making, problems in showing good judgment when there is a need to change plans, difficulties in initiation, organizing and following plans, being easily distracted and limitations in the use of various aspects of memory. Further, while executive disturbances often arise following damage to prefrontal regions, they may also occur in the context of dysfunction to other brain regions.

4.2.3 Working Memory

In the above subsection, you were informed that frontal cortex regulates the functioning of *working memory*. Let us understand the process and relevance of working memory in detail. Baddley and Hitch developed the concept of working memory for explaining the principle of use of immediate memory for cognitive processing. They postulated immediate memory as part of larger memory system called the working memory, in which information is transiently stored. The information thus stored is employed for current planning and processing. They considered working memory as a *dual buffer memory system*, one for storing verbal and the other for visual information. A third component was called the central executive, which has a managerial function to manipulate and coordinate the information stored in the buffer areas for planning, problem solving and other organizational activities. The buffer memory could store words, names, numbers and visual images required for online processing of information and execution of planned actions. The most significant aspect of the working memory was considered its transient nature as it was considered to operate only for seconds.

Thus working memory refers to the capacity to store as well as manipulate information in the brain for relatively brief periods of time. In that way, it provides a mental workspace required for day-to-day activities. The main difference between working memory and episodic/semantic type of memory is the direction of time in which the two processes take place, working memory is an online process, while in the other, relevant information stored in the past is brought to the present. Working memory involves holding selected information for a current processing. Current processing may involve several sequential steps based on a certain action plan or consider several aspects of a problem simultaneously, so that the different steps (aspects) are carried out in a forward direction.

An arithmetic problem is given below for solving it mentally. Read out the problem in one stretch, do not read it in parts, and solve the problem mentally.

Add 3 and 4 and subtract the total from the sum of 5 and 6: The answer is 4

Let us see how we managed to arrive at this answer. First, we added 3 and 4 and got the answer as 7. We held on to the 7, and added 5 and 6. The second addition gave us 11 as the answer. In the next step, we subtracted the 7, which we were holding on so far, from 11 and got the final answer of 4.

It shows that we have to carry out three separate arithmetical operations in parts (two additions and one subtraction) and hold on to the answer of each part temporarily till the whole problem was solved. The arithmetic operations additions and subtraction are the functions of the Central Executive. The other function of the Central Executive is to hold on to the action plans as well as answers that are generated as part of the ongoing operation in awareness. It is said to be held in awareness, as the information is considered available on line, and not retrieved from memory.

Impairment in working memory will lead to loss of such awareness and instant use of available information. It may also lead to inability in planning, problem solving and other organizational activities.

4.2.4 Memory

Memory refers to the processes of encoding, storing and retrieving information. Long-term memory refers to permanent storage and it is further divided into explicit (or declarative) and implicit (or procedural) memory. Explicit memory is the conscious recall of stored information and implicit memory refers to more heterogeneous abilities, such as priming, skill learning, procedural memory and habit formation (Strauss, Sherman et al. 2006). Dysfunctioning of memory will lead to inability in encoding and storing of the information received and recall of existing information.

4.2.5 Language

Language is the ability to communicate verbally and through symbols in human societies. It is the way of social interaction. Deficit in speech and language inhibits effective communication. Numerous tests have been developed to assess speech and language functions. There are comprehensive batteries, specific-function tests, tests for receptive and expressive language functions and tests directed at the functional ability to communicate in everyday life situations (Strauss, Sherman et al. 2006).

4.2.6 Visual Perception and Visuo-spatial Ability

The two main goals of higher-level vision have been described as the identification and localization of stimuli ('what and where'). The first refers to difficulties in locating single objects in space (provided normal visual acuity) and the second refers to spatial analysis in more complex tasks. A faulty analysis of relative spatial information can be assessed with the help of measures of assembling and drawing.

4.2.7 Complex Motor Programming

Brain also regulates the ability to regulate ongoing voluntary motor behaviour. Anticipation of outcome in response to a stimulus and the actual outcome of behaviour is the chief aspect of complex motor programming. Anticipation is the perception of the intended act, even before the act is executed. Sensory information facilitates an action plan and the anticipated effect of the action allows altering the plan of action even before and during the course of action. Anticipation regulates the actions at every step. It can be said that anticipation is a process of predicting an outcome; the brain carries out the prediction

based on stored information and online sensory input. Brain is continuously involved in anticipation of effects and regulates the execution of actions. Motor programming explains how actions are composed, and synchronized sequentially for achieving a predefined effect and goal.

Self Assessment Questions 1

State whether the following statements are ‘true’ or ‘false’:

- 1) Memory refers to the processes of encoding, storing and retrieving information
- 2) *Attention* is the process of inhibiting resources to various inputs
- 3) Dysfunction in executive functions can be manifested as inappropriate social behaviour, difficulties in decision-making, problems in showing good judgment
- 4) *Arousal* refers to our ability to sustain attention over time on the same stimulus that is, concentration

4.3 BRAIN DISEASE

Several diseases and injuries affect the brain and its functions. Some of the diseases have been discussed in the following subsections:

4.3.1 Delirium

Delirium is marked by short-term confusion and disorientation and tends to develop with rapid onset and fluctuates in intensity. It usually occurs more frequently in older people. Typically, delirium is characterized by fluctuating course, deficits in attentional ability, disorganization of behaviour, cognitive changes, perceptual deficits, and alterations in sleep- wake cycle. It may also be accompanied by psychotic features such as hallucinations and delusions.

The causal factors (aetiology) of delirium are:

- General medical condition (example- infection)
- Substance induced (example- cocaine, opioids)
- Multiple causes (example- head trauma and kidney disease)
- Delirium not otherwise specified (example- sleep deprivation).

4.3.2 Dementia

Dementia is typically characterized by the loss of previously acquired cognitive functions. It affects memory, thinking, judgment and behaviour. Most types of dementia involve changes in the functioning of the brain that cannot be stopped or turned back. However, with recent advancement in medicines, these can be slowed down. Problems with cognitive functions include those in the areas of language, memory, perception, emotional behaviour or personality, and cognitive skills (calculation, abstract thinking or judgment). Some of the types of Dementia are:

Dementia of Alzheimer's type, which usually occurs in the persons over 65 years of age and is manifested by progressive intellectual disorientation

Vascular dementia caused by vessel thrombosis or hemorrhage

Other medical conditions (HIV, head trauma, Pick's disease, Creutzfeld-Jacob disease, etc.)

Substance, toxin or medication induced

Multiple etiologies

In the early stages of Dementia, individuals have mild forgetfulness that is only slightly noticeable and annoying. Symptoms gradually increase and they become obvious. They may also severely affect the capacity of the person to take care of oneself. For example, memory loss is initially only a mild impairment such as being unable to retain new information. They worsen gradually, and the person affected will be unable to remember basic facts about themselves and their lives.

4.3.3 Amnestic Disorder

Amnestic disorder is marked by memory impairment and forgetfulness. It is a kind of total loss of memory. Subcategories include:

Caused by medical condition (for example – hypoxia, vitamin B1 deficiency)

Substance, toxin or medication induced

4.3.4 Mild Cognitive Impairment

It is a stage between normal forgetfulness due to ageing and the onset of dementia. Symptoms include-difficulty in performing more than one task at a time, difficulty in solving problems or making decisions, forgetting recent events or conversations, and taking a longer time to perform more difficult mental activities.

4.3.5 Stroke

Stroke is a condition which occurs when the blood supply in brain is interrupted or reduced. It may occur in the condition of blockage in artery or bursting of blood vessels. Impairments after stroke vary, depending on the site and extent of the lesion in the brain. Fundamental cognitive functions such as attention, motivation, affect and emotion could be impaired, as also abilities vital for information retrieval, speed and ability of processing, e.g. perception (visuospatial difficulties such as visuospatial neglect), memory and executive functions. Language and communication abilities are often also impaired – after left hemisphere lesions as different kinds of aphasias and after right hemisphere lesions as pragmatic language disturbances.

4.3.6 Traumatic Brain Injury

TBI can occur when there is exposure to trauma resulting in damage to the brain. TBI patients show a variety of cognitive dysfunctions and also behavioural, emotional and social problems. Their problems may be long-lasting. Prominent problems with patients with traumatic brain injuries are related to cognitive and emotional issues that increase with passage of time. Cognitive performance on attention, memory, language and reaction time can be severely impaired.

4.4 NEUROPSYCHOLOGY AND NEUROPSYCHOLOGICAL ASSESSMENT METHODS

Neuropsychology is the study of the relationship between human brain functions and human behaviour. The behavioural expression of brain dysfunction is studied with the help of clinical neuropsychology. It is an applied science and involves assessment of brain functions. The goal of clinical neuropsychology is to:

- Diagnose the presence of brain damage and dysfunction as well as the preserved cognitive and executive functions, emotion and motivation.
- Facilitate patient care and rehabilitation. It is also useful as it serves as a baseline for cognitive training.

4.4.1 Purposes of Neuropsychological Examinations

As mentioned earlier to you that clinical neuropsychology is the study of brain functions and its impact on human behaviour. With the advancement of technologies, the diseases/ disorders of brains can now be studied as well as assessed with the help of neuropsychological examinations. Some of the relevant purposes of neuropsychological examinations are:

- It helps in diagnosing and patient care in terms of treatment management and planning;
- It helps in identification of patient needs; e.g. when designing individualised treatment programmes;
- It helps in evaluation of treatment efficacy; and
- It also helps in research and exploration of brain dysfunctions.

A typical neuropsychological evaluation will involve assessment of the following:

- General intellect
- Higher level executive skills (e.g., sequencing, reasoning, problem solving)
- Attention and concentration
- Learning and memory
- Language
- Visual–spatial skills (e.g., perception)
- Motor and sensory skills
- Mood and personality

Neuropsychological assessment can help with the answers to diagnostic questions. For example, it can be used to discriminate between psychiatric and neurological patients, when distinguishing between different neurological disorders and when localizing the site or brain hemisphere side of a lesion.

A neuropsychological assessment can also be used as a predictive instrument and it can also identify mild disturbances in cases when other diagnostic tools

have produced ambiguous results. It also aids in the assessment of recovery of function after brain injury and thus in rehabilitation planning and in determining the effectiveness of medical treatment. The results of neuropsychological assessment not only helps the patients, it also assists the responsible family members to understand the requirements in home environment which can encourage the patients to involve in activities and participation so that realistic life goals and rehabilitation programmes can be planned.

An emphasis on greater consideration of the functional implications of neuropsychological test results has emerged. Referrals to neuropsychological assessments are now being made in order to establish the abilities of patients to perform activities of independent living or return to a previous occupation.

The two commonly used comprehensive neuropsychological assessments batteries are:

- 1) The Halstead–Reitan and
- 2) The Luria–Nebraska
- 3) NIMHANS Battery in India.

Self Assessment Questions 2

Answer the following questions:

- 1) What is neuropsychology?
.....
- 2) What is a stroke?
.....
- 3) What is mild cognitive impairment?
.....
- 4) What are the aetiology of delirium?
.....

4.5 LET US SUM UP

It can be summed up from the above discussions that impairment in the brain functions can lead to change in normal behaviour of humans. Understanding cognitive processes in explaining behaviour is important aspect of mental health. It can be seen that cognitive processes can affect both normal and abnormal behaviour. Assessment of these functions and relating it to behavioural aspects helps in diagnosis and treatment of abnormal behaviour. Neuropsychology has contributed significantly towards the assessment of brain disorders and their treatment.

4.6 UNIT END QUESTIONS

- 1) What are the various cognitive functions?
- 2) What are the types of memory?

- 3) Describe how memory is affected in Dementia.
- 4) Explain how executive functions are important?

4.7 ANSWERS TO SELF ASSESSMENT QUESTIONS

Self Assessment Questions 1

- 1) True
- 2) False
- 3) True
- 4) False

Self Assessment Questions 2

- 1) Neuropsychology is the study of the relationship between human brain functions and human behaviour.
- 2) Stroke is a condition which occurs when the blood supply in brain is interrupted or reduced. It may occur in the condition of blockage in artery or bursting of blood vessels.
- 3) It is a stage between normal forgetfulness due to ageing and the onset of dementia.
- 4.) The causal factors (aetiology) of delirium are:

General medical condition (example- infection); Substance induced (example- cocaine, opioids); Multiple causes (example- head trauma and kidney disease) and Delirium not otherwise specified (example- sleep deprivation).

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