UNIT 1 ARTIFICIAL INTELLIGENCE (AI): KEY NOTIONS

Contents

1.0 OBJECTIVES

The objective of this unit is to introduce the key notion of artificial intelligence. . In the first section, we will focus on the various definitions of artificial intelligence, and organize it into the four categories which are, systems that think like humans, systems that act like humans, systems that think rationally and systems that act rationally. In the second and third sections, we will explore the field of AI, and the issue of what computers can do, respectively.

1.1 INTRODUCTION

The object of research in artificial intelligence (AI) is to discover how to program a computer to perform the remarkable functions that make up human intelligence. This work leads not only to increasing use of computers, but also to an enhanced understanding of human cognitive processes which constitute what we mean by 'intelligence', and the mechanisms that are required to produce it. What is needed is a deeper understanding of human intelligence and the human mind. The basic tenet of this thesis is that the brain is just a digital computer and that the mind is a software program. In the last section, we will focus on the relation between AI and the functional theory of mind.

1.2 WHAT IS ARTIFICIAL INTELLIGENCE?

It is difficult to give a precise definition of artificial intelligence. Some recent artificial intelligence scientists have attempted to define artificial intelligence (in short AI) in various ways. According to Haugeland, artificial intelligence is, "the exciting new effort to make computers think … machines with minds, in the full and literal sense (1985)" For Bellman, it is "the automation of activities that we associates with human thinking, activities such as decision making, problem solving, learning…(1978)." Charniak and McDermett define AI as "the study of mental faculties through the use of computational model(1985)." And for Winston, it is "the study of the computations that make it possible to perceive, reason and act (1984)" AI, for Kurzweil is "the art of creating machines that perform functions that require intelligence when performed by people (1990)." Rich and Knight say that AI is "The study of how to make computers thinks at which, at the movement, people are better (1984)" For Schalkoff, AI is "a field of study that seeks to explain and emulate intelligent behavior in terms of computational process (1990)" Luger and Stubblefield hold it to be "the branch of computer science that is concerned with the automation of intelligent behavior (1993)"

Let us look at all the definitions from different angles. Haugeland and Bellman point out that artificial intelligence is concerned with thought process and reasoning. They have explained the mind as a machine that is completely associated with human thinking. That is to say, computers do think. But Schalkoff, Luger and Stubblefield are concerned with the behavioural aspects of systems. For them, computers behave as intelligently as human beings. Moreover, Kurzweil, Rich and Knight are concerned with or measure success in terms of human performance. For them, artificial intelligence can be attributed to machines, but it belongs basically to the human mind. At last, Charniak, McDermett and Winston are concerned with an ideal intelligence. They explain the mental faculties through the use of computational models.

To sum up, all the definitions of AI can be organized into four categories. They are as follows:

(i) Systems that think like humans.
(ii) Systems that act like humans.
(iii) Systems that think rationally.
(iv) Systems that act rationally.

Now, we have to look at each aspect in detail.

(i) Acting Humanly: Turing Machine Approach

The Turing test, as named after Alan Turing, was designed to provide a satisfactory operational definition of intelligence. Turing defined that intelligent behavior as the ability to achieve human-level performance in all cognitive tasks to fool an interrogator.[10] In his 'C*omputing Machinery and Intelligence*', Turing says the new form of the problem can be described in terms of a game which we call the '*imitation game*.' It is played by a man (A), a woman (B), and an interrogator (C) who may be of either sex. The interrogator stays in a room apart from the other two. The object of the game for the interrogator is to determine which of the other two is the man and which is the woman. He or She knows them by labels X and Y, and at the end of the game, he or she says, either 'X is A and Y is B' or 'X is B and Y is A.' The interrogator is allowed to put questions to A and B. Thus, C: will X please tell me the length of his or her hair?

Now suppose X is actually A, then A must answer to the question. It is A's object in the game to try to cause C to make the wrong identification. His or her answer might therefore, be 'my hair is singled, and the longest strands are about nine inches long.'

However, because the tones of voice may not help the interrogator, the answer should be written or better still be typewritten. The ideal arrangement is to have a tele-printer for perfect communication. Alternatively, an intermediary can repeat the questions and answers. The object of the game for the second player (B) is to help the interrogator. The best strategy for her is probably to give truthful answers. She can add to her answer such things as 'I am the woman, do not listen to him,' but it is of no avail as the man can make similar remark.

Now, we can ask the question, what will happen when a machine takes the part of A in this game? Will the interrogator decide wrongly as often when the game is played like this as he does when the game is played between man and a woman?

Turing's answers to these questions are more or less summed up in the following passage; "I believe that in about fifty years time it will be possible to program computers, with a storage capacity of about 10^9, to make them play the imitation game so well that an average interrogator will not have more than 70 percent chance of making the right identification after five minutes of questioning (1950)"

What Turing had predicted at that time, now is a fact that the machine or the computer can imitate human behaviuor. It should be pointed out that Turing's beliefs about the capabilities and capacities of machines are not limited to such activities as playing the imitation game as successfully as human beings. Roughly speaking, the test Turing proposed is that the computer should be interrogated in the place of human beings.

Turing's test deliberately avoided direct physical interaction between the interrogator and the computer, because physical limitation of a person is unnecessary for intelligence. However, the so-called Turing test includes a-video signal so that the interrogator can test the subject's perceptual abilities. In order to pass through total Turing test, the computer will need computer vision to perceive objects and robotics to move them. Again, the issue of acting like a human comes up primarily when artificial intelligence programs have to interact with people, as when expert system explains how it came to its diagnosis, or a natural language processing system has a dialogue with a user. These programs must behave according to certain normal covertness of human interaction in order to make them understood. The Turing test shows that machines can interact with human beings the way human beings interact amongst themselves. That is to say that machine can behave the way the human beings do.

(ii) Thinking Humanly: The Cognitive Modeling Approach

The interdisciplinary field of cognitive science brings together computer models from Artificial Intelligence and experimental techniques from cognitive psychology to try to construct precise and testable theories of the workings of the human mind. And if we are going to say that a given program thinks like a human being, we must have some way of determining how human beings think. For that, we need to get inside the actual workings of the human mind. Stuart Russell and Peter Norvig say that there are two ways to do this: through introspection–trying to catch our own thoughts as they go by –or through psychological experiments. Once we have a sufficiently precise theory of the mind, it becomes possible to express the theory as a computer program. If the program's input/output and timing behavior matches human behaviour, that is evidence that some of the program's mechanisms may also be operating in humans.

Now it is almost taken for granted by many psychologists that a cognitive theory should be like a computer program. But we know that cognitive science is the science of mind. Therefore cognitive scientists seek to understand perceiving, thinking, remembering, understanding language, learning and other mental phenomenon. Their research is remarkably diverse, ranging from observing children’s mental operation, through programming computers to do complex problem solving, to analyze the nature of meaning. In order to appreciate the work in artificial intelligence, which is a necessary part of cognitive science, it is necessary to have some familiarity with theories of human intelligence. The cognitive scientists introduce the notion of machine intelligence and emphasize the relationship between human and machine intelligence. The aim of artificial intelligence is to develop and test computer programs that exhibit characteristic of human intelligence. The most fundamental contribution of symbolic computational modeling has been the physical symbol system hypothesis. According to Newell and Simon, a physical symbol system has the necessary and sufficient means for general intelligent action. By ‘necessary’ we mean that any system that exhibits general intelligence will prove upon analysis to be a physical symbol system. By ‘sufficient’ we mean that any physical symbol system of sufficient size can be organized further to exhibit general intelligence. Lastly, by ‘general intelligent action’ we wish to indicate the same scope of intelligence as we see in human action; that in any real situation behaviour appropriate to the events of the system and adaptive to the demands of the environment can occur within some limits.

However, the ability of computer simulations to model such process is interpreted as a proof of the broader claim that a symbol system is at the center of human intelligence. In this hypothesis it shows that intelligence is an essential aspect of machines. If the machines have the capacity of intelligence, intelligence is the essence of human cognitions. Therefore, machines have cognitive capacity like the human beings. In the cognitive modeling approach, thus, human beings and machines show the property of being intelligent.

(iii) Thinking Rationally: The Laws of Thought Approach

“Right thinking” is the inferential character of every reasoning process. Aristotle in his famous syllogisms provided patterns of argument structures that always give correct conclusions from given correct premises. In the syllogisms, the Laws of Thought play a vital role because these give law the right explanation of a syllogistic inference. There are three Laws of Thought recognized by the logicians. These have traditionally been called the law of Identity, the law of Contradiction, and the law of Excluded–Middle. These Laws of Thought are appropriate to different contexts. The formulations appropriate as follows:

a) The law of Identity asserts that *if any statement is true, then it is true.* This law asserts that every statement of the form $P \supset P$ is true, and that every such statement is a tautology.
b) The law of Contradiction asserts that *no statement can be both true and false*. This law asserts that every statement of the form $P \cdot \sim P$ is false, that is, every such statement is self-contradictory, and its negation is logically true.
c) The law of Excluded-Middle asserts that *any statement is either true or false*. This law asserts that every statement of the form $P \vee \sim P$ is true, that is, every such statement is a tautology.

In the ‘Laws of Thought’ approach to artificial intelligence, the whole emphasis is on correct syllogistic inferences. For example-

"Socrates is a man;
All men are mortal;
Therefore, Socrates is mortal."

In this inference, the conclusion is based on the premises according to the rules of inference. The above syllogistic inference is the best example to formulate an AI program. In all reasoning of this type the emphasis is on the logical inference of a conclusion from the premises. In the AI programme this type of logical inference is of much use since this programme provides a variety of logical reasoning. In an inference, a set of variables, a set of constant terms, a set of functions, the set of connectives *if, and, or,* and, *not,* the quantifiers '*exists'* and '*for all'* are the most important symbols to build an AI program. All these constants and variables are the arbitrary representations of the world. With the help of these symbols, the so-called logistic tradition within artificial intelligence hopes to build on such programs to create intelligent systems.[17]

(iv) Acting Rationally: The Rational Agent Approach

Here, the word 'agent' refers to mechanical agent (computer). Acting rationally means acting so as to achieve one's goal, given one's beliefs. An agent (mechanical) is something that perceives and acts. Stuart Russell and Peter Norvig point out that making correct inferences is a part of being a rational agent because one way to act rationally is to reason logically to the conclusion that a given action will achieve one's goals, and then to act on that conclusion.

According to them, the study of artificial intelligence as rational agent design therefore has two advantages. First, it is more general than the 'laws of thought' approach, because correct inference is only a useful mechanism for achieving rationality, and not a necessary one. Second, it is more amenable to the scientific development than approaches based on human behavior or human thought, because the standard of rationality is clearly defined and completely general. As we have seen, an agent is something that perceives and acts in an environment. The job of artificial intelligence is to design the agent program, that is a function that implements the agent mapping from percepts to action. We assume this program will run on some sort of computing device A human agent has eyes, ears, and other organs for sensors, and hands, legs, mouth and other body parts for effectors. The relationship among agents, architectures, and programs can be summed up as:

Agent = Architecture + Program.

The agent is autonomous to the extent that its behaviour is determined by its own experience. A truly autonomous intelligent agent should be able to operate successfully in a wide variety of environments, given sufficient time and scope. But before we design an agent, we must have a pretty good idea of the possible percepts and actions, the agent's goal is supposed to achieve, and what sort of environment it will operate in it.

Again, as we have mentioned, an agent is just something that perceives and acts. In this approach, artificial intelligence is viewed as the study and construction of a rational agent. One of the important factors is that correct inference is not the whole of rationality. There are also ways of acting rationally that cannot reasonably be said to involve inference. For example, pulling one's hand off a hot stone is a reflex action that is more successful than a slower action taken after careful deliberation.

1.3 THE FIELD OF ARTIFICIAL INTELLIGENCE

Artificial intelligence is a new research area of growing interdisciplinary interest and practical importance. People with widely varying backgrounds and professional knowledge are contributing new ideas and introducing new tools into this discipline. Cognitive minded psychologists have developed new models of the mind based on the fundamental concepts of artificial intelligence, symbols systems and information processing. Linguists are also interested in these basic notions while developing different models in computational linguistics. And philosophers, in considering the progress, problems and potential of this work towards non-human intelligence, have sometimes found solution to the age-old problems of the nature of mind and knowledge. However, we know that artificial intelligence is a part of computer science in which are designed intelligent systems that exhibit the characteristics we associate with intelligence in human behaviour, understanding language learning, reasoning, problem solving, and so on. It is believed that insights into the nature of the mind can be gained by studying the operation of such systems. Artificial intelligence researchers have invented dozens of programming techniques that support some sort of intelligent behaviour.

Now the question is: Is artificial intelligence a science or an Art? According to Tanimoto, the activity of developing intelligent computer systems employs both proved mathematical principles, empirical results of studying previous system, and heuristic, pragmatic programming techniques. Information stored in rational data structures can be manipulated by well–studied techniques of computer science such as tree searching algorithms. At the same, experimental or vaguely understood 'rules of thumb' for problem solving are often crucial to the success of a system and must be carefully accommodated in intelligent systems. Thus artificial intelligence is both an art and a science. It is a science because it develops intelligent computer systems by employing proved mathematical principles. It is an art because it designs systems by employing programming techniques. Information stored in relational data structure can be manipulated by well-studied techniques of computer science such as tree searching diagram. Thus, the field of artificial intelligence is fascinating because of this complementing of art and science.

Artificial intelligence research may have impact on science and technology in the following way:

- **(i)** It can solve some difficult problems in chemistry, biology, geology, engineering and medicine.
- **(ii)** It can manipulate robotic devices to perform some useful, repetitive, sensory-motor tasks;

Besides, artificial intelligence researchers investigate different kinds of computation and different ways of describing computation in an effort not just to create intelligent artefacts, but also to understand what intelligence is. According to Charniak and McDermott, their basic tenet is to create computers which think. Thus AI expands the field of intelligent activity of human beings in various ways. Now the question is: What would the world be like if we had intelligent machines? What would the existence of such machines say about the nature of human beings and their relation to the world around them? These questions have raised profound philosophical issues which will be discussed in due course.

The hypothesis of artificial intelligence and its corollaries are empirical in nature whose truth or falsity is to be determined by experiment and empirical test. The method of testing the results of artificial intelligence is of the following types:

- **(i)** In the narrow sense, artificial intelligence is part of computer science, aimed at exploring the range of tasks over which computers can be programmed to behave intelligently. Thus it is the study of the ways computers can be made to perform cognitive tasks, which generally human beings undertake.
- **(ii)** In the wider sense, artificial intelligence is aimed at programs that simulate the actual processes that human beings undergo in their intelligent behaviour. And these simulation programs are intended as theories describing and explaining human performance. But they are tested by comparing the computer output with the human behavior to determine whether both the result and also the actual behavior of computers and persons are closely similar.

A digital computer is an example of a physical symbol system, a system that is capable of inputting, outputting, storing, etc., following different courses of operation. These systems are capable of producing intelligence depending on the level of mechanical sophistication they are. The computers with these capabilities behave intelligently like human beings, according to the AI researchers.

One of the important tenets of cognitive science is that it stresses the relationship between human and machine intelligence. It is interested in using artificial intelligence techniques to enlighten us about how human beings do intelligent tasks.[24] For example, in getting a machine to solve geometric or integral calculus problems, we are also interested in learning more about the power and flexibility of the human capacity for problem solving. Thus, the AI researcher attempts to develop and test computer programs that exhibit characteristics of human intelligence. The AI researcher always works with an artifact, which is only inferentially related to the human mind. As Boden says, The 'machines' in question are typically digital computers, but artificial intelligence is not the study of computers. But it is the study of intelligence in thought and action. Moreover, as Bonnet would say, artificial intelligence is the discipline that aims to understand the nature of human intelligence through the construction of computer programs that imitate intelligent behaviour.

Further, Bonnet says, we cannot define human intelligence in general we can highlight a number of criteria by which it can be judged, such as the ability to make abstractions or generalizations, to draw analogies between different situations and to adopt new ones, to detect and correct mistakes in order to improve future performance, and so on. AI is concerned with the intelligent properties of the computational systems, which perform many intelligent tasks. These tasks can be of very varied nature, such as, the understanding of a spoken or written text in a natural language, playing chess, solving a puzzle, writing a poem, making a medical diagnosis, finding one's way from Hyderabad to Delhi. The AI programme selects such activities include information and reasoning processes which are part of any intelligent system.

Artificial intelligence includes commonsensical tasks, such as understanding English language, recognizing scenes, finding a way to reach an object that is far overhead, heavy and frigid, and making sense of the plot of a mystery novel. In addition, artificial intelligence includes expert tasks, such as diagnosing diseases, designing computer systems, locating mineral deposits, and planning scientific experiments. The techniques that artificial intelligence applies to solve these problems are representation and inference methods for handling the relevant knowledge, and search based problem-solving methods for exploiting that knowledge. Although the tasks with which artificial intelligence is concerned may seem to form a very heterogeneous set, in fact, they are related through their common reliance on techniques for manipulation of knowledge and conducting search which we will discuss in the next section.

1.4 WHAT COMOUTERS CAN DO

Within the scientific discipline of artificial intelligence, there are several distinct areas of research, each with its own specific interests, research techniques, and terminology. However, as Avron Barr and Edward A. Feigenbaum point out, artificial intelligence is part of computer science concerned with designing intelligent computer systems, that is, systems that exhibit the characteristics we associate with intelligence in human behavior such as understanding language, learning, reasoning, solving problems and so on.

In artificial intelligence, this specialization includes research on language understanding, automatic programming, and several others. The following discussion of the status of artificial intelligence attempts to show the sub–fields identifying some aspects of intelligent behaviours and indicating the state of relevant research. Like the different sub–fields of artificial intelligence, the different behaviours discussed here are not at all independent; separating them out is just a convenient way of indicating what current artificial intelligence programs can do.

(i) The Problem Solving

The first big successes in artificial intelligence were programs that could solve puzzles and play games like chess. Techniques like looking ahead several moves and dividing difficult problems into easier sub-problems evolved in the fundamental artificial intelligence techniques of search and problem reduction. Another problem solving program that integrates mathematical formulas symbolically has attained very high level of performance and is being used by scientists and engineers. According to Avron Barr and Edward A. Feigenbaum, human beings often solve a problem by finding a way of thinking about it that makes the solution easy, but so far, artificial intelligence programs must be told how to think about the problems they solve.

Elaine Rich defines problem solving, as that which chooses the best technique(s) and applies it (them) to the particular problem. Another view is that a goal and a set of means of achieving the goal are called a problem solving. Before an agent can start searching for solutions, it must formulate a goal and then use the goal to formulate a problem. According to Stuart Russell and Peter Norvig, a problem consists of four parts. The initial state, a set of operators, a goal test function, and a path cost function. The environment of the problem is represented by a state space. A path through the state space from the initial state to a goal state is a solution. And a search can be judged on the basis of completeness, optimality, time complexity, and space complexity. There are different search paths for an intelligent agent. The agent has to search which is the minimum path to reach the goal. To solve a problem is the main task of the agent in artificial intelligence.

Moreover, one of the important searches in artificial intelligence is the technique of 'heuristic' search. The word 'heuristic' is derived form the Greek verb '*heuriskein*', meaning 'to find' or 'to discover'. Some people use heuristic as the opposite of algorithmic. According to Newell, Shaw and Simon, process that may solve a given problem, but offers no guarantees of doing so is called a heuristic for that problem.We know that heuristic techniques dominated early application of artificial intelligence. Heuristic method is still used in problem solving. For example, game playing is also a form of problem solving. Games have engaged the intellectual faculties of the humans. And game playing is also one of the oldest areas of endeavour in artificial intelligence. A chess-playing computer is a proof of a machine doing something though intelligence. Furthermore, the simplicity of the rules and their application in the program implies that it is easy to represent the game as a search through a space of possible game positions.

The initial state, the operators, a terminal test, and a pay-off function can define a game. According to Carpenter and Just, an intelligent machine can follow all these rules and play more efficiently than human beings. For example, in speed chess, computers have defeated the world champion, Gary Kosparov, in both five-minutes and twenty five minutes games. Such a system would be a significant achievement not just for game playing research, but also for artificial intelligence research in general, because it would be much more likely to be applied to the problem faced by a general intelligent agent. There are so many kinds of search in order to solve a problem. But we are not explaining the entire search. We are mainly concerned with how artificial intelligence programs solve different problems within a few seconds.

(ii) Natural Language Processing

The most common way that people communicate is by speaking or writing in one of the natural languages like, Hindi, English, French or Chinese. However, the computer-programming language seems to differ from human languages. These 'artificial' languages are designed so that sentences have a rigid format, or syntax, making it easier for compliers to phrase the programs and convert them into the proper sequences of computer instructions. Besides, being structurally simpler than natural language, programming language can easily express only those concepts that are important in programming: 'Do this, then do that', 'See whether such and such is true'.

One of the important facts is that if computers could understand what people mean when people use English language, the systems would be easier to use and would fit more naturally into people's lives. Artificial intelligence researchers hope that learning how to build computers that can communicate as people do would extend our understanding of human language and mind. The goal of cognitive linguistics is to specify a theory of language comprehension and production to such a level of detail that a person could write a computer program that could understand and produce natural language. Thus, the intelligent machine program has the capacity to understand natural language. It also responds to questions in an appropriate manner. Thus, if the question were 'Is Rome the capital of France?' the simple reply 'No' would be appropriate but, 'no, it is Paris,' or, 'No, Rome is the capital of Italy' would be more complex. Machine programs would also be able to explain the meaning of the word in other terms and also to translate from one language to another.

(iii) Machine Vision

Vision is the information processing of understanding a scene from its projected images. An image is a two-dimensional function (X, Y) obtained, with a sensing device that records the value of an image feature at all points (X, Y). Images are converted into a digital form for processing with a computer. The task of a computer-vision system is to understand the scene that an imaginary of pixels depicts. Generally, machine vision means the vision of a machine that can see or perceive the things in the world. According to David Marr, vision is the process of discovering form images what is present in the world, and where it is. Thus, vision is, first and foremost, an information-processing task. Moreover, there is a distinction between human vision (perception) and machine vision, because human vision is defined as the eye is just a sensor; the visual cortex of the human brain is our primary organ of vision. In the case of human vision, the sensory organ necessarily forms a representation or physical encoding of the received information that facilitates the answering of some questions about the environment, but makes it extremely difficult to answer others. For example, an examination of the encoded information produced by the human eye reveals that at any instant of time the eye has sensed only a small part of the electromagnetic spectrum, and has extracted an image of the scene from a particular viewpoint in space. It possesses the visual information with the help of the lens fitted within it. Thus machine vision works more or less like human vision.

Learning is now perceived as a gateway to understanding the problem of intelligence. Because seeing is also intelligence, seeing is also learning which is a key to the study of intelligence and biological vision. Visual neuroscience develops the methods of understanding how human visual systems work. Visual neuroscience is beginning to focus on the mechanisms that allow the cortex to adapt its circuitry and learn a new task. Machine vision as a part of the AI programme, however, tries to develop systems that can simulate human vision.

(iv) Machine Learning

Learning for an intelligent agent is essential for dealing with unfamiliar environments. Learning a function from examples of its input and output is called inductive reasoning. According to Bonnet, the ability to learn is one of the fundamental constituents of intelligence, ‘learning’ being understood in its general sense as indicating the way in which the humans and animals can increase their stock of knowledge and improve their skill and reasoning powers.

Moreover, from the very beginning of artificial intelligence, researchers have sought to understand the process of learning and to create computer programs that show learning behaviour. Ordinarily, learning is a very general term denoting the way in which people increase their knowledge and improve their skills. There are two fundamental reasons for studying learning. One is to understand the process itself. By developing computer models of learning, psychologists have attempted to gain an understanding of the way humans learn. Philosophers since Plato have also been interested in the process of learning, because it might help them understand and know what knowledge is and how it grows.

The second reason for learning research is to provide computers with the ability to learn. Learning research has potential for extending the range of problems to which computers can be applied. In particular, the work in machine learning is important for expert systems development, problem solving, computer vision, speech understating, conceptual analysis of databases, and intelligent authoring systems. In this way, a computer can do more work than human beings. According to James R. Slagle, computers can do arithmetic at an unbelievable speed, and no human can compete with them. Besides, computers can do many other odd jobs like detecting a certain disease from the available data.

1.5 LET US SUM UP

Thus, AI as a study of machine intelligence, especially of computers and robots, opens up new vistas of understanding mind and intelligence. Intelligent behaviour can be studied in many dimensions. This is made possible by the invention of computers as high-processing computing machines. The computers can do many things that seem to require intelligence and other mental abilities.

1.6 KEY WORDS

Artificial Intelligence, Turing Machine, and Physical Symbol System

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UNIT 2 PHILOSOPHICAL IMPLICATIONS

Contents

2.0 OBJECTIVES

In this unit, an attempt will be made to understand the philosophical presuppositions of artificial intelligence; especially, the nature of mind as presupposed by artificial intelligence. Artificial intelligence as a programme in cognitive science is based on many theoretical presuppositions like the distinction between natural and artificial intelligence, the information-processing character of mental representations, the idea of mind as a computer, and so on. The nature of cognition is a complex process which needs to be studied for understanding the nature of artificial intelligence.

2.1 INTRODUCTION

Cognition involves issues how we acquire, store, retrieve, and use knowledge. If we use cognition every time and acquire a bit of information, place it in, or use that information in some way, then cognition must include a wide range of mental processes. Cognition, generally, is a process in which information is encoded in the brain by receiving signals from the outer world through the sense organs. It seems that human cognition is largely different from that of other animals because of the enormous richness of the human cognitive process.

2.2 THE NATURE OF COGNITION IN MACHINES

There are different models of understanding cognition such as the neuro-scientific, psychological, representational, connectionist and computational model. These six approaches explain cognition from different standpoints. Neuroanatomy is the study of the nervous system's structure, and is concerned with identifying the parts of the nervous system and describing how the parts are connected to each other. Neuroanatomy can be made at many descriptive levels. According to neuroscientists, investigation can be made at two levels. Firstly, gross neuroanatomy is about general structures and connections, whereas fine neuroanatomy is the main task that describes the components of individual neurons. Secondly, histology is the study of tissue through dissection. The primary concern of neuroanatomy is to ideally connect the patterns of connectivity in the nervous system, and to layout the mechanism that allows information to get from one place to another. For neuroscientists, this neuroanatomy is the analogy of cognition.

While explaining neuro-scientific approach to cognition, Francis Crick, a famous neuro-scientist observes that the brain does not make a distinction between hardware and software, as a computer does. Theories [of thought] have made this distinction are unfortunate. Crick argues for theories of cognition that are strictly tied to biology, which implicitly force him to argue for the study of simple cognitive acts, such as visual word detection, rather than the complex acts such as paragraph comprehension, etc. For neuroscientists, mental action depends on the psycho-neurological factors underlying in it. No mental action is without these factors which determine the mental history of an agent. Although Crick's general discussion is on the concept of conscious thought; virtually all the specific studies he cites deal with visual cognition. For him, it might be most profitable to deal with vision entirely within the field of neuro-science, while dealing with language comprehension in terms of psychological machines has no known neural basis. Cognition is a multi-dimensional process which needs a many-sided approach.

The psychological approach to cognition is defined as the psychology of understanding and knowing. It is also the study of mental processes. It is concerned with the way we take in information from the outside world, and how we make sense of that information, and what use we make of it. According to Groome, there have been three main approaches to the study of cognitive psychology, namely, experimental psychology, computer modelling, and cognitive neuropsychology. Firstly, experimental psychology involves the use of psychological experiments on human subjects to investigate the ways in which we perceive, learn, remember or think. Secondly, cognitive psychology is the use of computer modelling of cognitive processes. This approach involves the simulation of some aspects of human cognitive function by writing computer programs, in order to test out models of possible brain function. Lastly, cognitive neuropsychology is concerned with the activities of the human brain during cognitive processing. These three approaches of cognitive psychology explain the psychological levels of cognitions.

The representational theory of cognition tries to show how our knowledge of the world is represented in the mind. When human knowledge is represented in an abstract format, we call it propositions. Thus all knowledge representations take place in language. The representational theory studies the mental representation in a formal language called language of thought by Jerry Fodor. A representation is something that stands for something else. For example, the words of any human language are forms of a representation because they stand for objects, events, and ideas; words are an abstract representation because the relation between a word and the object signified or the idea it represents is arbitrary; words in other language can refer to the same objects and ideas, and in few cases the referent of a word cannot be predicted from its auditory form. But in the case of mental representations, mind preserves information about objects or events in the world. For example, when we have a mental representation of table and this representation preserves locations of objects in the space, it supports a number of abilities, including imaging the place, estimating distance from memory, and so on. This mental representation is necessary because human behaviour cannot be explained without specifying how individuals represent the world to themselves.

According to cognitive scientists, all cognitive processes are computational processes, and all computational processes require internal representations as the medium of computation. And then the nature of this medium is such that the internal representations are symbols. The symbol-system facilitates the computational processes. Computational modelling in cognitive science and artificial intelligence has profoundly affected how human cognition is viewed and studied.

Computational levels of cognitions show that the mind is a computer, which is based on symbolic computation. In symbolic computation, the abstractions provided are symbols and rules. But according to the classical computational theory of mind, mental representations are symbolic structures, and the mental processes consist in the manipulation of these representations according to symbolic algorithms as computation is based on symbolic rules.

Herbert Simon, one of the founders of Computer Science, discusses the nature of cognition while constructing models of human mental activity. According to him, cognition is a mental process based on mechanisms of the brain. The brain mechanisms can be studied by neurophysiology. Further, he argues that human brain functions like a computer so that the human cognitive processes are computational in nature. Therefore, if we manage to programme a computer to play chess, we may well have discovered how human thought proceeds. Thus, Simon argues for a sharp distinction between the brain as a physical system and the programs the brain executes; and therefore, he urges us to concentrate our attention on the program. A great deal of the modern study of cognition depends on the insight that representational level and neural level events can be linked through the development of intermediate, computational theories of thought. Newell and Simon point out that this insight is based upon a rather sophisticated notion, both of thinking and computation as activities that are carried out by physical symbol systems.

As we know, a machine or computer is a physical device that manipulates electrical signals that stand for the symbols in the equation. The physical systems translate signal system into a symbol system. Computers and engineer-paper-pencil devices are general computing systems in the sense that they can, in principle, compute any computable function that is defined by a symbol system. In order to actually compute something, the physical device must be given a set of instructions which are stated in terms of symbols. Thus computing systems operate systems of symbols to arrive at results. We have to note that the algorithm is not stated in terms of the physical machine, because the physical operations that achieve the primitive function such as writing down, multiplying, and subtracting have not been specified.

According to Newell, a physical symbol system has the necessary and sufficient means for general intelligent action. By ‘necessary’ we mean that any system that exhibits general intelligence will prove upon analysis to be a physical symbol system. By ‘sufficient’ we mean that any physical symbol system of sufficient size can be organized further to exhibit general intelligence. Lastly, by ‘general intelligent action’ we wish to indicate the same scope of intelligence as we see in human action. Thus physical symbol systems as discussed above give rise to intelligent actions because of the presence of symbol manipulations according to rules.

The physical symbol system hypothesis plays an important role in showing computational levels of cognition because the symbol system hypothesis implies that the symbolic behaviour of humans arise because he or she has the characteristics of a physical symbol system. Hence, the success in modelling human behaviour on the symbol systems becomes an important part of the evidence for the hypothesis. The hypothesis helps research in cognitive psychology. Research in information processing psychology involves two main kinds of empirical activity. Firstly, it conducts observations and experiments on human behaviour in tasks requiring intelligence. Secondly, it formulates the hypothesis about the symbolic processes found in the human system. Not only are psychological experiments required to test the veridicality of the human behaviour, but also out of experiments come new ideas for the design and construction of physical symbol systems.

According to Newell, Rosenbloom, and Laird, human beings can be described at different levels of the system. For him, at the top is the knowledge level which describes the persons having goals and knowledge about the world, where knowledge is used in the service of attaining goals. The person can operate at the knowledge level because that involves a symbol system, which is a system that operates in terms of representations and information processing operations on this representation. They says that the symbol level must also be realized in terms of some substrate, that the architecture is that substrate defined in an appropriate descriptive language. For computers this turns out to be the register-transfer level, in which bit-rectors are transported from one functional unit (such as an adder) to another, subject to gating by control bits. For human beings it is neural circuit level, which currently seems well described as highly parallel interconnected networks of inhibitory and exlitatory connections that process a medium of continuous signals.
Thus according to Newell, Rosenbloom, and Laird, the role of architecture in cognitive science is to be the central element in a theory of human cognition. The fixed structure provides the frame within which cognitive processing in the mind takes place. This structure is called architecture. The central function of architecture is to support a system capable of universal computations. Symbols do provide an internal representation function, but representation of the external world is a function of the computational system as a whole so that the architecture supports such representation. It is not the sole or even the predominant determinant of the behaviour of a person, but it is determinant of what makes human behaviour psychological. For him, to have a theory of cognition is to have a theory of the architecture.
The model of the brain, on the other hand, is a technique for analyzing the anatomy and physiology of the brain. This view suggests that the brain consists of a network of simple electrical processing units, which simulate and inhibit one another. This style of explanation of the brain, in cognitive science, is generally considered as the brain-style computation. Now, the question is: Why should there be a brain-style computation? The basic assumption is that we seek explanation at the program or functional level rather than the implementational level. Thus it is often pointed out that we can learn very little about what kind of program a particular computer may be running by looking at the electronics with which it is made. In fact, we do not care much about the details of the computer at all. All we care about it is the particular program that is running. If we know the program, we will know how the system will behave in any situation. It does not matter whether we use vacuum tubes or transistors, the essential characteristics are the same. It is true for computers because they are all essentially the same. Whether we make them out of vacuum tubes or transistors, we invariably use computers of the same design. But when we look essentially at a difficult architecture, we see that the architecture makes a good deal of difference. It is the architecture that determines what kind of algorithms are most easily carried out on the machine in question. It is the architecture of the machines that determine the essential nature of the program itself[12]. Thus, it is reasonable that we should begin by asking what we know about the architecture of the brain and how it might shape the algorithms underlying the biological intelligence and human mental life.

Rumelhart says that the basic strategy of the connectionist approach is to take the neuron as its fundamental processing unit. Computation is carried out through simple interactions among such processing units. Essentially, the idea is that these processing elements communicate by sending numbers along the lines that connect the processing elements. This identification already provides some interesting constraints on the kinds of algorithms that might underlie the identifications of human intelligence. A question may arise here: How does the replacement of the computer metaphor as model of mind affect our thinking? Rumelhart says that this change in orientation leads us to a number of considerations that further inform and constrain our model building efforts. Neurons are remarkably relative to the components in modern computers. These neurons operate in the time scale of milliseconds, whereas computer components operate in the time scale of nanoseconds- a vector of 10^6 time faster. This means that the human brain process that receives the order in a second or less can involve only a hundred or so times steps. Because, most of the computational processes like perception, memory retrieval, etc take about a second to function. That is, we seek explanations for these mental phenomena that do not require more than about a hundredth elementary sequential operations.

The human brain contains billions of such processing elements. As the computer organizes computation with many serial steps, similarly the brain can deploy many processing elements in cooperation and in parallel to carry out its activities. Thus, the use of brain style computational system offers not only a hope that we can characterize how brains actually carry out certain information processing tasks but also offers solution to computational problems that seem difficult to solve in more traditional computational framework. The connectionist systems are capable of exploiting and mimicking brain-style computation like artificial intelligence. Connectionism operates both as a system and a process. The connectionist systems are very important because they provide good solutions to a number of difficult computational problems that seem to arise often in models of cognition. Connectionism as a processing mechanism is carried out by a number of processing elements. These elements, called nodes or units, have a dynamics, which is roughly an analogue to simple neurons. Each node receives input from some number of the nodes and responds to that input according to a simple activation function, and in turn excites or inhibits other nodes to which it is connected.

All the levels of cognition, which we have discussed, are not universally accepted. There are levels of cognition which are better explained in the connectionist model. The connectionist approach refers to the functions of the neurons. According to Crick, the 'astonishing hypothesis' is that consciousness and all the thinking that goes with it are the product of neurons, and therefore, the primary business of the scientific study of thought has to be the reduction of cognitive psychology to neurology. He says that one may conclude, then, that to understand the various forms of consciousness, we need to know their neural correlates.
Crick is not opposed to the study of the computational level of cognition when they are linked to the physiological investigations of the brain. But, advocates of computational level models are careful to dissociate themselves from the idea that the computer, as a physical device, is being used as a model for the brain. According to David Chalmers, a computational basis for cognition can be challenged in two ways. First, it can be argued that computation cannot do what cognition does: that a computational simulation cannot reproduce a human cognition, because the causal structure in human cognition goes beyond what a computational description can do. Second, computation might capture the human capacities, but something more is required to replace the human capacity. The human cognition can be applied to what is known as memory attention, pattern recognition, language, problem solving etc. The most intriguing aspect of the human mind is the selection of information for further processing and storage. The information available during each moment, except sleep and unusual occasions, is vast and complex; we are constantly bombarded by our senses. All the external senses give us information which the mind

deals with at different stages. Cognition is the output produced after a long process of getting the inputs.

2.3 THE COMPUTATIONAL MODEL OF MIND

As we have already seen, artificial intelligence is the discipline that aims to understand the nature of human intelligence through the construction of computer programs that imitate intelligent behavior. It also emphasizes the functions of the human brain and the analogical functioning of the digital computer. According to one extreme view, the human brain is just a digital computer and the mind is a computer program. This view, as John Searle calls it is strong artificial intelligence. According to strong artificial intelligence, the appropriately programmed computer with the right inputs and outputs literally has a mind in exactly the same sense that you and I do. This tells that not only the devices would just referred to indeed be intelligent and have minds, etc. but mental qualities of a sort can be attributed to teleological functioning of any computational device, even the very simplest mechanical ones such as a thermostat. Here, the idea is that mental activity is simply the carrying out of some well-defined operations, frequently referred as an algorithm. We may ask here as to what an algorithm actually is. It will be adequate to define an algorithm simply as a calculation procedure of some kind. But in the case of thermostat, the algorithm is extremely simple: the device registers whether the temperature is greater or smaller than the setting, and then, it arranges for the circuit to be disconnected in the former case and to remain connected in the latter. For understanding any significant kind of mental activity of a human brain, a very complex set of algorithms has to be designed to capture the complexity of the human mental activities. The digital computers are approximations to the complex human brain.

The strong artificial intelligence view is that the differences between the essential functioning of a human being (including all its conscious manifestations) and that of a computer lies only in the much greater complication in the case of brain. All mental qualities such as thinking, feeling, intelligence, etc. are to be regarded, according to this view, merely as aspects of this complicated functioning of the brain; that is to say that they are the features of the algorithm being carried out by the brain. The brain functions like a digital computer according to this view. The supporters of strong AI hold that the human brain functions like a Turing machine which carries out all sets of complicated computations. The brain is naturally designed like a computing machine to think, calculate and carry out algorithmic activities. To strong AI supporters, the activities of the brain are simply algorithmic activities which give rise to all mental phenomena like thinking, feeling, willing, etc.

David Chalmers, mentions that the field of artificial intelligence is devoted in large part to the goal of reproducing mentality in computational machines. The supporters of strong AI argue that we have every reason to believe that eventually computers will truly have minds. Winston says that intelligent robots must sense, move and reason. Accordingly, intelligent behaviour is interpreted as giving rise to abstract automation. That is to say that an artificial, non-biological system could thus be the sort of thing that could give rise to conscious experience. For the supporters of strong AI, humans are indeed machines, and in particular, our mental behaviour is finally the result of the mechanical activities of the brain.

John Searle, in his *Is the Brain a digital computer*? mentions that the basic idea of the computer model of the mind is that the mind is the software and the brain is the hardware of a computational system. The slogan is that the mind is to the program, the brain is to the hardware.

For strong AI, there is no distinction between brain processes and mental processes. Because the process which is a happening in the brain is a computational process, the mind is the alternative name of the brain which is a machine.
According to David Chalmers, the theory of computation deals wholly with abstract objects such as Turing machine, Pascal program, finite state automation and so on. These abstract objects are formal structures which are implemented in formal systems. However, the notion of implementation is the relation between abstract computational objects and physical systems. Computations are often implemented in synthetic silicon based computers.
Whereas the computational systems are abstract objects with a formal structure determined by their states and state transition relations, the physical systems are concrete objects with a causal structure determined by their internal states and the causal relations between the states. It may be pointed out that a physical system implements a computation when the casual structure of the system mirrors the formal structure of the computation. The system implements the computation, if there is a way of mapping states of the system onto states of the computations so that the physical states which are causally related map onto the formal stares that are correspondingly formally related. The fact is that there is rich causal dynamics inside computers, as there is in the brain. There is real causation going on between various units of brain activity precisely mirroring patterns of causation between the neurons. For each neuron, there is a specific causal link with other neurons. It is the causal patterns among the neurons in the brain that are responsible for any conscious experiences that may arise.
The brain, as Marvin Minsky says that happens to be a meat machine. He points out that the brain is an electrical and chemical mechanism, whose organization is enormously complex, whose evaluation is barely understood and which produces complex behavior in response to even more complex environment. Artificial intelligence understands the nature of human intelligence in terms of the computational model of the brain.

2.4 ARTIFICIAL INTELLIGENCE & THE FUNCTIONALIST THEORY OF MIND

Functionalism arose as a result of the phenomenal rise of interest in computing machines and artificial intelligence. The functionalists say that mental processes are computational processes realized in a machine. Functionalism is a theory that explains mental phenomenona in terms of the external input and the observable output. It explains the mind as a machine. Functionalism as a conception of mind explains the reality of the mental phenomena in terms of the mechanical phenomena. Mind is not just a part of the physical organism but is itself characterized as the physical organism called the brain. The brain is further characterized as a complex physical system working like a computing machine. Functionalism explains the mechanical behaviour of the brain/mind. Functionalism as a theory of mind is supported by various scientific theories like those of artificial intelligence, cognitive science, and neuroscience, etc., Artificial intelligence advocates a computational theory of mind which argues in favour of the functional similarity between the computation states of the artificial system and the neurophysiological states of the brain.
The hypothesis of artificial intelligence that “machine can think” became very popular after Alan Turing’s “C*omputing Machine and Intelligence.*” Turing’s hypothesis is that machines think intelligently like human beings. Putnam says that probabilistic automation has been generalized to allow for ‘sensory inputs’, and ‘motor outputs’, -that is, the Machine Table specifies, for every possible combination of ‘state’ and a complete state of ‘sensory inputs’ an ‘instruction’ which

determines the probability of the next 'state' and also probabilities of the 'motor out puts'. The following are the steps which explain how a machine functions in general:

(i) The description of the sequence of states (procedure)
(ii) Description of rules
(iii) The explanation of the rationale of the entire procedure.

The computing machine is thus a system constructed out of different subsystems that function inside it to process the inputs and to produce the output once the input is simulated in the machine. It tries to match the simulating state with the states already computed and mapped in the system. This mapping order follows certain syntax or rules. The syntax is responsible for the correlation of total cognitive states. Thus, the entire process of simulation can be called an intelligent process. This simulation process takes place between the functions of the two functionally isomorphic systems. As Putnam defines that two systems are functionally isomorphic if there is a correspondence between states of one and the states of the other that preserves the functional relation.

There is functional isomorphism, according to Putnam, between the brain/mind and a machine. This functional isomorphism holds due to the causal capacity of the functional states of the machine. For example, when I have a pain, there is a neurophysiological process corresponding to the mental state because of the firing of the C-fiber. The brain/mind identity follows as there is functional identity between the two. Thus, identity between the mental states and the physical processes of the brain is established from the functional point of view. That is, in functional terms, the brain state is isomorphic with the mental state. That is, there is identity between software that constitutes the program and the hardware of the machine, which helps the software to be realized in the machine.

There can be indefinitely many different physical properties, which constitute the realizations of the same functional property. However, it is also true that the same physical state can realize different functional properties at different times or in different circumstances or in different creatures. The functional states are 'multiply realizable' in the sense that a functional state cannot be identical to any particular physical realization of it. For example, someone could write a program using two completely different types of computer, which use different sorts of hardware to run the same program. In this sense, the program is said to be 'multiply realizable' in that any number of computers may be used to realize the same program. Functionalism takes states of mind and mental properties to be functional states and properties. Mental properties are realizable by, but not identical with, material properties. For example, the same mental property, the property of being in pain, may be realized by one property in a human being and to a certain extent by another property in an invertebrate. For the functionalist, if someone has now a particular pain, then he/she can imagine that this pain is realized through a particular neural state. That neural state has an identifiable material structure, and this may be studied by a lower-level hardware science like neurobiology. Therefore, for functionalism, what makes the state a realization of pain, is not its material constitution but it's occupying a particular kind of causal role within our nervous system. Multiple realizability thus implies that there is a higher-level functional description of physical states in terms of their causal role, which abstracts from their lower-level physical constitution. It is with such functional properties that mental properties can be identified.

In his essay "*Mad Pain and Martian Pain*", David Lewis discusses two kinds of beings, which experience pain differently than normal humans. In the case of mad pain, the subject experiences pain when doing moderate exercise in an empty stomach; further, it improves his concentration for mathematical reasoning. On the other hand, Martian pain takes place in a Martian organism constructed of hydraulic hardware rather than neurons. Here the point is that pain is associated only contingently with either its causes (as in mad pain) or its physical realization (as in Martian pain). We cannot specify *a priori* its causal role or physical

Daniel Dennett has suggested a multiple-draft-model, approach to the nature of mind. According to this model, there is similarity between the functions of the human mind and those of the computer. The brain system functions in relation to different sub-systems. So there are multiple drafts, which operate within an artificial system. Such an analogy is beneficial because it analyses consciousness from the point of view of language processing. This is given importance precisely in the sense that a linguistic or language speaking being is considered not only as a conscious being but also a rational being. Even the robots as information processing systems can also be characterized as intelligent systems. According Dennett, we are machines! we are just very, very complicated, evolved machines made of organizes molecules instead of metal and silicon, and we are conscious, so there can be conscious machines – us. So the human thought process and language processing in the artificial systems are analogous to each other. In the case of the conscious thought process, we are aware of our thoughts, at the same time, there is physico-chemical process, which goes on in our brain.

Dennett's functional analysis of consciousness is divided into two parts. There are the sub-personal view of consciousness and the multiple draft-model of consciousness respectively. The sub-personal model explains consciousness and other mental activities through the help of neurological states and processes of the organism, whereas the multiple-draft-model discusses how an artificial system behaves intelligently. Thus Dennett provides a functional explanation of consciousness at the sub-personal level. According to him, sub-personal theories proceed by analyzing a person into an organization of subsystems (organs, routines, nerves, faculties, components-even atoms) and attempting to explain the behaviour of the whole person as the outcome of the interaction of these subsystems. Thus in the present instance the short-coming emerged because the two access notions introduced computational access *simpliciter* and the computational access of a print-out faculty, were defined at the sub-personal level; if introduced into a psychological theory they would characterize relations not between a person and a body, or a person and a state of affairs or a person and anything at all, but rather, at best relations between parts of person (or there bodies) and other things.

Therefore, the sub-personal level of explanation of consciousness tries to explain not only how the human beings are systems of organism but also how the system is being constituted and how the various functions involved in different physiological parts of the organism function together. And that functional structure would help us in defining the capacity involved in causing consciousness or what we call conscious behaviour. A state of consciousness is simply one which exhibits a certain characteristic pattern of causal relations to other states, both mental and physical.

We know that human beings perform various activities; they learn language; acquire various knowledge states or belief states, and there are changes in their belief states, and so on. All these activities are independent biological activities of human life. Dennett anticipates that there would be a system whose programs would be such that it would be self-dependent in all its functions. That would be able to replace or stand parallel to human intelligence. Further, the functions of the artificial system help us in explaining the various mysterious features that are ascribed the human life. Thus, the strong notion of functionalism advocates the identity between the mental states and the brain processes. It also explains the different basic features of human beings such as consciousness, intentionality and subjectivity, etc, by bringing the feature of the functional isomorphism into account.

Functionalism holds that the mental states are abstract, functional states, characterized solely in terms of their casual relationships to each other, to input, and to outoput.[37] Human purposive behaviour is then explained in terms of how this hypothesized system of states take the organism from sensory input to behaviour. Because functionalism insists upon a network of mental states, it insists upon the holism of the mental upon the way in which mental states operate together to explain behaviour. It accepts structure of mental states in which each is necessarily connected with the other. The mental states do not function in isolation; rather they function within the causal co-relationship with other mental states. The function of mental states also takes into account the effect of the environment in which the subject or agent is placed with the system that must be well equipped to receive the input from the environment and to produce the output.

The functionalist program has been strongly influenced by analogies drawn from computer science and AI, both in its general outlook and in several of its specific applications to problems about the nature of mind. Because a functional state is like a computational state of a computer. A computer program can be described as a functional organization of the hardware. As already discussed, the functionalists argue that mental states are like the 'information processing' states of a computer. Accordingly, for computer functionalism or artificial intelligence, the brain is a computer, and the mind is a computer program implemented in the brain. Thus artificial intelligence is strongly founded on a functionalist conception of mind. It is dependent on the idea that human functions like a digital computer with multifunction computational abilities.

2.5 LET US SUM UP

In this unit an attempt is made to understand the philosophical presuppositions of artificial intelligence; especially the nature of mind as presupposed by artificial intelligence. Artificial intelligence as a programme in cognitive science is based on many theoretical presuppositions like the distinction between natural and artificial intelligence, the information-processing character of mental representations, the idea of mind as a computer, and so on. The nature of cognition is a complex process which needs to be studied in order to understanding the nature of artificial intelligence. In this way, we have explored mental representations like beliefs and thoughts which constitute the broad domain of cognitive science. These representations explain how cognition takes place in the human mind. Cognitive science (including cognitive linguistics and cognitive psychology) has brought about a cognitive revolution in the study of mind.

2.6 KEY WORDS

Artificial intelligence, functionalism, cognitions & computational theory of mind

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UNIT 3 NEUROLOGICAL STUDIES AND CONSCIOUSNESS

Contents

3.0 OBJECTIVES

- To give general overview of neurological studies.
- To figure out the important fields of neurology.
- To see the relationship between neurology and consciousness/

3.1 INTRODUCTION

This introductory unit tries to give an over-view of neurology. We first deal with the history of neurology. Then we take up some general features of brain. Then we deal with the development of brain leading to the evolution of consciousness.

3.2 ETYMOLOGY

The word Neurology comes from the Greek word *neurologia* and deals with *disorders of the nervous system*. Specifically, it deals with the diagnosis and treatment of all categories of disease involving the *central, peripheral, and autonomic nervous systems,* including their coverings, blood vessels, and all effector tissue, such as muscle. Neurology can be defined as the medical specialty concerned with the diagnosis and treatment of disorders of the nervous system -the brain, the spinal cord, and the nerves. According to the World English Dictionary; Neurology means the study of the anatomy, physiology, and diseases of the nervous system. Similarly, a neurologist is a specially trained physician who diagnoses and treats disorders in the nervous system, whether caused by disease or injury. This includes diseases of the brain, spinal cord, nerves and muscles. Neurologists possess a comprehensive knowledge of the neurological structures of the body, including the cerebral cortex and its division into various lobes and their individual jobs in making the body work as a whole. In short neurology can be defined the branch of medical science that deals with the nervous system.

3.3 HISTORICAL DETAILS OF NEUROLOGY

We list below some of the major discoveries that have advanced neurological research and studies. The list is only indicative and not exhaustive.

a. The first scientific studies of nerve function

All living things are built of cells. These are not just passive building blocks; they are busy active places. The first scientific studies of nerve function were done in the 18th century. However, clinical neurology had very less scope for further development and findings until the mid-19th century as a result it was very difficult to name and find out the information about the causes of epilepsy, aphasia and other problems due to brain damage. It is interesting to note that the Knowledge of the brain and nervous functions came from studies of animals and the analysis of human nerve cells under the microscope.

b. Beginning of Neurology

With the invention of the electroencephalograph (EEG) in the 1920s which was meant to record electrical brain activity, the diagnosis of neurological disease became easy and speedy. Next came the development of cerebral angiography which helped to see the blood vessels in the brain. Specific drug therapies have been introduced to treat neurological conditions. Thus the future form of neurology will be shaped by knowledge of the human genome and proteome. Electroencephalograph is particularly useful in picking up abnormal brain activity that might be associated with seizure disorders like epilepsy, head injury, brain tumours, infection and inflammation of the brain, chemical disturbances and some sleep disorders.

c. New findings in Neurology

Positron emission tomography in clinical neurology was researched by Karl Herholz MD, and W.D. Heist MD from the Department of Neurology, University Cologne, and Max-Planck Institute for Neurological Research, Köln, Germany. According to them, the Positron emission tomography (PET) imaging in clinical neurology serves different purposes like differential diagnosis, especially in the early stage of neurological disorders, description of path physiologic changes that are responsible for manifestation and course of a disease, and evaluation and follow-up of treatment effects and so on. Positron emission tomography relies on a radioactive phenomenon, “positron decay”. Certain radioactive materials will release positively charged particles, called positron as they decay (Al-Chalabi, Turner, Delamont 2006).

MRI- Magnetic resonance imaging

It is helpful in revealing the blood vessels of the brain- angiography. An abnormal expansion of a blood vessel, an aneurysm can be made visible by injecting a dye into the blood vessels. the dye is opaque to X-rays and so outlines the aneurysm (Al-Chalabi, Turner, Delamont 2006).

Computed axial tomography- the CT scan

CT was discovered independently by a British engineer named Sir Godfrey Hounsfield and Dr. Alan Cormack. It has become a mainstay for diagnosing medical diseases. For their work, Hounsfield and Cormack were jointly awarded the Nobel Prize in 1979. CT scanners first began to be installed in 1974. Further, in the late 1980s the spiral CT was invented .in this , the X- ray camera rotates spirally downwards and can encompass data from an entire organ within half a minute. this has also permitted the development of CT angiography (Al-Chalabi, Turner, Delamont 2006).

Check Your Progress I

Note: Use the space provided for your answers.s.

1) What is the etymology of neurology?

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2) How did EEG help the progress in neurology?

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Developmental dyslexia and animal studies

At the interface between cognition and neurology was researched by the American neurologist, Albert M. Galaburda. Recent findings in autopsy studies, neuroimaging, and neurophysiology indicate that dyslexia is accompanied by fundamental changes in brain anatomy and physiology, involving several anatomical and physiological stages in the processing stream, which can be attributed to anomalous prenatal and immediately postnatal brain development. Epidemiological evidence in dyslexic families led to the discovery of animal models with immune disease, comparable anatomical changes and learning disorders, which have contributed a lot in finding about mechanisms of injury and plasticity to indicate that substantial changes in neural networks concerned with perception and cognition are present.

Identifying a Molecular Switch That Controls Neuronal Migration in the Developing Brain

St. Jude Children's Research Hospital investigators have identified key components of a signaling pathway that controls the departure of neurons from the brain niche where they form and allows these cells to start migrating to their final destination. However the defects in this system affect the architecture of the brain and are associated with epilepsy, mental retardation and perhaps malignant brain tumors. Thus the findings provide insight into brain development as well as clues about the mechanism that are helpful in the other developing tissues and organ systems, particularly the epithelial tissue that covers body surfaces.

Neurological Diseases Major Discovery

Researchers at the University de Montreal and the Montreal Neurological Institute, McGill University have discovered that cells which normally support nerve cell (neuron) survival also play an active and major role in the death of neurons in the eye.

New Findings on the Neurological Organization of Dreaming

Sigmund Freud is still the most widely read author on the subject of dreams.he concluded his studies of dreams by saying that “the dreams serves preponderantly to guard against pain”

(Searle 2004). The fundamental neuropsychological mechanisms involved in dreaming appear to be (1) inhibitory mental control, (2) spatial thought, and (3) quasi-spatial (symbolic) operations. The essential factor in REM sleep, by contrast, is basic arousal. Dreaming is a natural mental activity. most dreams are clear, coherent, realistic and detailed accounts of a situation involving the dreamer and other people. More often than not, dreams are about very ordinary activities and preoccupations, although they can also be fantastic or ridiculous things.so dreamiong can be looked upon as a continuous stream of mental activity, which we become aware of when aroused, occurring particularly during REM and to a lesser extent during NREM sleep (Al-Chalabi, Turner, Delamont 2006).

Brain Underpinnings for Auditory and Visual Illusions and Everyday Experiences

New research indicates that the integration of senses and functions in the brain is very common. It is found that about two percent of the population has a condition called synesthesia, in which two different sensations, like color and sound, are experienced at once. Although this condition is rare, the new findings suggest the brain is wired in complex and sometimes overlapping ways to help people interpret and understand their environments. Scientists have also found the relationship between stroke and brain damage caused by the lack of oxygen. Dr Sharlin Ahmed, Research Liaison Officer at The Stroke Association says: "When a stroke strikes the brain is starved of oxygen and as a result brain cells in the affected area die. The use of stem cells to replace dead brain tissue is a promising technique which could help to reverse some of the disabling effects of stroke. Damage to the rhinal cortex of both hemispheres causes severe memory loss or amnesia. The crucial feature of the amnesic syndrome is a devastating absence of memory for events since the injury (Gellatly and Zarate1998).

Emergence of neuroculture

NeuroCulture is the relation between the sciences that study the functioning of the brain and culture. We normally understand culture as the knowledge, history, habits, ideas and values of the human race, and their manifestations in any form of expression: social, scientific, artistic, philosophical, moral or religious, etc. It is interesting to note that the basis of NeuroCulture is that everything a human being creates is generated in the brain, from the most primary functions which resulted from millions of years of evolution. This lead to superior expressions, like art, religious or scientific thinking. Thus, the link that relates the biological functioning of the brain to the results of its processes creates a method of explaining how human beings respond to their environment in every possible way. Neuroscience, together with the humanistic and scientific disciplines, creates a new level of study that leads to a reassessment of some of its fields of study and, of course, the enrichment of neurological studies.

3.4 THE GENERAL STRUCTURE OF THE BRAIN

The brain is the portion of the central nervous system in vertebrates (animals with bones) that lies within the skull. 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. The brain is a pinkish-gray mass that is composed of about 10 billion nerve cells. The nerve cells are linked to each other and together play a vital role in the control of all mental functions. 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 brain is

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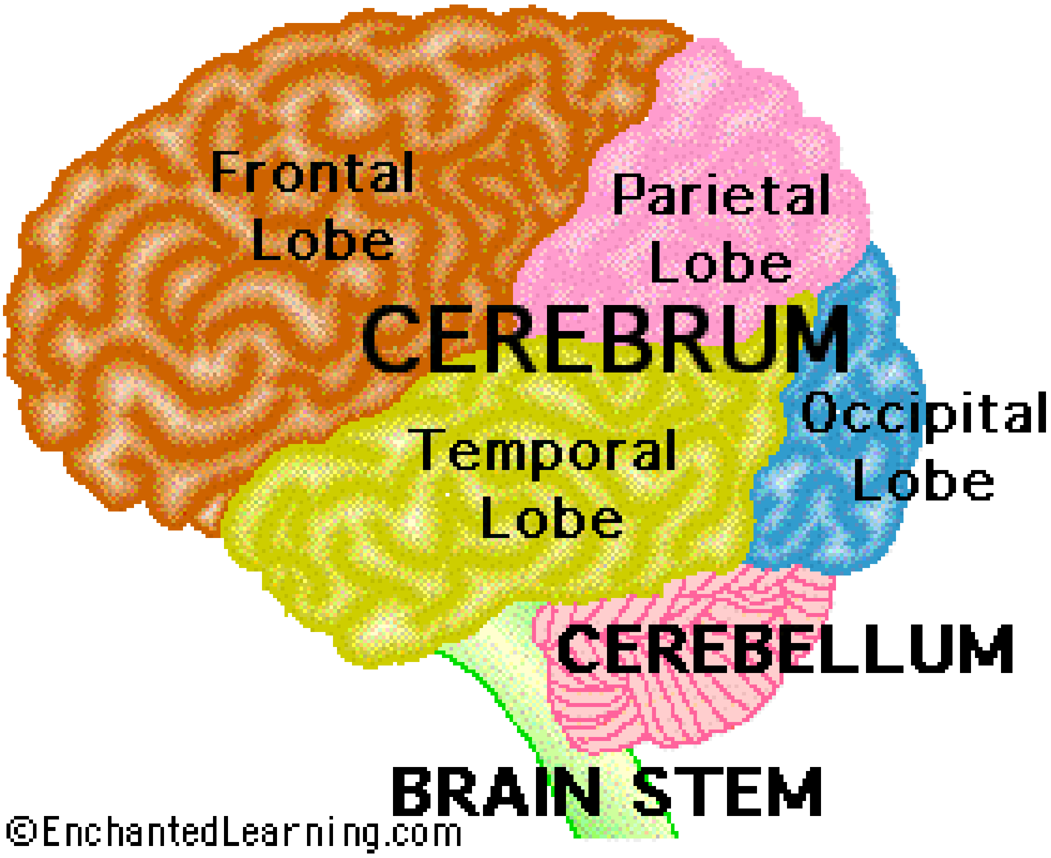
Frontal
Lobe
Parietal
Lobe
CEREBRUM
Temporal
Lobe
Occipital
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- Inhibition
- Coordination of movements
- Generalized and mass movements
- Some eye movements
- Sense of smell
- Muscle movements
- Skilled movements
- Some motor skills
- Physical reaction
- Libido (sexual urges)

Occipital Lobe

- Vision
- Reading

Parietal Lobe

- Sense of touch (tactile senstation)
- Appreciation of form through touch (stereognosis)
- Response to internal stimuli (proprioception)
- Sensory combination and comprehension
- Some language and reading functions
- Some visual functions

Temporal Lobe

- Auditory memories
- Some hearing
- Visual memories
- Some vision pathways
- Other memory
- Music
- Fear
- Some language
- Some speech
- Some behavior amd emotions
- Sense of identity

Right Hemisphere (the representational hemisphere)

- The right hemisphere controls the left side of the body
- Temporal and spatial relationships
- Analyzing nonverbal information
- Communicating emotion

Left Hemisphere (the categorical hemisphere)

- The left hemisphere controls the right side of the body
- Produce and understand language

Corpus Callosum

- Communication between the left and right side of the brain

THE CEREBELLUM

- Balance
- Posture
- Cardiac, respiratory, and vasomotor centers

THE BRAIN STEM

- Motor and sensory pathway to body and face
- Vital centers: cardiac, respiratory, vasomotor
-

Hypothalamus

- Moods and motivation
- Sexual maturation
- Temperature regulation
- Hormonal body processes

Optic Chiasm

- Vision and the optic nerve

Pituitary Gland

- Hormonal body processes
- Physical maturation
- Growth (height and form)
- Sexual maturation
- Sexual functioning

Spinal Cord

- Conduit and source of sensation and movement

Ventricles and Cerebral Aqueduct

- Contains the cerebrospinal fluid that bathes the brain and spinal cord

3.6 THE EVOLUTION AND DEVELOPMENT OF THE HUMAN BRAIN

The evolution of the brain acquired a process of continuous change and selection in all aspects of life on earth, including the human brain. The scientists have discovered that billions of years ago, life existed only in the form of single celled organisms. These organisms were continued through their own chemical processes until they gradually evolved into the multi-celled beings that first appeared approximately 680 million years ago. Thus the more complex animals, including man, afterward evolved from these multi-celled beings. The evolution of the human brain followed a similar course; moving from the simple to the complex over an extended period of time. The billions of cells that work together to make the brain and body function harmoniously have numerous critical functions. The brain is after all a far more multi-functional organ by nature than other, less complex organs such as the heart or the liver.

It is a fact that as man evolved, certain mutations took place within the nervous system that forced it to evolve in time with the body. For example, just as external physical changes were selected as either worthy or unworthy by the environment, mutations in the nervous system were also forced to prove their might against environmental challenges. The brain of an embryo starts off as a simple tube of tissue. It then develops three enlargements that will become the forebrain later divides into the two cerebral hemispheres, which grow outwards to cover much of the lower brain regions. (Angus Gellatly Oscar Zarate 1998)

Configuration of the brain

The adult human brain weighs on average about 3 (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. At the age of 20, a man has around 176,000 km and a woman about 149,000 km of militated axons in their brains. The two cerebral hemispheres are the largest and most obvious features of human and other primate brains. Their surface grey matter is the cortex, sometimes called neo-cortex to distinguish it from the cortex found in lower, and more ancient, brain structures (Al-Chalabi, Turner and Delamont 2006).

Functions of the Brain

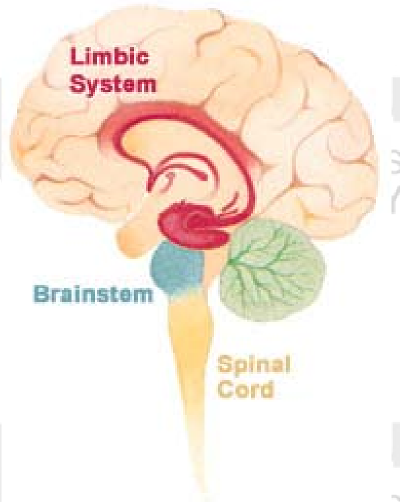
From an organismic perspective, the primary function of a brain is to control the actions of an animal. To do this, it extracts enough relevant information from sense organs to refine actions. Sensory signals may stimulate an immediate response as when the olfactory system of a deer detects the odor of a wolf; they may modulate an ongoing pattern of activity as in the effect of light-dark cycles on an organism's sleep-wake behavior; or their information may be stored in case of future relevance.

Functional subsystems. One of the most important of these is on the basis of the chemical neurotransmitters used by neurons to communicate with each other. Another is in terms of the way a brain area contributes to information processing: sensory areas bring information into the brain and reformat it; motor signals send information out of the brain to control muscles and glands; arousal systems modulate the activity of the brain according to time of day and other factors .In the first signs of a nervous system, the notochord develops and causes the elctoderm above to become tissue, which in turn sinks down to become a tube of nervous tissue- the future spinal cord and brain (Al-Chalabi, Turner and Delamont 2006).

As per the Neurotransmitter systems, with few exceptions, each neuron in the brain consistently releases the same chemical neurotransmitter, or combination of neurotransmitters, at all of the synaptic connections it makes with other neurons.Thus, a neuron can be characterized by the neurotransmitters it releases.

Sensory systems

Like animals, humans learn about the world through their senses. traditionally, there are five senses. taste and smell are closely associated with the limbic system. One of the primary functions of a brain is to extract biologically relevant information from sensory inputs. Even in the human brain, sensory processes go well beyond the classical five senses of sight, sound, taste, touch, and smell: our brains are provided with information about temperature, balance, limb position, and the chemical composition of the bloodstream, among other things. All of these modalities are detected by specialized sensors that project signals into the brain (Gellatly and Zarate 1998).


Limbic
System
Brainstem
Spinal
Cord

Some Interesting facts about the Brain

- The brain uses 20% of your body's energy, but it makes up only 2% of your body's weight.
- The average human brain weighs around three pounds or 1.4 kilos.
- Your brain is about 1300-1400 cubic centimeters in volume, about the size of a cantaloupe and wrinkled like a walnut.
- In 1874, Carl Wernicke discovered that damage to an area of the temporal lobe, close to tissue involved in hearing resulted in anoathaer type of language disorder (Gellatly and Zarate 1998).
- A brain generates 25 watts of power while you're awake enough to illuminate a light bulb.
- A newborn baby's brain grows almost 3 times in course of first year
- Humans have the most complex brain of any animal on earth.

The brain is divided into two sides. The left side of your brain controls the right side of your body; and, the right side of your brain controls the left side of your body.

Check Your Progress II

Note: Use the space provided for your answers.s.

1) When did neurology originate?

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2) What is NeuroCulture and its significance for neurological studies?

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3.7 DISEASES AND CONDITIONS OF THE BRAIN

There are many diseases connected with the brain. Advances in neurological studies, it is hoped, will be able to find remedy for at least most of these conditions.

- Stroke, meningitis, multiple sclerosis, coma, paralytic polio, Parkinson's disease, Leu Gehrig's Disease, Cerebral Palsy, and migraine headaches are all diseases and conditions that affect the brain.
- A stroke is damage to the brain due either to blockage in blood flow or to loss of blood from blood vessels in the brain.
- Coma is an extended period of unconsciousness from which a person cannot be aroused even with the most painful stimuli.

- Damage in the cerebellum has a variety of consequences .defects include loss of the ability to learn new movements, disruption of posture, jerkiness of movements inability to make rhythmic movements, and impaired sequencing of movements.
- People with Parkinson's disease, characterized by tremor and an inability to initiate movements, have a shortage of dopamine in the BG (Gellatly and Zarate 1998).

3.8 BRAIN DEATH AND THE LOSS OF PERSONHOOD

It is obvious that the sense of self or personhood (identity) is connected to the brain. And brain death is connected to the loss of personhood. There are two theories with regard to the death of a person from the neurobiological perspective; i) the whole-brain death definition and ii) the higher-brain death definition (Jones 2004). The whole-brain death is considered as the traditional definition of neurobiological death which states that death occurs due to the cessation of the functioning of the whole brain. This is considered a biological concept of death since it takes account of the irreversible cessation of the functioning of the whole brain and the whole body. In this definition of brain death there is no difference between the death of any other organism and that of a human being. Gareth Jones writes, "This (whole-brain death) entails the cessation of functioning of a biological unit, in the sense that there is no difference between the deaths of any biological life, be it a dog, rat or human being" (Jones 2004).
As opposed to the whole-brain death, higher-brain death defines death as the higher capacities of a human being ceasing irreversibly due to the irreparable cerebral cessation. This is known as the personalist conception of death, as a person is considered dead when his higher functions which are considered essentially human cease to function or stop working in an irrecoverable way. This definition of death accords the human being personhood which states that he is more than a biological organism.

This higher-brain definition stresses the irreversible loss of functions regarded as characteristic of human existence and of our meaning as human persons: our individual personalities, conscious life, and uniqueness, and the capacity for remembering, judging, reasoning, acting, enjoying and worrying. Such a personalistic concept focuses attention onto our humanness and onto the responsibilities lying at the core of human community." (Jones 2004) Whether we accept either of the definitions of death, the important point in this regard is that both are related to the cessation of the functioning of proper or total termination of the brain processes.

3.9 NEUROLOGY AND CONSCIOUSNESS

The problem of consciousness has been away from the scientific arena for a long time since many scientists considered it as a philosophical problem. But with the emergence of neuroscience as a well-established discipline and with the technological advancements by developing new methods of brain mapping neuroscientists also find it plausible to delve into this 'hard problem'. Francis Crick and Christof Koch write in a review of *the Astonishing Hypothesis*, "We have taken exactly the opposite point of view. We think that most of the philosophical aspects of the problem should, for the moment, be left on one side, and that the time to start the scientific attack is now" (Crick and Koch 2004).

a. Francis Crick's Theory

Consciousness, as many hold, is a multi-dimensional phenomenon. This is one of the problems that makes the explanation of consciousness a hard one, be it for scientists or for philosophers. However scientists like Francis Crick and the Paul Churchland firmly believe that this is the opportune time to begin the scientific attack on consciousness. Crick's astonishing hypothesis is that "it's all done by neurons" (Crick 1994). Francis Crick tried to crack the hard problem of consciousness through the explanation of the any single aspect of consciousness - visual consciousness. Here Francis Crick writes: In approaching the problem, we made the tentative assumption that all the different aspects of consciousness (for example, pain, visual awareness, self-consciousness, and so on) employ a basic common mechanism or perhaps a few such mechanisms. If one could understand the mechanism for one aspect, then, we hope, we will have gone most of the way towards understanding without further discussion" (Crick and Koch 2004). Francis Crick, thus, tries to solve the problem of consciousness by providing a solution to 'visual consciousness'.

For Francis Crick, the whole brain is not the part of the generation of consciousness. His whole attempt is to find the 'Neural Correlate of Consciousness'. His finding is that only specific types of neurons are conscious. These neurons should project themselves to the centres of the brain which control the motor activity and planning)Crick and Koch 2004) Francis Crick hopes to solve the problem of visual consciousness by the 'Frontal Lobe Hypothesis' where we may find the neural correlate of visual consciousness (Crick 1994). He solves the binding problem of perceptual unity by yet another neuron doctrine – mainly by the conjoining simultaneity and the speed of the firing of the neurons which may be involved in a particular act of perception, say, seeing an angry face. Crick writes: "The simplest idea would be that awareness occurs when some special set of neurons fire at very high rate (e.g., at about 400 or 500 Hertz), or that the firing is sustained for a reasonably long time. Thus "binding" would correspond to a relatively small fraction of cortical neurons, in several distinct cortical areas, firing very fast at the same time (or a long period)" (Crick 1994).

b. Qualia: The Opponent Pathway Hypothesis

The problem of qualia has been a thorn in the flesh of the philosophers and scientists who claim to explain all the aspects of human conscious experience. Among the *qualia* colour has attracted the attention of the philosophers and scientists. Neuroscientists try to solve the problem of *qualia* of colour through 'the opponent pathway hypothesis'. The opponent process account is one of the popular theories in neuroscience which explains how does the brain code sensory qualities. The scientists and philosophers who hold this view of processing sensory *qualia* by the brain generally hold the view that photoreceptor present in the human retina are in the opponent path ways like, red-green, black-white etc. (PN 2008). The colour that strike the retina of the human eye then activate the three dimensional vector space, production activity in each of the isolated pathways. In this understanding, the representation of colour *qualia* is due to the activation of the vector space in the colour opponent pathway. Each dimension in that three-dimensional space will represent the average frequency of action potentials in the axons of one class of ganglion cells projecting out of the retina.

The process of the representation of the colour, according to the opponent pathway hypothesis, is as follows. Each colour perceivable by humans will be in a region of a particular vector space in which opponent colours are present. For example, an orange stimulus produces a relatively low level of activity in both the red-green and yellow-blue opponent pathways and middle-range activity in the black-white opponent pathway. Pink stimuli, on the other hand, produce low activity in the red-green opponent pathway, middle-range activity in the yellow-blue opponent pathway, and high activity in the black-white opponent pathway (PN 2008). Location and geometrical proximity between regions reflect the structural similarities between the perceived colours.

c. Backward Referral Hypothesis

The backward referral hypothesis of consciousness has been proposed by the neuroscientist-philosopher Benjamin Libet, following an experiment he conducted to know whether conscious awareness precedes or follows an event (Libet, Sinnott-Armstrong and Nadel2011). Libet found out that the neural event happens in a delayed 500 milli-second time after the onset of the stimulating of the event (Gazzaniga, Ivry and Mangun 1998). According to him conscious awareness of an event actually follows the event, though we often think that we are aware of the event from its very onset. Rodeny Cotterill following the hypothesis of Libet, proposed a neural circuit called “vital triangle” (fig:2.1), for the cause of the delay in the conscious awareness of an event. This neural circuit includes, sensory cortex, frontal cortex and various thalamic nuclei. The delay in conscious awareness of an event, according to Rodeny Cotterill, is because these regions are not singly responsible for the consciousness awareness but it is the feedback–feed forward connections among these three partners that enable consciousness (Gazzaniga, Ivry and Mangun 1998).

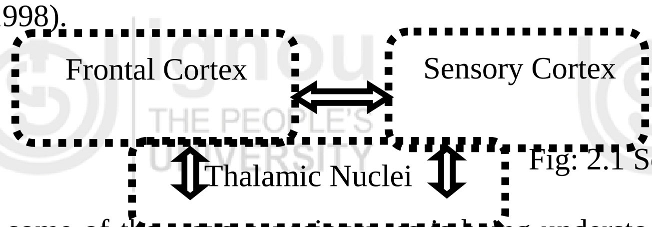

Fig: 2.1 Schematic of the Vital Triangle

There are some of the ways consciousness is being understood and explained by neuroscience. There is definitely a long way to go.

Check Your Progress III

Note: Use the space provided for your answers.s.

1) How is brain death related to the loss of personhood or identty?

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2) What is “Backward referral hypothesis”?

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3.10 LET US SUM UP

In this unit we tried to have an overall view of neurological studies and brain functions, with special focus on the emergence of human consciousness.

3.11 KEY WORDS

Aphasia: Inability to use or understand language (spoken or written) because of a brain lesion

Dyslexia: A general term for disorders that involve difficulty in learning to read or interpret words, letters, and other symbols, but that do not affect general intelligence

Hypothalamus: a region of the brain, between the thalamus and the midbrain, that functions as the main control center for the autonomic nervous system by regulating sleep cycles, body temperature, appetite, mood, etc., and that acts as an endocrine gland by producing hormones, including the releasing factors that control the hormonal secretions of the pituitary gland.

NeuroCulture: NeuroCulture is the relation between the sciences that study the functioning of the brain and culture.

Qualia: Qualia is the term used for the description of the sensory quality one subject experiences which is thought to be subjective and private.

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UNIT4 NEUROTHEOLOGY

Contents

4.0 OBJECTIVES

- The introduce the students to the basics of neurotheology
- To give some ideas of the relationship between nurological studies and religious experiences.
- To understand some aspects of mystical experience through neurology.

4.1 INTRODUCTION

Pascal Boyer is a professor at Washington University in St Louis, a pre-eminent scholar of religious behaviour in humans and the author of *Religion Explained: The Evolutionary Origins of Religious Thought.* Boyer is an atheist and proposes that religions exist because their proponents have learnt to successfully recruit a variety of low-level systems in the human brain. He views religions not as a source of morality but as a canvas on which people project their own folk ethics. However, Boyer seems to miss the concept of neurotheology. The brain after millions of years of evolution has developed the capability to conceptualize religious thoughts and feelings. Anthropologically why did the human species evolve this capability? Boyer is critical of neuroimaging for religious purposes. Still he acknowledges, "that people can experience a sudden feeling of peace, of communion with the entire world.... (that) can be to some extent correlated with particular brain activity; it is plausible that such experience stems from a particular activation of cortical areas that handle thoughts about other people's thoughts and those that create emotional responses to people's prescience" (Jacob 2006).

What Boyer has stated above is exactly what neurotheologians are trying to find out.] He misses the point that the brain's capacity to conceptualize religious tenets can be insinuated in all equations of brain evolution. The anthropological changes that occurred during evolution influenced the very nature of society, environment and human awareness of God, and their openness to religious an mystical experiences.

4.2 MEANING AND SIGNIFICANCE

Neurotheology, also known as spiritual neuroscience, is the study of correlations of neural phenomena with subjective experiences of spirituality and hypotheses to explain these phenomena using neurological terms. Neurotheology in other words is primarily concerned with identifying the mechanisms underlying brain functions leading to the conceptualization of God, moral values, spiritual experience, guilt, faith and transcendental longings that have become an integral part of human personality. It does not address the subject of experience, beliefs, inner promptings that may belong to another dimension of reality, are also necessarily brain based. Aldous Huxley used the term *neurotheology* for the first time in the utopian novel *Island*. The discipline studies the cognitive neuroscience of religious experience and spirituality. The term is also sometimes used in a less scientific context or a philosophical context. Some of these uses, according to the mainstream scientific community, qualify as pseudoscience. Huxley used it mainly in a philosophical context. "Only one or two thousand nerve fibers connect the brain to the hundred million nerve cells in the small intestine. Those hundred million nerve cells are quite capable of carrying on nicely, even when every one of their connections with the brain is severed..."

In fact, the word Neurotheology at first glance would seem to combine neurological science (which explains the mechanics or the HOW of brain phenomena) with religious doctrine (which explains the WHY behind our life experiences and brain functions). Neurotheology is in fact primarily concerned with the mechanisms underlying brain functions like the conceptualization of God, moral codes, spiritual experiences, guilt, faith and transcendental longings that are an integral part of the human personality. It does not address the subject of theology except to acknowledge that mystic experiences, inner promptings and other phenomena dealing with another dimension of reality are necessarily brain based. It is important for scientists and theologians alike to understand HOW the brain works in a particular phenomenon and WHY it works in that particular pattern.

Thus Neurotheology, still in its infancy promises to fill a very important hiatus in our understanding of things transcendental. The term Neurotheology has been in use for at least 15 or more years. The discipline came into being because tremendous innovations in the mapping of brain fuctions (like fMRI – Functional Magnetic Resonance Imaging and related techniques) created an explosion in the knowledge of how the brain works. These new techniques have been used to map changes in specific regions of the brain during deep meditation, drug consumption, the telling of falsehoods, track action in the brain of serial killers who show no remorse and study brain injured patients who suddenly exhibit abnormal or nonethical behaviour. Neurological science has become a tool readily available for analyzing the reductionist aspects of transcendental happenings (Abraham 2006).

4.3. THE POWER OF HUMAN MIND

A group of neuroscientists have identified a region of the human brain that has some connection to thoughts of spiritual matters and prayer. Their findings tentatively tell that we as a species are genetically programmed to believe in God. However these studies do not in any way negate the validity of religious experience or God rather they just give an explanation in terms of brain regions that may be involved. What is really important is that the only manifestation of God that the human mind can respond to in a coherent ways is God's love, because we are unable to relate or understand a spirit. The mind is what drives us, the spirit is our personality or ego, and the body is the vehicle that is used to experience the physical world. So what we perceive as reality is only a canvas waiting for us to draw upon it any picture we want .Anything is possible with us. As Buddha, holds: "We are what we think. All that we are arises with our thoughts. With our thoughts we make the world." Even at this neurological age, his insight is valid. It is by making using this very mind that humans have visions of God and neurologist try to explain it.

Check Your Progress I

Note: Use the space provided for your answers.s.

1) What do you understand by "Neurotheology"?
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2) In the light of neurotheology comment on Buddha's insight: "We are what we think. All that we are arises with our thoughts. With our thoughts we make the world."
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4.4 VISION & DREAMS

A mystical vision is more profound that ordinary seeing. Throughout the centuries, mystics, prophets, and ordinary people from all religions have experienced visions from their deities or higher levels of consciousness that have informed them, warned them, or enlightened them. From Genesis to Revelation, God uses visions and dreams as a principal means of communicating with his prophets and his people. For example, in Numbers 12:6, God declares, "If there is a prophet among you, I the Lord make Myself known to him in a vision and speak to him in a dream." And in Joel 2:28: "And it shall come to pass afterward that I shall pour out my spirit upon flesh; and your sons and your daughters shall prophesy, your old men shall dream dreams, your young men shall see visions."

Roman Catholics holds that there are two kinds of visions. One is the imaginative vision, in which the object seen is but a mental concept of symbol, such as Jacob's ladder leading up to heaven. For example, St. Teresa of Avila (151–1582) had numerous visions including images of Christ. The other is the corporeal vision, in which the figure seen is externally present. Along with visions, dreams are also connected to our inner world. Priests and prophets as well as the common people, often experienced God as well as animal spirits and the souls of the dead, during the course of a dream. Dreams occur only in sleep. So it is pertinent of us to review some of the current views on the nature of sleep. There are two types of sleep- REM (Rapid Eye Movement) Sleep and NREM (Non rapid Eye Movement) sleep. These nomenclatures are based on the simple observation that during REM sleep the eyeballs move rapidly and continuously beneath the closed eyelids. Sleep, new information is processed and stored in the memory banks.

REM sleep plays a role in problem solving, memory consolidation, information processing and creativity (Abrahm 2006).

Vision recorded in the Bible, are the result of activation of the neural circuits in a very organized sequential manner. Most visions occur as the result of deep concentration. However the brain-mind ability to interpret impulses that have by-passed the five senses is the key to most spiritual experiences. We might, therefore, think of God as a non-local reality, not only permeating the cosmos but also communicating with the individual man. Einstein talked of "a knowledge of the existence of something we cannot penetrate, our perception of the profoundest reason and the most radiant beauty." It is this knowledge and emotion that constitutes true religiosity. Are dreams, visions meditation just purposeless phenomena? Why does a sense of holiness permeate some of these encounters? We need to recognize that in these encounters God impinges the; Brian, and a deep spiritual awareness is created as "Spirit speaks to spirit". Everyone should realize as Moses did on the mountain of Horeb that we perhaps are on holy ground and in the presence of God, in these spiritual encounters (Abraham 2006).

4.5 NEUROTHEOLOGY AND RELIGIOUS EXPERIENCE

In the year 1844, long before the establishment of neuroscience as a separate field of investigation and study, Orson Flower wrote, "This science shows … that a large section of the brain is set apart exclusively for the exercise of the moral and religious feeling." Now with the introduction of the most sophisticated imaging machines and new evolutionary insights into the brain organization, neuroscientists are confident of mapping the 'God Spot' in the brain. Brain, although, it has come under the scanner of scientists over the recent years, its mysterious nature still remains intact. Eelectroencephalography (EEG) is used to measure the electrical activity in the brain. EEG is commonly used because of it is relatively noninvasive and produces images with very good temporal resolution. Functional neuroimaging studies of religious and spiritual phenomena have utilized positron emission tomography (PET), single photon emission computed tomography (SPECT), and functional magnetic resonance imaging (fMRI). In general, such techniques can measure functional changes in the brain in pathological conditions, in response to pharmacological interventions, and during various activation states.

Spirituality is the heritage of all humankind and a function for our brain-mind construct. In fact, it is the result of millions of years of biological evolution. It is true to say that my mystical journey that commenced with the Big Bang and the birth of life is ongoing even now. The mystic experience of oneness and dependent communion with the spiritual is actualized in finite conscious experience and thus brain has a significant role to play there.

There are some basic structural and functional patterns that essential for the mystical experience. Some of brain parts involved are:

- A highly developed complex brain and mind connections.
- During the mystic experience some areas of the Brain are metabolically more active than others, although the Brain works as a whole.
- The pre-frontal neuronal connections especially the right orbital and medical surfaces
- The temporal lobes and parts of the parietal lobes
- The limbic system

- The rest of the brain acting in coordination

Every mystical experience is a highly individual experience and the mystic is never able to express and interpret it for others as he actually experienced it. The mystic experience may take myriad forms because extensive areas of the right brain are involved in its manifestations. It is important to differentiate between hallucinations and mystic experiences though the brain areas involved may be identical in both phenomena. Mystic experiences may originate in the brain from energies impinging on the cortex from other dimensions .Hallucinations are initiated exclusively by focal cortical neuronal activation. Hallucinations may occur secondary to brain lesions in any part of the cortex or due to high fever, drugs, starvation etc. Basically hallucinations occur due to loss of sensory input like vison and hearing.

St. Teresa of Avila (1515- 1582), considered one of the greatest mystic saints of Christendom described her mystic experience as follows: "I threw myself down in despair before an image of the Mother of God. With many tears, I implored the Holy Virgin to become my mother now. Uttered with the simplicity of a child, this prayer was heard. From that hour on, I never prayed to the Virgin in vain." Therefore it is amazing to say that St Teresa Avila was one of the great Christian mystics. Overcoming physical ailments, she became fully absorbed in her devoted to God. In Spain, Teresa of Avila offered to the world something profoundly mystical. Her mystical experience is the most successful culmination of the divine marriage between the aspiring soul and the liberating Christ, and it is here that man’s helpless crying will and God’s omnipotent all-fulfilling will embrace each other.

a. Limbic System Hyper-activation Theory of Religious Experience

The main proponents of this neurobiological theory of religious experience are R. Joseph and Vilayanur Ramachandran. Their main contention is that religious experience is nothing but the activation of the limbic-amygdalial region of the human brain. These neuroscientists link the universality of religious experience to the fact that every human being has a limbic system. R. Joseph writes: The limbic system is common to all peoples; this might explain why belief in souls, spirits, haunted houses, angels or demons, and the capacity to have mystical experiences, including the sensation of being possessed by gods or devils or hearing their voices, is worldwide.”

That the limbic system is the seat of a number of activities inspires these types of neuroscientists to link all those activities to religious experience. It is commonly believed and is a scientifically proved fact that the limbic system has been the seat of sexual pleasure, and emotions such as violence, fear etc.; whose hyper activation may also lead to hallucination. R. Joseph writes: “Perhaps it is because activation of limbic system generates spiritual and religious, as well as fearful and enraged, murderous feelings that so many of those who claim to be religious, including members of innumerable religious sects, become “righteous” belligerent, hateful, and murderous. Indeed throughout the recorded history, cults and organized religious have employed torture and human or animal sacrifice and have sanctioned if not encouraged the murder of non-believers, what could be referred to us limbic system blood lust” (Joseph 2001).

He continues to write (Joseph 2001): “Sex and food (along with fear, rage and aggression) are probably the most powerful of all limbic emotions and motivators and when harnessed or stimulated they can completely overwhelm or control the brain and lead to limbic hyperactivation coupled with religious or spiritual sensation, or at a minimum, complex dreams or hallucinations. Hence, hungry men will dream of food, and those who are sexually aroused will dream sex. A parched and starving man however, will not just dream, he will hallucinate food and water and will attempt to slake his desires by consuming a hallucination."

Another important aspect of this kind of neurobiological explanation of religious experience is that religious experiences could be relegated to the level of a pathological state, especially with the temporal lobe epilepsy. The fact that many epileptic patients do exhibit signs of religious hallucinations and experiences of religious fervour leads these types of neuroscientists to make the bizarre conclusion that those religious experiences are pathological. Joseph writes (Joseph 2001): "Many modern-day religious writers who also happen to suffer from epilepsy are in fact exceedingly prolific, whereas conversely, those who feel impelled to preach tend to do just that. In part this is a consequence of amygdala activation of Wernicke's area, the adjacent inferior parietal lobe, and Broco's area, which give rise to "voices", or strange thoughts, and/or a desire to speak."

R. Joseph argues that Moses and St. Paul, the two epitomes of Christian religious fervor in the Bible, one in the Old Testament and the other in the New Testament, might have had such epileptic seizures, which brought them to the brim of the arduous religious fervour which they exhibited in life; Moses in the freedom struggle of his own people and Paul in the evangelisation of the Gospel of Jesus respectively after their 'visions.' R. Joseph writes in the following vein (Joseph 2001): "If Moses subsequently (*after the exposure to the scorching sun in the desert*) developed temporal lobe epilepsy, this could explain his hyperreligious fervor, his rages, and the numerous murders he committed or ordered. Similarly his speech impediment, hypergraphia, and hallucinations, such as hearing the voice of God are not uncommonly associated with temporal lobe seizures and limbic hyperactivation."

b. The Triune Brain and the God-Talk

The main proponents of this theory of religious experience in neuroscience are neuroscientists Paul D. MacLean and James B. Ashbrook and Carol C. Albright (See Rottschaefer 1999). The latter two authors take the basic idea of the triune brain from the former, who, largely depending on evolutionary theories, claims that our human brain has three main parts corresponding to the three main evolutionary stages of development (Ashbrook 1989).

According to MacLean the first level of human brain organization is the reptilian Brain – whose main anatomic structure is the brain-stem. MacLean calls this the primal mind, as this is the first type of mind in the evolutionary development. The main function of this part of the brain is "life support" and "self-protection" (Ashbrook and Rausch 1997). The basic characteristic of life support is the phenomenon called 'my-turf' in which each organism finds its own place of settlement. Ashbrook writes, "The primal mind is literally territorial-my place my prerogative, my space, my inherited niche in the scheme of things" (Ashbrook 1989). Taking these anatomical insights of the reptilian brain, Ashbrook and Albright connect it to religion showing it as the biological base for the linguistic expression of territoriality in religion (Ashbrook and Rausch 1997). He writes in another article, "Such expressions may point to geographical territory such as the biblical concept of a Holy Land for the people of the Lord. They also may be psychological and theological analogical of territory based on the primal mind of the reptilian like brain" (Ashbrook 1989).

The second level of brain organization is the limbic system which MacLean calls the 'emotional mind'. This region according to MacLean plays a significant role in the nurturing, motivation, and preservation of continuity of species and familial bonds (Ashbrook 1989). This part's role in the symbolic expression is also emphasised. Ashbrook and Albright hold that this region is responsible for the picturing of a God who is nurturing, preserving humankind and saving them from slavery (Ashbrook 1989).

Neo-cortex, the new brain, is considered as the rational mind of the primates, especially in humans. Neo-cortex with its two hemispheres having two contrasting features - the right involved in more integrative processes and the left more analytical processes - makes human distinctiveness by assisting in the making of culture and science. However Ashbrook and Albright suggest in their book that both these hemispheres, though possessing contrasting features, act with a greater degree of cognitive integration through the help of the corpuscallosum. These hemispheric distinctions and the resultant integration, according to Ashbrook and Albright, represent different images of God. Regarding left-brain analogy of brain with God, they write, "It seems clear that the left brain that can begin to grasp the work of a creator of such surpassing reasonableness must, indeed, reflect one of the images of God." (Ashbrook and Rausch 1997) On the right brain they write, "Our human right brain, which comprehends all together, may, in a feeble sort of way, provide an image of this encompassing God who is manifested in the whole of reality." (Ashbrook and Rausch 1997) On the integration they write, "Surely God cannot be limited to one or another way of being God. … The conclusion is that God the mother/father/lover/ground of Being has cunningly designed the world, and supports its interactions and its inhabitants by perceiving and penetrating it whole." (Ashbrook and Rausch 1997).

Check Your Progress II

Note: Use the space provided for your answers.s.

1) What is limbic system hyper-activation theory of religious experience?
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2) What is the rational mind of the primates and its significance?
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c. The Biological Tendency to Transcendence: The Neurobiology of Mystical Experience

Andrew Newberg, Eugene D'Aquili, Victor Turner and Colwyn Tevarthen are the main proponents of this theory of religious experience in which they argue that the potency to transcend the material existence of this world to the immateriality of the mystical experience is a built-in mechanism of the human brain which has evolved. "After years of scientific study, and careful consideration of our results, Gene and I … saw evidence of a neurological process that has evolved to allow us humans to transcend material existence and acknowledge and connect with a deeper, more spiritual part of ourselves perceived of as an absolute, universal reality that connects us to all that is" (Newberg, D'Aquili and Rause 2001). The proponents of this theory further try to show this by demonstrating that there is a biological drive to make myths and rituals, which will lead to transcendental experiences.

The proponents of this theory do this by dividing the brain into six operators of which the holistic operator is the one intimately related to the religious transcendental experiences. Situating at the right hemisphere of the brain this holistic operator helps to explain the mystical experiences which transcend temporal and spatial limitations (Barbour 1998). Eugene G. d'Aquili writes, "In certain rare cases, often induced by meditation, ritual behaviour, starvation, hypoxia, prolonged sensory deprivation, or various drug effects, the holistic operator can function as if it were on its own, independent of content upon which to impose wholeness. In these rare states of absolute function the operator generates simply the sensation of wholeness itself devoid of any specific content." (A'quili and Newberg1993).

6. "WHOLLY OTHER" AND THE "ABSOLUTE UNITARY BEING"

In mystical experiences as well as religious practices two commonly occurring notions regarding God or the Absolute are "Wholly Other" and "Absolute Unitary Being." he phrase 'wholly other' refers to the experience of divine as somebody who is transcendent, high above the heavens. Religious experiences, in this tradition, refer to the religious experience of the divine as the mysterious 'other.' Neuroscientific explanation of this type of experiencing God as the totally other or the mysterious other revolves around the process of deafferentation of those neural circuits within the inferior parietal lobule which generate the sense of causality in our ordinary processing of sensory input, and which we have termed in previous works the causal operator (A'quili and Newberg1993). This process of cutting of the passage of the neuronal activities would generate a kind of 'reified causality' – the great cause: the mysterious other.

The absolute unitary being is the form of mystical experience where the practitioner experiences an obliteration of the self-other dichotomy. She feels totally one with such a being, thereby giving up her own identity. It is believed that posterior superior parietal lobe is responsible for the sense of space and the distinction of subject and object in our normal perception. While the total deafferentation of the left PSPL results in the obliteration of the self-other dichotomy the deafferentation of the right PSPL generates a sense of absolute transcendent wholeness. Though it the inputs to this area is cut-off, neuronal impulses can shoot out of PSPL, and pass to hippocampi and to the limbic structures which are responsible for the emotions of happiness and joy. Thus the practitioner would experience deep sense of quiescence coupled with ecstasy. hus some of the salient features of mystical and religious experiences can be better understood through neurotheology.

Check Your Progress III

Note: Use the space provided for your answers.s.

1) How do you relate the biological tendency to transcendence with neurotheology?
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2) What is the importance of "Absolute Unitary Being" in mystical experiences?
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4.7 LET US SUM UP

After having given a brief introduction to neurotheology, we have tried to understand and interpret visions and dreams. Then we saw how neurotheology can explain religious experiences. Finally we came to relate God ("Wholly Other" or "The Absolute Unitary Being") in terms of neurotheology. Ours is just the beginning of a long research that will be carried out further in the next decades.

4.8 KEY WORDS

Deafferentation: The elimination or interruption of sensory nerve fibers. Such destruction of the afferent connections of nerve cells, performed esp. in animal experiments, to study the effect on brain.

Eelectroencephalography: The measurement of electrical activity in different parts of the brain and the recording of such activity as a visual trace (on paper or on an oscilloscope screen. Abbr. EEG

Functional magnetic resonance imaging (fMRI): Functional magnetic resonance imaging, or fMRI, is a technique for measuring brain activity. It works by detecting the changes in blood oxygenation and flow that occur in response to neural activity – when a brain area is more active it consumes more oxygen and to meet this increased demand blood flow increases to the active area. fMRI can be used to produce activation maps showing which parts of the brain are involved in a particular mental process.

NREM sleep: A recurring sleep state during which rapid eye movements do not occur and dreaming does not occur; accounts for about 75% of normal time of sleep.

Positron emission tomography (PET): using a computerized radiographic technique to examine the metabolic activity in various tissues (especially in the brain).

Single photon emission computed tomography (SPECT): Single photon emission computed tomography (SPECT, or less commonly, SPET) is a nuclear medicine tomographic imaging technique using gamma rays. It is very similar to conventional nuclear medicine planar imaging using a gamma camera. It is able to provide true 3D information.

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